T.R.
ISTANBUL SABAHATTIN ZAIM UNIVERSITY
GRADUATE EDUCATION INSTITUTE
DEPARTMENT OF FOOD ENGINEERING

INTERACTION BETWEEN FOOD SAFETY CULTURE, HALAL FOOD ASSURANCE AND PROCESS HYGIENE IN FOOD PRODUCTION COMPANIES: A MULTIPLE CASE STUDY IN TÜRKİYE

Ph.D. DISSERTATION

Marin NEIO DEMIRCI

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This study has been approved in partial fulfillment of the requirements for Ph.D. Degree in Food Engineering

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DECLARATION OF SCIENTIFIC ETHICS AND ORIGINALITY

This is to certify that this PhD dissertation titled "**Interaction between food safety culture, Halal food assurance and process hygiene in food production companies: a multiple case study in Türkiye**" is my own work and I have acted according to scientific ethics and academic rules while producing it. I have collected and used all information and data according to scientific ethics and guidelines on thesis writing of Sabahattin Zaim University. I have fully referenced, in both the text and bibliography, all direct and indirect quotations and all sources I have used in this work.

Marin NEIO DEMIRCI

PREFACE

'In the Name of Allah — the Most Compassionate, Most Merciful.'

I started my PhD journey, hoping to achieve a meaningful contribution and be a part of researchers making a difference in the field of food safety and Halal food assurance. Now, looking back, I realize how Allah has placed people in my path, who have had different roles supporting me in these endeavors.

I started my PhD journey with Prof. Dr. Carol A. Wallace, one of my current advisors, who was also my advisor and guide during my Master's at University of Central Lancashire. Throughout the years she has offered her unwavering support and instilled confidence in me that research would be my cup of tea, despite past experiences leading me to believe otherwise. Thus, without her, I would not even have started this PhD, let alone progress through it so successfully, as she has guided me ever so subtly empowering me to take ownership of my research.

Prof. Dr. Hasan Yetim, also one of my current advisors, appreciated my passion for food safety and Halal food management and supported me in this interdisciplinary study, enabling me to develop in my area of expertise. By sharing his network and guiding me in the ways of communicating with the companies in the Turkish context, he helped to kick-start the project, and his valuable input enabled me to navigate through the PhD process. Finally, both his and Dr. Chi-Ching Lee's encouragement, open-minded discussions and support with research funding, gave me an opportunity to explore, experiment and challenge the status quo.

Prof. Dr. Bülent Nazlı, my former advisor, encouraged my ideas for the PhD topic and work as a lecturer in the İstanbul Sabahattin Zaim University, enabling me to grow and eventually start the current PhD journey with the mindset and skills of a 'Hoca' (*eng. teacher*). He supported my personal and academic growth guiding me towards a PhD advisory team, which could guide me through the difficult journey. May he rest in peace.

At the background, my husband's never-ending motivation and understanding has given me strength to stand tall and face difficulties in a completely different cultural setting compared to my comfort zone. My sister, with her interest in my research and her sense of humor, helped me to take the pressure off and think things through from different perspectives. Both, my Estonian and Turkish families stepped in, taking care of me, my home and my baby boy, that I could focus and concentrate my efforts. I feel blessed and am ever so grateful for such great people surrounding and supporting me and am excited to see what the future holds.

Marin NEIO DEMIRCI

ABSTRACT

INTERACTION BETWEEN FOOD SAFETY CULTURE, HALAL FOOD ASSURANCE AND PROCESS HYGIENE IN FOOD PRODUCTION COMPANIES: A MULTIPLE CASE STUDY IN TÜRKİYE

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Despite developments in both food safety and Halal food management and their certifications, in both sectors, globally and in Türkiye, there are issues impacting both consumer health and sectors' reputations. Evaluating and maturing food safety culture, as a behavior-based approach, has been proven to be the missing link for successful food safety assurance. On the other hand, Halal food assurance has been demonstrated to be, in theory, closely tied with food safety and hygiene. Thus, this study aimed to evaluate food safety culture, Halal food assurance and process hygiene and their interactions in food production companies. Accordingly, 5 large-sized food production companies participated in this multiple case study, using a mixed-methods approach, including semi-structured interviews, focus group discussions, company-wide survey, document analysis, in addition to observations and microbiological analyses at the production environment. As one of the novel outcomes, the Food Safety-Halal food assurance culture approach was suggested and accordingly evaluated. Findings demonstrated a lower, in other words, reactive culture maturity and unidentified risks in the participating companies in both cases. This also reflected from behaviors and working conditions in the processing environment, which in turn resulted in increased microbiological hygiene risks. The latter was put forth through a novel scenario analysis approach, in addition to incorporating behavior into the Zoning concept to determine sampling priority and using indicator organism enrichment to properly identify food safety risks. Furthermore, it was found that Halal food management did not have much impact on food safety and hygiene practices in the companies, as the relationship between food safety and Halal food was not translated into a company-wide belief, value and/or norm. Finally, a conceptual framework using behavioral models was constructed on the impact of Turkish organizational culture on both companies' food safety culture and applying its evaluation methods. This ultimately demonstrated that it is important to mature FSC to a foundational level, before using quantitative evaluation methods encompassing majority of company employees, such as a survey. In conclusion, it could be suggested that these companies could leverage aspects, such as the food safety-Halal food relationship, the new approach to process environment hygiene evaluation suggested and applied by this study and national organization culture impact from a behavioral science perspective, to take a step toward maturing their food safety and Halal food assurance cultures. Regarding Halal food management in particular, food production companies could take more ownership of the Halal supply chain, by focusing on both their own and their suppliers' practices.

Keywords: Food safety culture, food safety management, Halal food management, microbiological hygiene, organizational culture.

ÖZET

GIDA ÜRETİM ŞİRKETLERİNDE GIDA GÜVENLİĞİ KÜLTÜRÜ, HELAL GIDA GÜVENCESİ VE PROSES HİJYENİ ARASINDAKİ ETKİLEŞİM: TÜRKİYE’DE BİR ÇOKLU VAKA ÇALIŞMASI

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Ocak-2025, 404 + xxiii Sayfa

Hem gıda güvenliği hem de Helal gıda yönetimi ve sertifikasyon sistemlerindeki gelişmelere rağmen, her iki sektörde de küresel olarak ve Türkiye'de, tüketici sağlığı ve sektörlerin itibarını etkileyen sorunlar devam etmektedir. Davranış temelli bir yaklaşım olarak gıda güvenliği kültürünün değerlendirilmesi ve olgunlaştırılmasının, başarılı bir gıda güvenliği stratejisi için eksik halka olduğu kanıtlanmıştır. Öte yandan, Helal gıda güvencesinin de teorik olarak gıda güvenliği ve hijyen ile yakından bağlantılı olduğu ortaya konulmuştur. Dolayısıyla bu çalışma, Türkiye’de bulunan bazı gıda üretim şirketlerinde gıda güvenliği kültürü, Helal gıda güvencesi ve proses hijyeni ile bunlar arasındaki etkileşimi değerlendirmeyi amaçlamaktadır. Bu doğrultuda, ülkede faaliyet gösteren 5 büyük ölçekli gıda üretim şirketi, yapılan bu çoklu vaka çalışmasına katkıda bulunmuştur. Araştırmada; yarı yapılandırılmış görüşmeler, odak grup görüşmeleri, şirket çapında anket, doküman analizi ve üretim sahasındaki gözlemler ile sahanın mikrobiyolojik analizlerini içeren karma bir yöntem yaklaşımı kullanılmıştır. Özgün sonuçlardan biri olarak sektöre, gıda güvenliği ve Helal gıda güvence kültürü yaklaşımı önerilmiş ve buna göre değerlendirmeler yapılmıştır. Bulgular, şirketlerin her iki konuda da reaktif bir kültür olgunluğuna sahip olması yanında hem gıda güvenliği ve hem de Helal gıda güvencesi ile ilgili bazı riskleri tespit edemediklerini göstermiştir. Ayrıca, söz konusu gıda güvenliği kültürü olgunluğu seviyesindeki davranışlar ve çalışma koşulları nedeniyle mikrobiyolojik hijyene ilişkin risklerin de arttığı tespit edilmiştir. Kastedilen mikrobiyolojik hijyen riskleri, yeni bir senaryo analizi yaklaşımıyla ortaya konulmuş ve ayrıca üretimde,

çevresel izleme programlarına yeni bir bakış açısı önerilerek uygulaması gerçekleştirilmiştir: burada numune alma önceliğini belirlemek için ölçülecek davranışlar, bölgelere ayırma (eng. Zoning) konsepti ile birleştirilmiş ve gıda güvenliği riskini daha doğru bir şekilde belirleyebilmek için de seçilen indikatör organizmaların zenginleştirmeleri yapılmıştır. Sonuçta, gıda güvenliği ve Helal gıda arasındaki ilişki, şirket çapında bir inanç, değer ve/veya norma dönüştürülemediği için şirketlerdeki Helal gıda yönetiminin, gıda güvenliği ve hijyen uygulamalarını yeterince etkilemediği tespit edilmiştir. Bunların yanı sıra, Türkiye'deki kurum kültürünün, şirketlerin gıda güvenliği kültürü ve onun değerlendirme yöntemlerinin uygulanması üzerindeki etkisini ortaya koyan kavramsal bir çerçeve de oluşturulmuştur. Bu da şirketlerde anket gibi nicel değerlendirme yöntemlerini kullanmadan önce onların gıda güvenliği kültürünü temel düzeyde olgunlaştırmalarının gerekli olduğunu göstermektedir. Sonuç olarak, şirketlerin, gıda güvenliği-Helal gıda ilişkisi, üretim hijyeni değerlendirmesine yönelik yeni yaklaşımlar ve davranış bilimi açısından da kurum kültürü gibi unsurları kullanarak, gıda güvenliği ve Helal gıda güvence kültürlerini olgunlaştırmak için farklı adımlar atabileceği düşünülmektedir. Özellikle Helal gıda yönetimi konusunda, gıda üretim şirketlerinin hem kendileri ve hem de tedarikçilerinin uygulamalarına odaklanarak Helal gıda tedarik zincirlerini daha da sağlamlaştırabilecekleri değerlendirilmektedir.

Anahtar Kelimeler: Gıda güvenliği kültürü, gıda güvenliği yönetimi, Helal gıda yönetimi, mikrobiyolojik hijyen, kurum kültürü.

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LIST OF ABBREVIATIONS

ABC Model	Antecedents Behavior and Consequences Model
ATP	Adenosine triphosphate
BRC	British Retail Consortium
C1 to 5	Company 1 to 5
CCP	Critical control point
CF	Coliform
EB	*Enterobacteriaceae*
FM	Factory manager
FSC	Food safety culture
FS-HFA culture	Food safety – Halal food assurance culture
FSMS	Food safety management systems
GFSI	Global Food Safety Initiative
GM	General manager / CEO
GMO	Genetically modified organisms
GMP	Good manufacturing practices
HACCP	Hazard analysis and critical control points
HAS	Halal assurance system
HC	Halal certificate
HCB	Halal certification body
HFA	Halal food assurance
HH zone/area	High hygiene zone
JAKIM	Department of Islamic Development Malaysia
KAP	Knowledge, attitudes and practices
KPI	Key performance indicators
LH zone/area	Low hygiene zone
LPPOM MUI	Halal inspection agency in Indonesia
MS1500 standard	Malaysian Halal food standard, named MS1500:2009 *Halal Food General Guidelines*
ND	No data
OD	operations director

OG	Overgrowth
OIC	Organisation of Islamic Cooperation´s
OIC/SMIIC standard standard	OIC/SMIIC 1: 2019 General requirements for halal food
oPRP	Operational prerequisite programs
OSF	Other support functions
PM	Production manager
PRP	Prerequisite programs
QA	Quality assurance department
QC	Quality chief
QDMS	Quality document management system
QM	Quality manager
QMA	Quality management assurance responsible
R&D	Research and development
SM	Shift manager
SME	Small and medium-sized enterprises
SMIIC	Standards and Metrology Institute for Islamic Countries
TBX	Tryptone-Bile-X-Glucuronate
TM	Technical/maintenance manager
ttCF	Thermotolerant coliform
VRBG agar	Violet Red Bile Glucose agar
VRBL agar	Violet Red Bile Lactose agar
Z	Zone
3xl	3 loopfuls

CHAPTER I

INTRODUCTION

Despite efforts in both food safety and Halal food management and certification, in both sectors, globally and in Türkiye, there are issues with non-compliance and lack of due diligence, impacting both consumer health and sectors' reputation (Ali & Suleiman, 2018; Soon, Chandia & Regenstein, 2017; Çetin & Durul-Özkaya, 2018; Terzi, Özdemir & Selçuk, 2018; Dorman et al., 2010; Oğur, 2019; Urazel et al., 2014; EFSA & ECDC, 2021; Jespersen et al., 2016), demonstrating the need for more effective and sustainable solutions. Regarding food safety assurance, evaluating and maturing food safety culture (FSC) has emerged as such a solution, which is defined as "*shared values, beliefs and norms that affect mindset toward and behaviour regarding food safety in, across and throughout an organization*" (GFSI, 2018). Thus, it is valuable to research this concept in both the food sector in Türkiye regarding food safety assurance and regarding its application in Halal food assurance, especially since in theory food safety and hygiene practices and Halal food assurance are tightly knit together (Neio Demirci, Soon & Wallace, 2016; Lestari et al., 2023; Raheem & Neio Demirci, 2018). Conducting such research in Türkiye is valuable, as Türkiye is considered globally among top agricultural food producers, food exporters, in addition to being among the leading Halal food markets (details in Chapter 2, Literature review) (Sanayi Genel Müdürlüğü, 2020; Aydın Can, 2022).

This study used a multiple case study approach to evaluate food safety and Halal food related practices in food production companies. As a case study, a mixed-methods approach was used to collect data from different positions across and throughout companies' organizational structures, including both management and shop floor. The methods included semi-structured interviews, focus group discussions, company-wide survey, document analysis, in addition to observations and process environment microbiological analyses at the shop floor. This enabled to gain in-depth insight into companies' food safety and Halal food assurance related practices and culture and possibilities around making theoretical generalizations. Furthermore, literature review revealed multiple research gaps in both FSC and HFA assurance research, which furthermore enabled to shape and pin-point the aims and the research framework according to food sector's needs, which are elaborated in the following section.

1.1. Research Framework

The aim of this study is to evaluate food safety culture, Halal food management and process environment hygiene in food production companies and explore how these concepts interrelated with each other. Accordingly, the research framework is depicted in Figure 1.1.

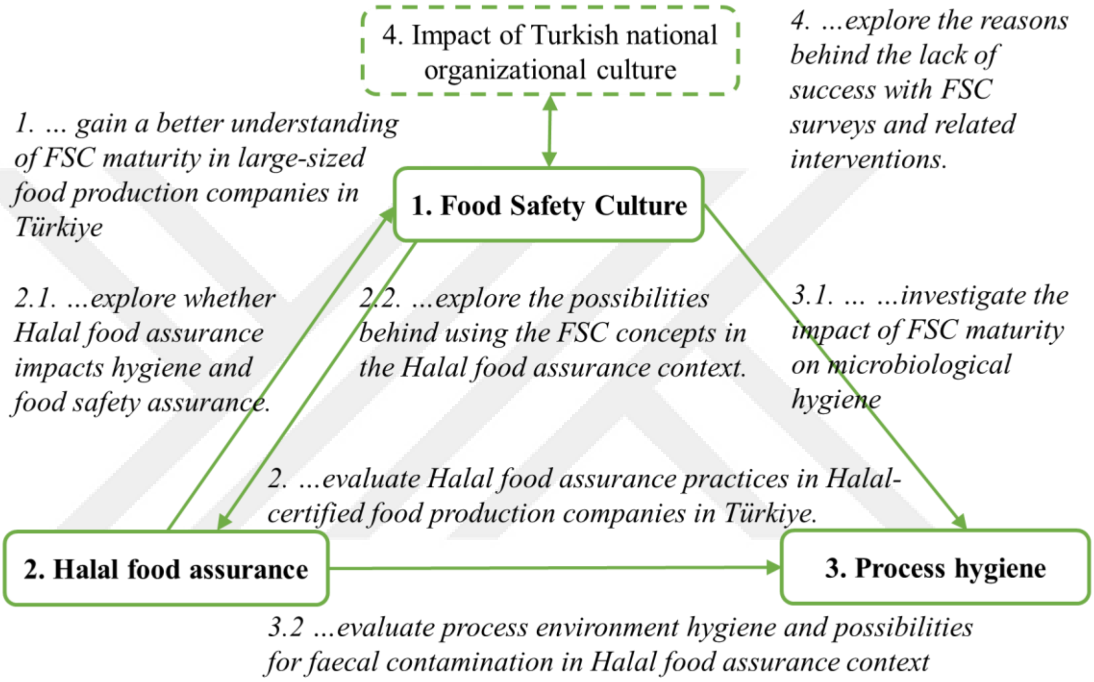


Figure 1.1: Research framework. Green dotted line – additional aim emerging from the research. FSC: food safety culture.
Source: Prepared by the researcher.

The reasoning behind choosing each of the research topics, food safety culture, Halal food management and process environment hygiene, and behind researching relationships between them, is brought out below:

a) Research framework aspect: 1. Food safety culture

The literature review (Chapter 2) showed that no studies have been conducted on food safety culture in Türkiye. Although the current body of scientific literature offers valuable insights on food safety culture aspects, there is still work needed for a more complete understanding.

Thus, one of aims of this research is to gain a better understanding of food safety culture maturity in large-sized food production companies in Türkiye.

b) Research framework aspect: 2. Halal food management

From the literature review (Chapter 2), it became apparent that there is a lack of research on what actions food companies take to manage Halal food assurance (e.g. whether all the possible risks have been identified and addressed appropriately) and that also the main body of Halal food research related to food companies has been conducted in the Malaysian and Indonesian context, with no insights into implementation of the widely renowned OIC/SMIIC Halal food standard.

Thus, another aim of this research was to evaluate Halal food assurance practices in Halal-certified food production companies in Türkiye.

c) Research framework aspect: 2.1. Better hygiene and food safety practices through Halal food management

Literature review (Chapter 2) put forth that food safety and hygiene is a part of Halal food assurance, and that religious commitment might have a positive impact on companies' food safety practices.

Thus, the aim of this research was to explore whether Halal food assurance impacts hygiene and food safety assurance.

d) Research framework aspect:2.2. Better Halal food management through the food safety culture maturity model

Again, the literature review (Chapter 2) reflected that an organizational culture-based approach would lead to better Halal food management and that the organizational culture-based aspects discussed regarding Halal food management are aligned with food safety culture dimensions.

Thus, this research aimed to explore the possibilities behind using the food safety culture concepts (e.g. definition, dimensions, maturity stages and methodological approaches) in the Halal food assurance context.

e) Research framework aspect:3.1. Relationship between process environment hygiene and food safety culture

The literature review showed that more empirical work is needed to fully demonstrate the connection between FSC maturity and microbiological hygiene, and that process environment microbiological sampling has not been used in the context of food safety culture research in food production companies.

Thus, one of the <u>aims</u> of this research was to investigate the impact of food safety culture maturity on microbiological hygiene in the processing environment.

f) Research framework aspect: 3.2. Process environment hygiene and faecal contamination in Halal-certified companies.

Literature review (Chapter 2) also showed that process environment hygiene, and faecal contamination potential had not been evaluated within the context of Halal food assurance, although faecal contamination, in addition to the food safety perspective, is regarded as Najis and as such an unwanted even in Halal food assurance.

Thus, another of this research was to evaluate process environment hygiene and possibilities for faecal contamination in Halal assurance context.

g) Research framework aspect: 4. Interpreting companies' actions from an organizational culture perspective

Additions to the research framework (Figure 1) also emerged from the research process. Namely, during FSC evaluations, it became apparent that companies were not able to achieve the targeted participation rate for the survey and were also not inclined to implement the interventions suggested to them as preparation before conducting the survey again.

Thus, an additional research <u>aim</u> emerged to explore the reasons behind the lack of success with FSC surveys and related interventions.

1.2. Dissertation Layout

As mentioned above, Chapter 2, Literature Review, enabled to pin-point the aims and shape the research framework. Accordingly, the review had three sections, the first pertaining to food safety management and hygiene related research in food production companies in Türkiye, the second to Halal food assurance related research and the third to process environment hygiene studies related to FSC and Halal food assurance. This enabled to set the scene, by defining the concepts and highlighting the main problems and research needs.

As the research framework shaped to have three strands (Figure 1.2), Chapter 3 on Research Methodology also was structured accordingly. The chapter first set the scene on how methods were connected with each of the research strands (FSC, Halal food assurance and process environment hygiene evaluation), followed by justifications behind the methods and their application details.

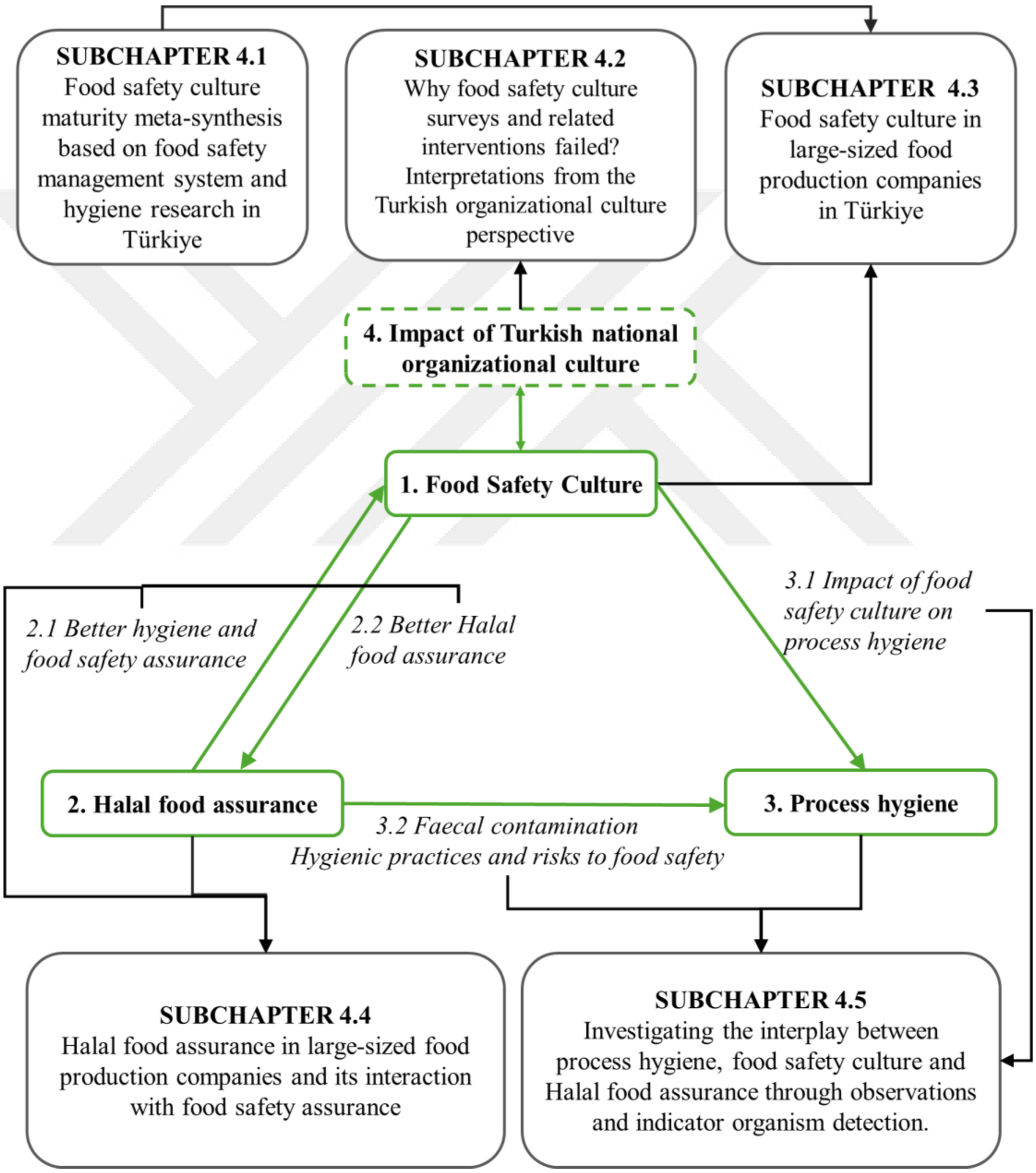


Figure 1.2: Results and discussion subchapters according to the research framework.
Source: Prepared by the researcher.

Chapter 4, Results and Discussion, includes the research outcomes in 5 subchapters. Figure 1.2 demonstrates how these subchapters are aligned with the different components of the research framework. Subchapter 4.1 is closely tied to the literature review and uses the studies found on food safety management and hygiene in food production companies in Türkiye in a meta-synthesis to gain initial insights into their FSC maturity. These results were further used in Subchapter 4.3, presenting FSC evaluation results in the participating companies, to demonstrate the contribution of these results in filling the research gaps in this area in Türkiye.

Subchapter 4.2 presented the outcomes of research framework point 4, subchapter 4.4 presented the outcomes of research framework points 2, 2.1 and 2.2 and subchapter 4.5 presented the outcomes of research framework points 3.1 and 3.2.

Finally, conclusions were presented in Chapter 5, which included the main findings on each of the aims presented in the research framework, novel contributions of this study and the recommendations for the food sector and future research.

CHAPTER II

LITERATURE REVIEW

2.1. Food Safety and Halal Food Assurance: Current State in Global Practices and Research

Despite the food safety legislative and certification efforts, 3086 reported outbreaks in the EU in 2020 and outbreak investigation reports indicate breaches with these requirements (Powell, Jacob & Chapman, 2011; EFSA & ECDC, 2021). This is also the case in Türkiye. According to the 2018 EFSA report, Türkiye is one of the most often reported probable countries of infection with campylobacteriosis, salmonellosis outside the European Union (EFSA and ECDC, 2019). Although Türkiye lacks a coordinated foodborne disease surveillance system, academic research based on foodborne disease outbreak data from Turkish news reports and foodborne disease occurrence data from hospitals and forensics medicine directorate databases reflect deficiencies in food safety measures taken by Turkish food production companies (Çetin & Durul-Özkaya, 2018; Terzi, Özdemir & Selçuk, 2018; Dorman et al., 2010; Oğur, 2019; Urazel et al., 2014; EFSA and ECDC, 2019). A recent study analyzed the presence of *L. monocytogenes* in different types of food in Türkiye and found its presence, especially in chicken meat, ground beef, deli meat, ready-to-eat foods, cheese, and raw bovine milk, to pose potential public health risks (Cufaoglu, Ambarcioglu & Ayaz, 2021). Furthermore, a study compared finished product pathogen contamination in three ISO22000 certified and three non-certified meat processing companies in Türkiye and found pathogens in both cases (Yörük & Güner, 2017). These examples again indicated the poor food safety management practices and the need for improvement in Türkiye as well.

Research suggests that food safety culture (FSC) is the missing link and a more mature FSC leads to better food safety performance (De Boeck et al., 2016; Nyarugwe S. , Linnemann et al., 2018; Wu et al., 2020). The globally accepted definition to FSC is '*Shared values, beliefs and norms that affect mindset and behaviour toward food safety in, across and throughout an organization*', (GFSI, 2018). The values, beliefs and norms of companies determine their FSC maturity. A FSC maturity model includes descriptions of values, beliefs and norms at different maturity stages, from low to high, thus setting FSC maturity within a measurable framework (Jespersen et al., 2016).

A comprehensive review by Zanin et al. (2021) shows how FSC has grown from a mere concept into a field of research (Zanin, Stedefeldt & Luning, 2021). Its importance has also started to be acknowledged internationally by the food sector. Namely, FSC has been incorporated in the Codex Alimentarius Commission's General Principles of Food Hygiene 2020 revision (FAO & WHO, 2020), followed by the incorporation to the update of European Union regulation 852/2004 (European Commission, 2021) and publication of The New Era of Smarter Food Safety Blueprint by the FDA (FDA & U.S. Food and Drug Administration, 2020). The private food safety standards sector also made changes accordingly, with the Global Food Safety Initiative (GFSI) including the FSC concept in its benchmarking requirements (GFSI, 2018). Thus, the FSC concept has been included in the revisions of the biggest global food safety standards, like the British Retail Consortium (BRC) Global Standard for Food Safety Issue 8 released is 2018 (Campden BRI, 2018), the FSSC22000:2018 (FSSC, 2020) and various horticulture standards (Frankish et al., 2021).

Regarding Türkiye, although Hazard Analysis and Critical Control Points system (HACCP) principles have been brought out in the Turkish regulation since 1997, followed by defining the acronym "HACCP" and describing the system in much more detail in 2005 (Presidency of Republic of Turkey, 2005; Presidency of Republic of Turkey, 1998), the legislation has yet to be updated regarding FSC. On the other hand, this wide adoption of the FSC concept in international codes, guidelines and standards also means that food production companies in Türkiye already have to evaluate and improve their food safety practices accordingly. For example, over 780 BRC and over 870 FSSC22000 certified companies in Türkiye are already required to do so (BRCGS, 2023; FSSC, 2023).

Not just the production sector, but also food safety research in Türkiye should keep up with these changes to support the sector in finding sustainable solutions. Especially since, it has been demonstrated that national culture impacts organizational culture, which in turn might impact companies' FSC (Tomasevic et al., 2020). FSC research at both a national and organizational level in food production companies includes a study using a survey encompassing both managers and food handlers in 17 companies in countries like Greece, China, Zambia and Tanzania (Nyarugwe et al., 2020), in addition to a survey study including 503 companies in 10 European countries: Croatia, Hungary, Montenegro, North Macedonia, Poland, Romania, Russia, Serbia, Slovakia and Ukraine (Tomasevic et al., 2020). Other studies food production companies at a national level include countries like Zimbabwe (Nyarugwe, Linnemann & Luning, 2020), Belgium (De Boeck et al., 2018). However, to the best of our knowledge, currently, no research has been conducted on FSC in Türkiye. Thus, research around FSC in Turkish food production sector becomes even more significant, as it will enable to identify and formulate solutions to problems and ways for improvement according to that specific national environment.

Türkiye not only holds a significant position at the food sector globally, by being among the top 10 agricultural food producers and the top 25 food exporters (Sanayi Genel Müdürlüğü, 2020), but also has a significant role in the Halal food sector by being 5th of the leading Halal food markets worldwide (Aydın Can, 2022). However, to the best of our knowledge, not only is there a lack of research on Halal food management practices in Türkiye, but studies on the topic all in all are limited, in addition to no studies with regards to the OIC/SMIIC 1: 2019 General requirements for halal food standard (Secinaro & Calandra, 2021). The Organization of Islamic Cooperation (OIC) is an organization to unite Muslim countries, with 57 member countries and a Standards and Metrology Institute for Islamic Countries (SMIIC) to unify practices and eliminate technical barriers to trade (SMIIC, 2024; OIC, 2024). Thus, the OIC/SMIIC 1: 2019 standard is expected to be a unifying standard of the Halal food market and as such is the standard used by the Halal Accreditation Agency of Türkiye, according to which Halal certification bodies (HCB) active in Türkiye should be accredited starting from June, 2023 (Presidency of the Republic of Türkiye, 2024; HAK, 2019). Thus, research on both Halal food management practices in Türkiye and within the OIC/SMIIC standard context would offer valuable insight into best practices, challenges in and improvement opportunities for the sector.

In theory, food safety, hygiene and Halal food assurance are tightly knit together, not only from the perspective that food should not cause harm, but regarding avoiding faecal contamination, which is an unwanted substance in Halal food assurance (Neio Demirci, Soon & Wallace, 2016; Lestari et al., 2023; Raheem & Neio Demirci, 2018). However, there is no empirical research on their impact to one another within food businesses. There is just a study, which had small and medium-sized enterprises' (SME) representatives participate in focus group discussions to give feedback regarding their hygiene practices (Lestari et al., 2023). Thus, no studies were encountered, which evaluate hygiene practices at the shop floor of food production companies in the Halal food assurance context. Interestingly, Lestari et al. (2023) study demonstrated that even the reported hygiene practices were scored as poor, emphasizing the need to further research the food safety-Halal food connection in food businesses for better Halal food assurance.

Organizational culture aspects are among the successful implementation factors for food safety/hygiene and Halal food assurance (Zailani et al., 2020; GFSI, 2018; Jespersen & Robach, 2018). With a sound theoretical and empirical foundation set for FSC in the food production sector (e.g. position papers, maturity models, best practices) (e.g. GFSI, 2018; Jespersen, et al., 2019; Nyarugwe, Linnemann & Luning, 2020), research could explore how the Halal food sector might also leverage this for better Halal food assurance. Further research on the connection between FSC maturity and microbiological hygiene has also been recommended by a recent systematic review (Westat, Inc. & FDA Food Safety Culture Research Subgroup, 2022) and this would further complement knowledge on effective food safety and Halal arrangements in food businesses.

Thus, combining FSC, process environment hygiene and Halal food management evaluations would enable to fill research gaps regarding,

- FSC maturity in the Turkish food sector,
- Halal food management practices in the Turkish food sector and within the OIC/SMIIC's Halal food standards' perspective,
- Food safety and hygiene practices and fecal contamination potential in Halal-certified companies,
- extend FSC work to Halal food assurance,
- the connection between FSC maturity and microbiological hygiene.

Thus, this study <u>aimed</u> to evaluate and explore the interplay between FSC, Halal food management and process environment hygiene. To set the scene and understand research needs better, a literature review was conducted in the following areas,

- fundamentals of the formation and maturity of FSC to set the theoretical background and highlight the main definitions and concepts used throughout the study;

- food safety management and hygiene research in Türkiye. Additionally, a meta-synthesis was conducted based on the results of existing studies, to better understand the FSC knowledge gaps in the Turkish food sector, which was presented separately in Chapter 4.1;

- Halal food management related research in food production companies, with no restrictions regarding country of research;

- FSC studies, which include microbiological hygiene evaluations in their research framework.

First, this chapter elaborates on literature search details, especially regarding the above-mentioned points 2-4, followed by the literature review content on each of the sections.

2.2. Literature Search Details

Research in both English and Turkish languages were included in the review using both international (ScienceDirect, Wiley, Emerald, SpringerLink, Taylor & Francis, Web of Science, Google Scholar) and Turkish national databases (Dergipark, Council of Higher Education Thesis Center). The database DergiPark includes articles published by academic journals in Türkiye. Studies published in this database, but which were conducted in food production companies in a different country, were excluded. The Council of Higher Education Thesis Center database was used to find MS and PhD theses published by universities in Türkiye, and while PhD studies were included in Subchapter 2.4, MA studies were additionally included in Subchapter 4.1, as these might offer novel and/or supporting insights in the study.

The following key words were used to search the databases for food safety management and hygiene research in Türkiye:

- Production, Hazard Analysis and Critical Control Points (HACCP), Critical Control Points (CCP),
- Food safety management systems (FSMS), food safety certification, food safety standards (ISO 22000, BRC, IFFC, IFS)

- Food safety knowledge, attitudes and practices (KAP)
- Microbial hygiene, hygiene and food safety
- Turkey, Türkiye (used as both key word and affiliation search)

The following key words were used to search the databases for Halal food management related research in food production companies:

- Halal food/assurance/management/certification
- Halal critical activities, Halal critical control points

The following key words were used to search the databases for studies on FSC and microbiological sampling in the process environment context:

- Food safety culture
- Process environment monitoring, environmental monitoring plans

FSC studies were scanned for their methodology and the use of microbiological sampling.

The lists of references of the identified publications were then in turn worked through to find other relevant publications.

2.3. Theoretical Background of Food Safety Culture

2.3.1. Fundamentals of Food Safety Culture

Schein and Schein (2017)´s work on organizational culture has been used by previous FSC research in food production companies as one of the foundational components to define and measure FSC (Jespersen, et al., 2019; Jespersen, MacLaurin & Vlerick, 2017). They suggest a dynamic definition, in that it includes aspects of how culture forms and evolves:

The culture of a group can be defined as the accumulated shared learning of that group as it solves its problems of external adaptation and internal integration; which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, feel, and behave in relation to those problems. This accumulated learning is a pattern or system of beliefs, values, and behavioral norms that come to be taken for granted as basic assumptions and eventually drop out of awareness (Schein & Schein, 2017).

As this definition sets the scene, the FSC definition expands on its latter part, as "*Shared values, beliefs and norms that affect mindset toward and behaviour regarding* *food safety in, across and throughout an organization*", (GFSI, 2018). The "*Values, beliefs and norms*", in the FSC definition, are the basic assumptions referred to in the Schein and Schein (2017)´s definition, which like with organizational culture, form the essence of FSC.

As the basic assumptions around values, beliefs and norms determine mindset and behaviour, organizational culture, and as such FSC maturity reveals itself at different levels of observability, which in turn guides data collection and interpretation (Schein & Schein, 2017):

1. Basic underlying assumptions (from now on will be referred to as the basic assumptions) – the non-observable unconscious network of interconnected assumptions forming the essence of culture, determining its values, beliefs and norms and with that the mindset and behaviour, in other words the artifacts.
2. Espoused beliefs and values – manifested part of culture related with how culture is depicted (espoused, published, preached) by its members through verbal accounts and published materials.
3. Artifacts – manifested part of culture related to the visible, feelable, and observable structures, processes and especially routine behaviours, which reflect the assumptions around values, beliefs and norms.

As the above three levels depict the structure of culture, the FSC maturity model describes the basic assumptions, espoused beliefs and values and related artifacts as behavioural norms under five dimensions of measurable characteristic to distinguish between different FSC maturity stages (Figure 2.1) (Jespersen et al., 2016; Jespersen et al., 2019). For example, under the Consistency dimension, the lowest maturity, stage 1, is described by behavioral norms in which data is not used to solve problems and the highest maturity, stage 5, is described by norms in which leading indicators are used (Jespersen et al., 2019).

As the manifested parts of culture, data on each FSC dimension is collected on its artifacts and the espoused beliefs and values (Schein & Schein, 2017). Then, the maturity model is used as a reference to compare the collected data with the descriptions of norms at each maturity stage to determine the cultural maturity of the company at the specific dimension (Jespersen et al., 2016).

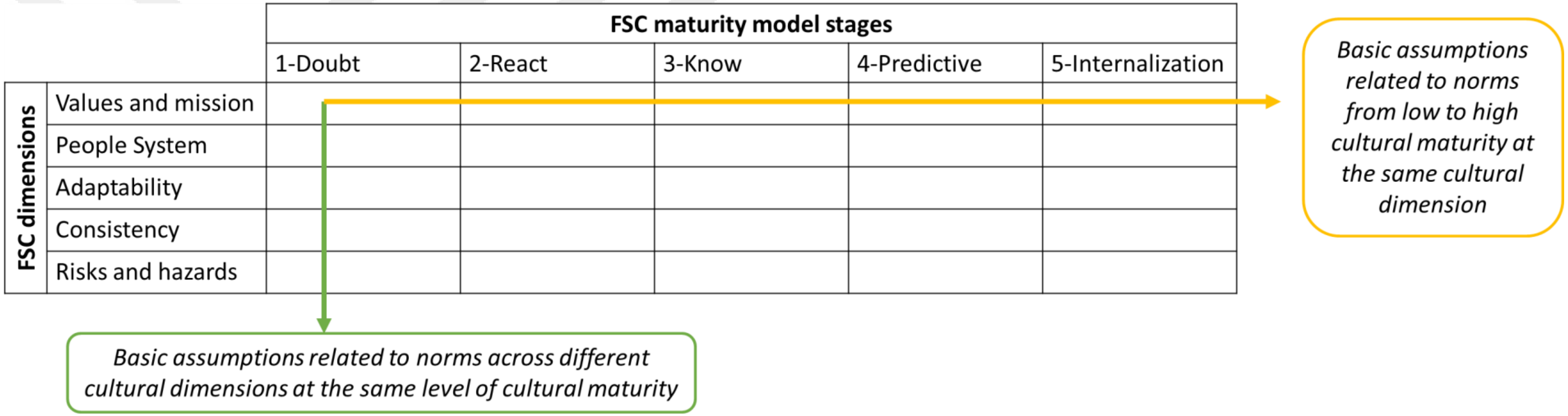


Figure 2.1: Simplified diagram of a FSC maturity model adapted from Jespersen et al. (2019). FSC: food safety culture.

Source: Jespersen et al., 2019

2.3.2. Formation of Food Safety Culture

Learning within organizations, or in other words its learning history, determines its values, beliefs and norms (Schein & Schein, 2017) and with that FSC maturity. Thus, it is important to consider the learning context in order to interpret the data, for which existing learning models, like the Competence model (Anderson & Ackerman Anderson, 2010) and the ABC (Antecedents, Behaviours and Consequences) models (Braksick, 2007), could be used, as these have also been previously discussed in the organizational management and FSC context (GFSI, 2018). First, the models are described, followed the explanation of dynamics of organizational learning through these models:

- <u>The Competence Model</u> – Also called the "universal path to learning" includes the following stages:

1. Unconsciously incompetent - We do not know that we do not know. We are either unaware or in denial. Learning is limited.
2. Consciously incompetent - We realize that we do not possess the knowledge and skill we need. Opens the possibility of learning and is the start of practicing.
3. Consciously competent - After practicing some time we are able to perform the new task as long as we are thinking about it. It is important to remain consciously aware and attentive to or in other words consistent practicing the new skill.
4. Unconsciously competent - Being proficient in the new skill. It becomes second nature. We become able to perform it successfully without thinking about it.

- <u>The ABC model</u> - The GFSI´s Position Paper suggests to use the ABC model in work around FSC and shaping behaviour, describing antecedents as follows: "*... something that comes before a behaviour and is required for an individual to understand what is expected and how to perform a behaviour e.g. stimulus, policy, stated expectations, training, job aids, circumstances, past experience"* (GFSI, 2018). Consequences, on the other hand, are somethings that come as a reaction to a behaviour, which either reinforce the behaviour, if the consequences are positive, or inhibit be behaviour if the consequences are negative. Consequences might include incentives, punishments, monitoring, following up, giving feedback and style of responding, like not listening, frowning, ignoring, dismissing, encouragingly nodding (Braksick, 2007).

Schein & Schein (2017)´s work on organizational culture and the described Competence and ABC models are consistent and overlap with each other as follows:

- As defined in the organizational culture dynamic definition above, organizational culture and with that FSC is formed and developed by solving problems around external adaptation and internal integration categories, also called the cultural elements (Table 2.1).

Table 2.1: Details of cultural elements

External Adaptation	**Internal Integration**
- Shared understanding of mission - Goals derived from the mission - Means (structure, systems, processes) to attain goals - Measurement on how well goals are fulfilled - Correcting and repairing strategies to be used if goals are not met	- Authority (including power and status) - importance of hierarchical levels and the extent of establishing psychological safety - Trust and openness – norms on task- and relationship- based communication - Rewards and punishment – consequences for obeying and disobeying norms - Identity and boundaries – group boundaries (who is in/who is out) and inclusion of new, temporary and contract workers - Establishing common language and concepts

Source: Schein & Schein, 2017

- After this foundation of structures, processes, beliefs and values has been set, it is up to the leadership to embed and reinforce these solutions (Schein & Schein, 2017). By doing this, the teaching/learning process of the company starts, which reflects people becoming consciously incompetent as they move from stage 1 to 2 in the Competence Model (Figure 2.2).

Competency model stages		
	1-Unconsciously incompetent	**Employees:** no learning
	2-Consciously incompetent	**Leadership:** solved problems around cultural elements and accordingly embeds (using consequences) and reinforces (using antecedents) cultural values, beliefs and norms. **Employees:** start of the learning process.
	3-Consciously competent	**Leadership:** continues to embed and reinforce. **Employees:** continues learning through repeated experiences.
	4-Unconsciously competent	**Organizational culture:** values, beliefs and norms, which have been taught and learned have become basic assumptions, which are taught to new members.

Figure 2.2: Organizational learning through the Competence Model.

Source: Prepared by the researcher based on Anderson & Ackerman Anderson, 2010, Braksick, 2017 and Schein & Schein, 2017

- Schein and Schein (2017) described this teaching process through primary embedding (e.g. role modelling, allocating resources, reactions to incidents) and secondary reinforcement (e.g. organizational and physical design, formal statements, procedures) mechanisms (Schein & Schein, 2017). The latter are secondary, because they are effective only when they are consistent with primary mechanisms. This is coherent with the ABC model, according to which antecedents are effective only when backed up by consequences (Braksick, 2007). As such, primary mechanisms reflect consequences, while secondary mechanisms reflect antecedents (Figure 2.3). Thus, a parallel could be drawn between the learning and consequences history of companies.

- The constant consistent usage of these mechanisms, leads to learning through repeated experiences, having employees progress from stage 2 to 4 in the Competence Model, until values, beliefs and norms become basic assumptions, eventually dropping out of awareness, or in other words employees become unconsciously competent (stage 4 of the Competence Model), in that these values, beliefs and norms become as second nature or unconsciously competent (Figure 2.2) (Anderson & Ackerman Anderson, 2010).

	Primary mechanisms	Secondary mechanisms
Antecedents	- How leaders allocate resources - Deliberate role modeling	- Organizational design and structure - Organizational systems and procedures - Design of physical space, façades, and buildings - Stories about important events and people - Formal statements of organizational philosophy, creeds, and charters (espoused)
Consequences	- What leaders pay attention to, measure, and control on a regular basis - How leaders react to critical incidents and organizational crises - How leaders allocate rewards and status - How leaders recruit, select, promote, and excommunicate - Deliberate teaching, and coaching	- Rites and rituals of the organization (categorized as secondary because the basic assumptions, which might be inferred from them are not implicit. Thus, these rather reinforce basic assumptions, which are embedded by primary mechanisms)

Figure 2.3: Primary and secondary mechanisms reflecting antecedents and consequences.

Source: Prepared by the researcher based on Braksick, 2017; Schein & Schein, 2017

In other words, this process describes how values, beliefs and norms form within a company and that company's solutions around external and internal issues and the styles of the leaders to embed and reinforce the culture determine the differences in these values, beliefs and norms and with that company's FSC maturity. This also reflects the learning cycle of new workers in a company and how they become to adapt to the existing values, beliefs and norm of the company.

2.4. Food Safety Management and Hygiene Research in Türkiye

2.4.1. General Overview of Study Details

From 1975 to 2022 a total of 85 studies have been conducted in relation to food production companies and their food safety practices. Since the beginning, research has focused on microbiological hygiene, HACCP and CCPs, followed by surveys (Figure 2.4).

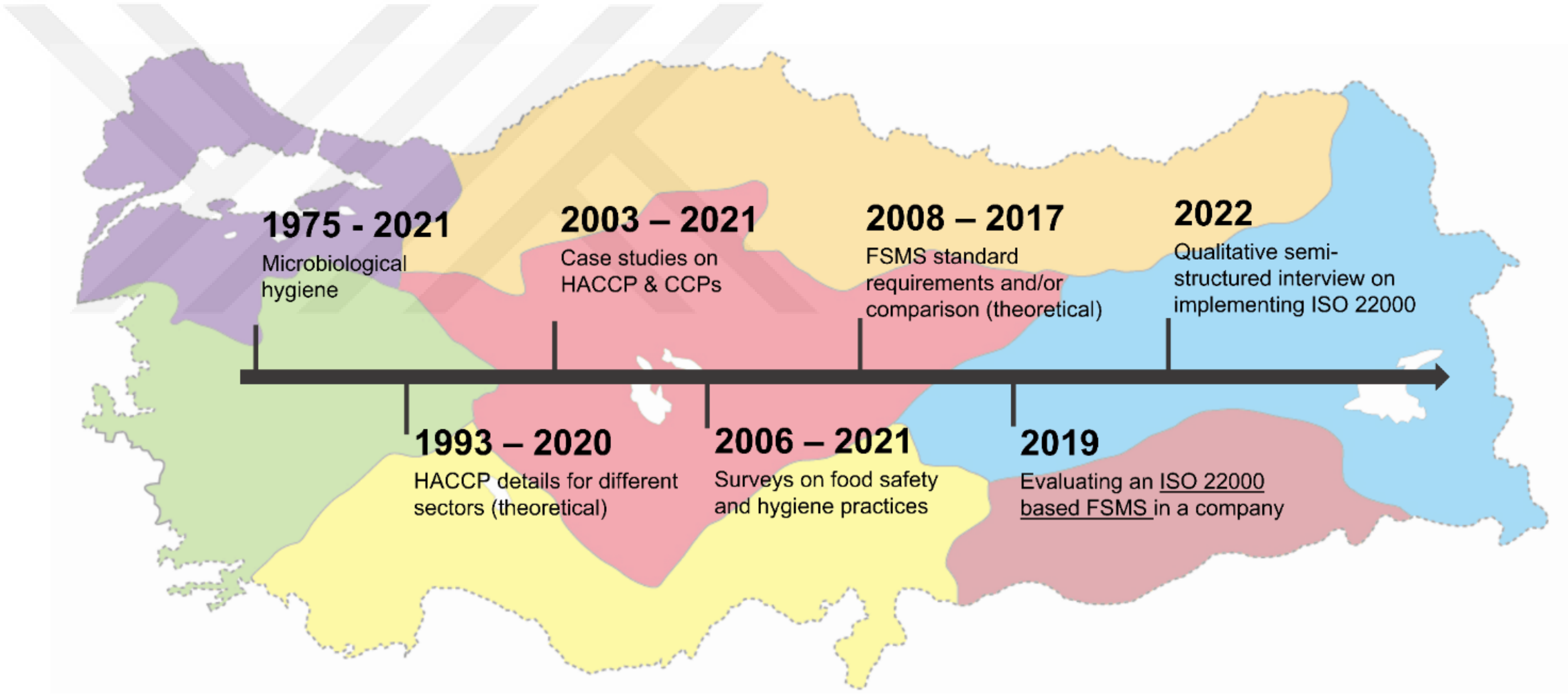


Figure 2.4: Timeline of the food safety management and hygiene studies in the food production sector in Türkiye. HACCP: Hazard analysis and critical control points; CCP: Critical control points; FSMS: food safety management systems.

Source: Prepared by the researcher based on Tables 2.2-2.7.

Only just recently have 2 empirical studies emerged using both interviews and targeting FSMS as a new approach, since previous studies focused rather on survey methodology and the working on the HACCP system. In both cases, the FSMS were based on the ISO 22000 standard (Çevik & Özpınar, 2019; Dilek & Üçüncü, 2022). Thus, it could be seen that the use of qualitative research methods has not been common practice in Turkish food safety management research. The lack of using qualitative research methods in turn impairs an in-depth understanding of food safety management practices. Furthermore, since 2010, food safety culture (FSC) has grown from a mere concept into a field of research (Zanin, Stedefeldt & Luning, 2021) and in some instances its evaluation and improvement has become a compulsory practice in the food sector, after being adopted by international codes, standards and legislations (FAO & WHO, 2020; Campden BRI, 2018; FSSC, 2020; European Union, 2021; FDA & U.S. Food and Drug Administration, 2020). Thus, future research in Türkiye could consider extending FSMS related research by including FSC, shifting to a management- and people/behaviour-orientated approach. Finally, research has focused on using surveys in the dairy sector of the Aegean region and microbiological hygiene evaluations mainly in the dairy and meat sector of the Marmara region (Figure 2.5). These results question whether existing studies give a deep enough insight on food sectors and regions and suggest that more work is needed throughout Turkish food industries.

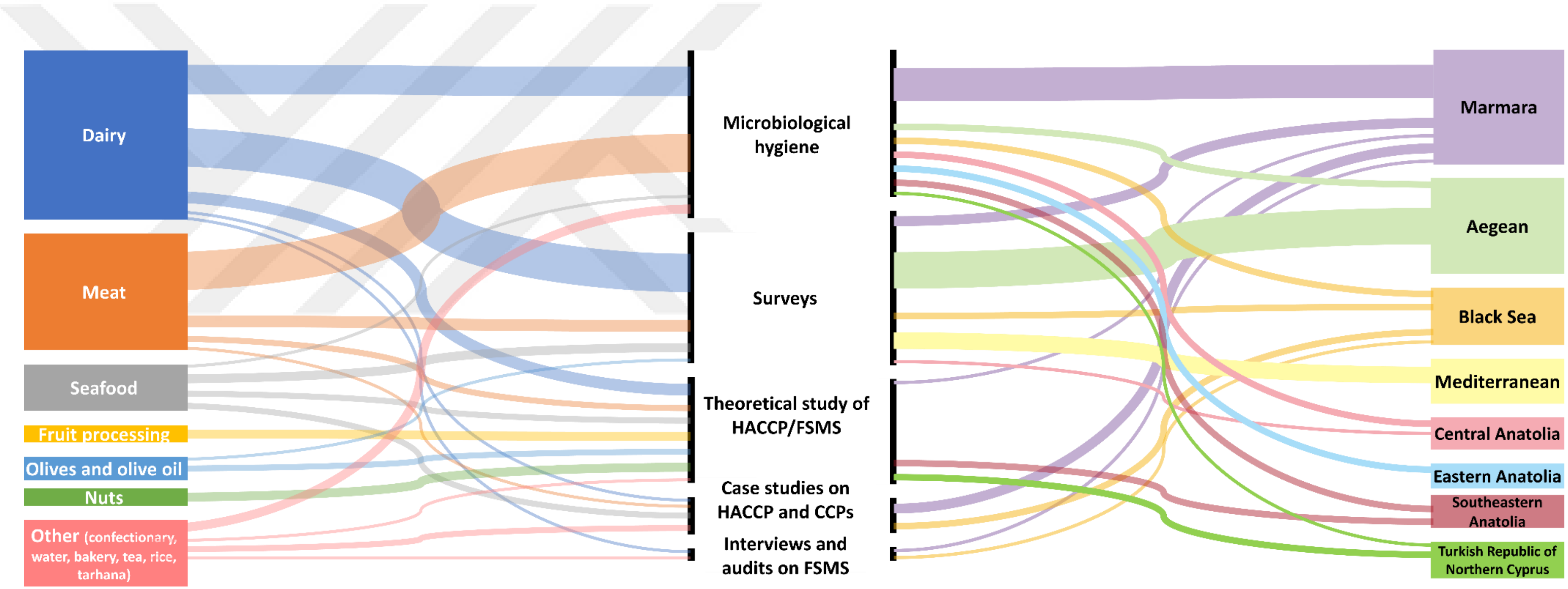


Figure 2.5: Distribution of research methodology based on food sectors and regions of Türkiye. Left: food sectors; middle: research methodology; right: regions of Türkiye. The height of lines and boxes are proportional with the amount of research conducted within these areas. Note: Same regional colour codes have been used in Figures 2.4 too. HACCP: Hazard analysis and critical control points; CCP: Critical control points; FSMS: food safety management systems.

Source: Prepared by the researcher based on Tables 2.2-2.7.

2.4.2. Surveys and Interviews

Throughout the years a total of 21 survey studies have been devoted to food safety practices in Türkiye, with 10 of them being published in international (Table 2.2) and 11 in national journals (Table 2.3). An additional 3 national studies had devoted only a section of their survey to this topic (Bars & Akbay, 2013; Bars & Akbay, 2016; Erkeç & Bilgin, 2020).

The HACCP related research peaked in 2005 (Figure 2.6), which might have been connected with the event that for the first time, the Turkish regulation specified that the HACCP system should be set up and implemented considering good hygiene practices or in other words prerequisite programs (Presidency of Republic of Turkey, 2005). Additionally, the producers were made responsible for training their staff according to these principles and making sure that these are implemented properly. The regulation also published detailed inspection forms on both the HACCP system and the prerequisite programs (PRPs), including the above-mentioned training as a subheading.

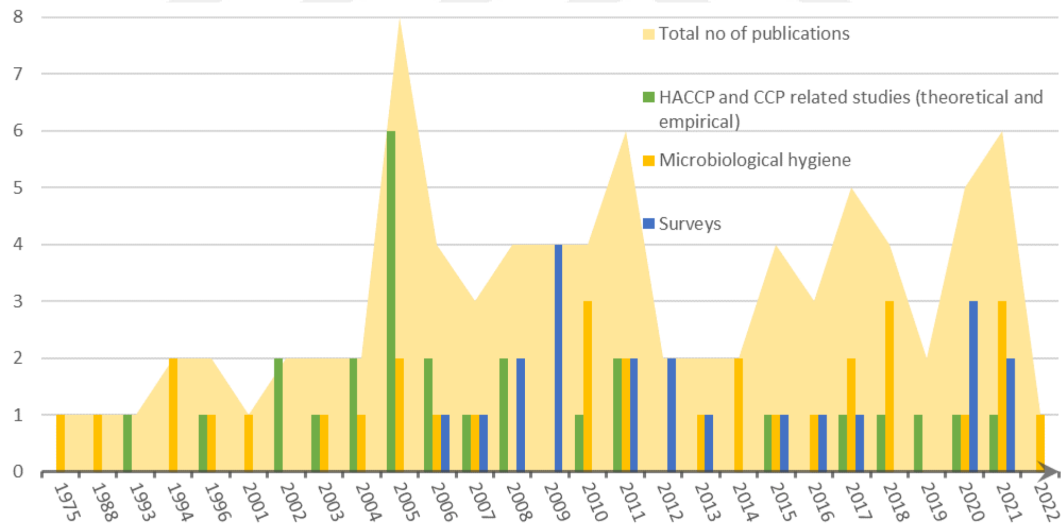


Figure 2.6: Trends in food safety and hygiene research in food production companies in Türkiye. HACCP: Hazard analysis and critical control points; CCP: Critical control points.

Source: Prepared by the researcher based on Tables 2.2-2.7.

Surveys started to be used in 2006 after these "milestone" events for food safety in Türkiye. As called for, the first surveys were related with evaluating employee hygiene knowledge and perceived barriers and benefits to implementing the HACCP system

(Çakır, Çolakoğlu & Berik, 2006; Demirbaş & Karagözlü, 2007). Throughout the years, surveys have been focusing on the following topics,

- Food safety/hygiene knowledge, attitude and/or practices (10 studies)
- Food safety/hygiene training (8 studies)
- Manager education level (7 studies)
- Existence of a HACCP/FSMS system (5 studies)
- Existence of a laboratory (5 studies)
- HACCP/FSMS benefits and/or barriers (4 studies)
- Expectations from legal authorities (2 studies)

Although, the topic of food safety and/or hygiene practices has been the most common in surveys, none have used the PRPs and HACCP check-lists conveniently published within the Turkish food safety regulation (Presidency of Republic of Turkey, 2005). There was just one study that based their questionnaire on the requirements brought out in in the Turkish regulation of hygiene rules for the production of food of animal origin (Presidency of Republic of Turkey, 2011) and 3 studies that referred to previous research (Bars & Akbay, 2013; Bars & Akbay, 2016; Kirdar, 2017). Thus, there seems to be an ad hoc approach to preparing survey questionnaires, which were mainly constructed by the authors themselves.

While commonly studies just included a question on whether companies conducted food safety and hygiene training, one study took advantage of the survey technique to get a more in-depth understanding (Karaman, 2012), including several questions on the topic, like

- who receive training,
- what were the barriers in providing training,
- different approaches used for training and
- further training needs.

This focused approach enabled to get more detailed insight, like the low importance given to training the management, temporary workers, and supervisors. Since these are important aspects of food safety culture (GFSI, 2018), future surveys might also focus on specific areas within food safety management and culture to gain a better understanding of companies´ practices.

Table 2.2: Overview of food safety and hygiene related research conducted in Türkiye using surveys and interviews published in international journals,

Survey questions related with...	Data collection approach (no of companies)	From whom the data was collected	Question types and analysis details	Published journal	Source
... manager education level. … existence of supply chain reward systems based on raw material quality. … existence of a quality control system.	Face-to-face survey (86)	Managers	Multiple choice, yes/no	Journal of Food Protection	(Demirbaş & Karagözlü, 2008)
… manager education level and experience … PRPs (facility conditions, health and temperature checks, disinfection) … existence of laboratory and analysis … food safety problems and solutions	Survey (43)	Managers	- 5 point Likert scale, yes/no - Mentioned conducting pre-surveys to modify the questions.	British Food Journal	(Demirbas et al., 2008)
... FSMS certification, control and updating. …food safety training source and frequency. … benefits and perceived cost of FSMS.	Face-to-face survey (or by post) (25)	Managers	Multiple choice	Journal of Food Protection	(Kök, 2009)

… KAP	Face-to-face survey (79)	Managers	5 point Likert scale; I know/ do not know	Milk Science International	(Armağan, Koç & Özden, 2009)
… KAP	Face-to-face survey (103)	Managers	5 point Likert scale; I know/ do not know	New Medit	(Demirbaş et al., 2009)
… economic obstacles to obtaining food safety certification	Survey (59)	Managers	- 5 point Likert scale, I know/ I do not know - Mentioned conducting in-depth interviews, but did not give further details.	British Food Journal	(Tunalıoğlu, Çobanoğlu & Karaman, 2012)
... food safety training (who receives, barriers, approaches, needs). … food safety problems and quality control practices.	- Face-to-face interview - Observations on building, grounds, environment, personnel hygiene (28)	Managers	- 5 point Likert scale, yes/no - Mentioned only that relevant data was transcribed.	Food Control	(Karaman, 2012)
... manager education level … perceived benefits, and barriers to implementing HACCP/FSMS. … expectations from legal authorities.	Face-to-face narrative interviews (28)	Managers and food safety responsible	5 point Likert scale, 1 open-ended question - To analyze the open-ended question responses, the times a topic was mentioned was counted.	Food Control	(Karaman et al., 2012)
… manager education level and education on quality management systems … existence of the HACCP system, its	Face-to-face survey (13)	Managers and other employees	5 point Likert scale, yer/no; I know/ do not know	Journal of Food Safety	(Kirdar, 2017)

certificate and supplier controls
… food safety knowledge.
… food safety problems and solutions.
… expectations from legal authorities.
… KAP of employees.

FSMS: food safety management systems; HACCP: Hazard analysis and critical control points; KAP: knowledge attitude and practices; PRP: prerequisite programs.

Table 2.3: Overview of food safety and hygiene related research conducted in Türkiye using surveys and interviews published in national journals,

Topic **Question related with...**	**Data collection approach (no of companies)**	**From whom the data was collected**	**Question types and data analysis details**	**Source**
... hygiene knowledge.	- Face-to-face survey - Evaluation of workers´ appearance through observation. (10)	All employees	- Multiple choice, yes/no and 1 open- ended question. - Counting the times, a topic was mentioned	(Çakır, Çolakoğlu & Berik, 2006)
... perceived barriers and benefits to HACCP.	Face-to-face survey (17)	Managers	5 point Likert scale	(Demirbaş & Karagözlü, 2007)
… existence of technical staff and laboratory … training program frequency and efficiency … PRPs (conditions of work uniforms, use of gloves and changing frequency, raw material and water hygiene issues, air quality, temperature control, hand washing facilities. … existence of HACCP, using consultancy, difficulties	- Face-to-face survey - Mentioned conducting observations in companies, which gave permission, to verify collected information. (25)	Managers	5 point Likert scale and yes/no questions	(Aral, Baygar & Kaplan, 2009)
… manager education level and experience ... barriers, challenges and solutions to implementing FSMS	Survey (30)	Managers	5 point Likert scale	(Çukur et al., 2011)

… existence of traceability and its details.	Face-to-face survey (55)	Managers	yes/no/ partially questions	(Sıkı, Budak & Avşar, 2012)
… managers´ education level and education on food safety and perception of their food safety knowledge … food safety training details (using training services, frequency) ... existence of laboratory and health examinations … company's goals for the future	Survey – just some questions targeting food safety (10)	Managers	5 point Likert scale, yes/no	(Bars & Akbay, 2013)
… PRPs (hand and equipment cleaning and disinfection, preventing contamination, transportation conditions) ... transportation conditions	Face-to-face survey (24)	Managers	yes/no questions	(Oruç, Onurlubaş & Gözener, 2015)
… managers´ education level and education on food safety and perception of their food safety knowledge … food safety training details (using training services, frequency) … conducting health checks. ... existence of laboratory and health examinations	Survey – just some questions targeting food safety (10)	Managers	5 point Likert scale, yes/no	(Bars & Akbay, 2016)
… ISO 22000:2005 standard requirements.	- Face-to-face interview / audit - Mentioned evaluation of the FSMS documents and that they asked workers questions about the food safety policy. (1)	Quality manager	yes/no and open-ended questions	(Çevik & Özpınar, 2019)

… managers’ education and experience … food safety knowledge … conducting laboratory analysis ... PRPs (cleaning, personnel hygiene. The focus was more on milking hygiene)	Survey (66)	Manager	5 point Likert scale, yes/no and I know/ do not know questions	(Demirbaş, 2020)
... existence of hygiene training and HACCP system, quality certificates. … common problems faced by the company	Face-to-face survey/ interview – just some questions targeting food safety (12)	Managers	yes/no, 1 open-ended question – results presented in discussion form.	(Erkeç & Bilgin, 2020)
... existence of hygiene training, … PRPs (habits to smoke and wear gloves). … foodborne disease symptoms during the study period	- Face-to-face survey - Samples were taken from personnel hands and stools analyze for viruses (55)	All workers	Multiple choice and yes/no questions	(Aydoğan, Gürsoy & Kale, 2021)
… availability and existence of qualified staff. … existence of quality and food safety certificates and a laboratory. ... PRPs (e.g. proper facilities, utensils, storage, waste management, disinfection).	Face-to-face survey (71)	Managers	5 point Likert scale and yes/no questions	(Tosun & Demirbaş, 2021)
... benefits, barriers and implementation details of ISO 22000	Face-to-face semi-structured qualitative interviews (30-50 min) (3)	Quality and hygiene manager	- yes/no and open-ended questions - Interviews were transcribed and coded. - Results presented according to interviewer mentioning a code.	(Dilek & Üçüncü, 2022)

FSMS: food safety management systems; HACCP: Hazard analysis and critical control points; PRP: prerequisite programs.

Just a few studies used other methods in addition to the surveys, like conducting observations on PRPs (Karaman, 2012), workers´ clothing (Çakır, Çolakoğlu & Berik, 2006) and taking samples to analyze viruses (Aydoğan, Gürsoy & Kale, 2021). Two other studies just mentioned observing production and conducting document analyses but did not give further details on how this was done (Çevik & Özpınar, 2019; Aral, Baygar & Kaplan, 2009). Surveys were conducted predominantly face-to-face with managers, with just 3 studies including interviews with all workers and 3 studies including the person responsible for food safety and quality (Table 2.2-2.3).

Surveys in general had a structured approach, using multiple-choice questions, with only two using an extra open-ended question, presenting their results by counting the times a specific topic was mentioned by the interviewees (Çakır, Çolakoğlu & Berik, 2006; Karaman et al., 2012). Although two studies used qualitative methods, like interviews and observations, only one of these studies had a clearly structured methodology, where they used semi-structured interviews, mentioned transcribing interviews and identified codes, according to which they analyzed the transcripts (Dilek & Üçüncü, 2022). The other study just mentioned that they asked questions based on the ISO22000:2005 standard to the quality manager, analyzed documents and asked questions to workers about the company´s food safety policy. However, the results were presented just in discussion form on the conformity of the FSMS to the ISO22000 standard (Çevik & Özpınar, 2019). Thus, future research could consider using a mixed methods approach, together with involving multiple functions within the companies, followed by structured data analysis for a stronger set of conclusions on food safety practices.

2.4.3. HACCP and CCP Related Studies

To the best of our knowledge, there were in total 21 theoretical studies on setting up the HACCP system in different food sectors and 6 case studies focusing on either setting up the HACCP system documentation (4 studies) or identifying CCPs by using microbiological analysis (2 studies) in food production companies in Türkiye. All of the studies in this category were published in national journals. Interestingly, none of the 4 case studies specified what data was collected and how (Table 2.4).

Table 2.4: Details on case studies setting up HACCP system documentation,

Source / Sector	**Data collection**	**Hazard Analyses Details**
(Akdeniz, 2008) / Poultry	No details were given on what data and how it was obtained.	In addition to the hazard analysis, they used company´s temperature measurement data to conduct variance analyses, calculated the process capability index, and graphically depicted temperature distribution averages.
(Özçakmak, Gökçek & Gül, 2017) / Rice	No details were given on what data and how it was obtained.	They conducted the hazard analysis, in which they identified PRPs and oPRPs. Depending on the probability-severity-based risk score PRPs turned into oPRPs.
(Günşen, Eseceli & Atan, 2019)/ Seafood	Mentioned that they collected raw material samples (100 fish samples) for analyses.	They conducted hazard analysis, in which they identified PRPs and oPRPs. Depending on the probability-severity-based risk score PRPs turned into oPRPs. Within the results and discussion part of the article they did not elaborate on the fish sample analyses´ results or whether these affected the hazard analysis.
(Onbaşı & Cinar, 2022)/ Dairy desserts	No details were given on what data and how it was obtained.	They conducted hazard analysis, in which they identified PRPs and oPRPs. Depending on the probability-severity-based risk score PRPs turned into oPRPs. Trained senior management and frontline staff on the HACCP system. Created a HACCP Implementation Procedure document as a guideline, which includes definitions, requirements, responsibilities, HACCP principles, legal requirements. Trained frontline staff on PRPs. Created hygiene procedure, which include all the rules staff should follow. Created cleaning plans, specifying responsible staff and verification procedures, among others. The HACCP team was schedules to meet every month and report meeting minutes to senior management. It was mentioned that the system was verified and validated, however details were not given.

HACCP: Hazard analysis and critical control points; oPRP: operational prerequisite programs; PRP: prerequisite programs.

3 of the 4 studies included identifying PRPs and operational PRPs (oPRP) based on probability-severity-based risk scores. Only the most recent study, conducted in 2021,

emphasized the importance of training both the senior management and the frontline staff, in order to implement the system properly and stated to have accordingly organized these trainings. They mentioned that it is important to gain senior management´s support, because it is necessary not only for allocating resources, but also for implementation purposes (Onbaşı & Cinar, 2022). None of these case studies included empirical evaluation on implementation afterwards, which future research might consider since this is essential to HACCP effectiveness in practice.

This literature review of food safety and hygiene research in Türkiye revealed that studies commonly used just one method, which was either microbiological analysis or surveys, the latter targeting mainly just one respondent, which was mostly the manager. Even work around setting up HACCP system´s documentation were stand-alone studies, except for just two studies, which to some extent combined microbiological and hazard analyses. Thus, in general the current body of research gives insight to managers´ perceptions of their food safety practices together with the state of microbiological hygiene within the production setting in two specific sectors, the dairy and meat. Future research could consider using multiple methods and/or multiple respondents per company for a more detailed and inclusive approach.

2.4.4. Microbiological Hygiene Studies

Related to microbiological hygiene, 27 studies conducted in the Turkish food production sector were found in the literature. In addition to microbiological analyses, one study also evaluated physical contamination in reusable demijohns (Çetin et al., 2013). 11 studies focused on process environment hygiene, including surfaces of equipment, utensils, floors, walls, or hands and using a selection of *Enterobacteriaceae* (EB), coliforms, thermotolerant coliform (ttCF) (referred to in the studies with the out-dated term faecal coliforms) and *E. coli*, among other microbiological parameters (Table 2.5). Also, 4 studies similarly evaluated the process environment hygiene but used only pathogens as microbiological criteria (Table 2.6). Finally, as set of 12 studies focused solely on process steps and its input, like raw materials, water, intermediate products and packaging materials, rather than process environment hygiene (Table 2.7).

Additionally, 2 studies mentioned HACCP or CCPs in their publication titles, but upon closer look of the contents, it became apparent that they had evaluated microbiological hygiene of the process steps and production area but had not conducted any hazard analysis (Bacak, Gönülalan & Ertaş, 2014; Evrensel, Temelli & Anar, 2003). Another 2 studies just mentioned that their results should be used by the companies to modify their HACCP systems to eradicate the identified problems (Irkin, 2010; Ipek & Zorba, 2018). Finally, there were 2 more studies, which actually used their microbiological analyses results to either conduct a CCP hazard analyses (Aydın & Başaran, 2018) or to validate the controls at CCPs (Dokuzlu, Günşen & Özöğretmen, 2006).

To collect samples, the number of visits per company ranged from 1 to 12 times. In general, 14 of the studies visited companies more than once and 10 studies more than 3 times. Multiple visits are a good practice, enabling to consider any fluctuations and obtain more representative results of the processing environments´ microbiological hygiene (ICMSF, 2018; Jacxsens et al., 2009).

Just one study elaborated on the time of the sampling, which was done after cleaning equipment and utensils (Civan & Ergün, 1994). Other studies on process environment hygiene did not mention the timing of the sampling. This is something that future studies could consider, because compared to taking samples after cleaning and sanitation procedures, taking samples during production gives a more relevant insight into the production environment's hygiene status (ICMSF, 2018; Spanu & Jordan, 2020). It is suggested that sampling should be done at least 2 to 4 hours after the start of production to get representative results (Bourdichon et al., 2021; Carpentier & Barre, 2012; Spanu & Jordan, 2020; Tompkin, 2002). It might just be assumed that in these studies samples were taken during production, since sampling areas included hands and/or clothing. Elaborating on the sampling time would also have better enabled to compare different research findings, especially since most of the studies on process environment hygiene were conducted either in the dairy (6 studies) or the meat sector (5 studies).

Table 2.5: Microbiological hygiene research conducted in Türkiye, which focus on process environment monitoring using indicator microorganisms,

Aim of the study	**Sector (No of companies)**	**Areas sampled**	**Microorganisms analysed**	**Total number of samples**	**Sampling details (Total number of samples)**	**Source (national or international publication)**
Hygiene control and its variations throughout the seasons	Meat (8)	Hands Final products Packaging materials Equipment and utensils (after cleaning) Air (after production) and water	Total plate count Coliform *E. coli* Mould, yeast	35	4 visits during 10 months	(Civan & Ergün, 1994) (national)
Evaluate microbiological hygiene	Dairy (1)	Hands Raw materials Intermediate products Equipment and utensils Air and water	Total plate count *Enterobacteriaceae* Enterococci Coliforms *E. coli* *Staphylococcus spp.* Coagulase positive staphylococci Yeast and molds	210	Samples were taken from 21 points during 10 unannounced visits.	(Evrensel, Temelli & Anar, 2003) (national)
Determine microbiological contamination sources	Dairy (4)	Hands Intermediate products	Total plate count Coliforms Faecal coliforms *S. aureus*	72	3 replicated were taken from each 6 sampling points,	(Kanbakan, Çon & Ayar, 2004) (international)

during ice cream production		Finished products Equipment and utensils Water (used in processing)	*Salmonella spp*. Mould and yeast		including processing steps.	
Evaluate hand hygiene	Meat and Dairy (4)	Hands	Total plate count *Enterobacteriaceae* Coliform *E. coli* *Staphylococcus spp.* Coagulase positive Staphylococci Mould and yeast	80	Not specified	(Temelli, Şen & Anar, 2005) (national)
Determine microbiological contamination sources during 'dil' cheese production	Dairy (1)	Hands Raw materials Intermediate products Finished products Equipment and utensils Floors and walls Packaging materials Air and water	Total plate count *Enterobacteriaceae* *E. coli* Lactic acid bacteria *Staphylococcus spp.* *Salmonella spp.* *Pseudomonas spp*. Yeast-moulds	108	Samples were taken 3 times and performed in 2 parallels from 18 different points (including processing steps)	(Irkin, 2010) (international)
Determine the relationship between microbial quality of raw material,	Bakery – yufka (3)	Hands Raw materials Equipment and utensils Water and air	Total plate count Coliform *E. coli* *Staphylococcus spp.* *S. aureus*	99	Samples were collected during 3 visits	(Arda & Aydın, 2011) (national)

processing hygiene and final product			Sulfite-reducing clostridia Mold Rope spore count *Salmonella spp.*			
Determine microbiological contamination sources during Lokum production	Confectionary (2)	Hands Raw materials Final Product Packaging materials Equipment and utensils	Total plate counts Coliforms *E. coli* Yeast and moulds Adenosine triphosphate (ATP)	72	Samples were taken in parallel during 3 different seasons	(Ipek & Zorba, 2014) (international)
Evaluate microbial hygiene	Meat (1)	Hands and clothing (during production) Carcass Equipment and utensils (during production)	Total plate count Faecal coliforms	60	Samples were taken 4 time with 15 day intervals	(Bacak, Gönülalan & Ertaş, 2014) (national)
Microbial loads before and after cleaning processes	Dairy (3)	Hands Equipment and utensils (processing steps)	Total plate counts *Enterobacteriaceae* *Pseudomonas spp.* *Bacillus spp.* ATP	Not specified	Samples were taken from 11 processing points	(Ipek & Zorba, 2018) (international)
Microbial loads of carcasses before and after training on hand washing and disinfecting.	Meat (2)	Hands and/or gloves Knives Water Carcasses	Total plate count *Enterobacteriaceae* *Salmonella spp.*	81	Totally 6 visits were made per company.	(Durmuşoğlu, 2018) (PhD thesis)

					Samples were taken before and after training on hand washing and disinfecting.	
Evaluate microbiological hazards during production	Dairy (4)	Hands Raw materials Intermediate products Final products Equipment and surfaces (processing steps) Air	Total plate count *Coliform* *L. monocytogenes* *Staphylococcus spp.* *S. aureus* *Salmonella spp.* Yeast and mold ATP	32	3 visits were made per company at 1 week intervals. Samples were taken from 4 processing points.	(Ulusoy, Hecer & Berkan, 2020) (national)

ATP: Adenosine triphosphate.

Table 2.6: Microbiological hygiene research conducted in Türkiye, which focuses on process environment monitoring using pathogens,

Aim of the study	Sector (No of companies)	Areas sampled	Microorganisms analyzed	Total number of samples	Sampling details	Source (national or international publication)
L. monocytogenes contamination sources	Fish (1)	Raw materials Intermediate products Finished products Equipment and utensils Water	*L. monocytogenes*	60	Samples taken from 30 different points, including processing steps	(Kışla, Üzgün & Demirhisar, 2007) (international)
Evaluate *Salmonella spp.* and *L. monocytogenes* on equipment and personnel hands	Meat (8)	Hands and clothes Equipment and utensils	*Salmonella spp.* *L. monocytogenes*	580	Samples were taken in 2 parallel during production	(Kahraman et al., 2010) (international)
Listeria prevalence and variation throughout the seasons	Meat and dairy (6)	Raw material Equipment Water Environment Feed, faeces	Different *Listeria* strains	719	Samples were collected once a month over 12 months	(Atıl, Ertas & Ozbey, 2011) (international)
Prevalence of *L. monocytogenes* in slaughterhouses	Meat (1)	Hands Carcasses Rectal swabs Equipment and utensils Walls and floors	*L. monocytogenes*	300	25 samples per month during 1 year	(Çadırcı et al., 2018) (national)

Table 2.7: Microbiological hygiene research conducted in Türkiye focusing on process and its input control and not on process environment per se,

Aim of the study	Sector (No of companies)	Areas sampled	Microorganisms analysed	Total number of samples	Sampling details (Total number of samples)	Source
Salmonella contamination and its serovar distributions	Poultry (3)	Chicken carcasses (during production) Water (used in processing)	Different *Salmonella* strains	270	15 samples were taken at 6 points throughout processing	(Sarımehmetoğlu at al., 1996)
CCP validation	Fish (1)	Samples were taken from processing steps defined as CCPs (frozen fish, thawing, fermentation, after placing into packages)	Total plate count Coliforms Fecal coliforms Coagulase positive staphylococci *Salmonella spp.* *V. parahaemolyticus* *V. cholerae*	50	10 visits were made to the companies	(Dokuzlu, Günşen & Özöğretmen, 2006)
Evaluate microbial surface contamination of beef carcasses	Meat (2)	Carcass	Total plate counts *Enterobacteriaceae* Coliforms *E. coli* Coagulase positive staphylococci *Salmonella spp.*	120	-	(Özdemir & Şireli, 2010) (international)
Evaluate recycled demijohn hygiene		Packaging material	Total plate count Coliform	388		(Çetin et al., 2013)

			E. coli *S. aureus*			
Determine the effects of air and water chilling on the microbiological quality of carcasses	Meat (1)	Broiler carcasses before and after air and water chilling procedures	Total plate count *Enterobacteriaceae* Coliforms *Staphylococcus spp.* Micrococci Coagulase-positive staphylococci Psychrophilic bacteria Yeast and mold	320	16 broiler carcasses were analysed per week. Samples were taken from 4 processing points.	(Şahin & Çelik, 2015)
Water safety	Dairy and meat (-)	Water	Total plate count Coliform *E. coli* Psychrophilic bacteria	83	Samples were taken two times in different seasons	(Çetin et al., 2016)
Post-slaughter hygiene	Meat (4)	Carcasses Organs	Total plate count *Enterobacteriaceae* *Salmonella* strains	400	-	(Erköse, 2017) (PhD thesis)
Evaluating the presence of pathogens	Meat (6)	Finished product	*Bacillus cereus* *C. perfringens* *S. aureus* *Salmonella spp.* *L. monocytogenes* *E. coli* O157:H7	96	Samples were taken 4 times over 4 seasons. For each season, 4 samples were collected per company.	(Yörük & Güner, 2017)

Identify the microbiologically CCPs in the halva production process	Confectionary – Halva (1)	Raw materials Intermediate products after 6 processing steps	*E. coli* *Salmonella spp.* Mould and Yeast Total aflatoxin	12	Samples were taken in total 12 locations	(Aydın & Başaran, 2018)
Milk microbiological and physico-chemical characteristics	Dairy (8)	Raw material	Total plate count	32	4 visits were made per company with 1 week intervals	(Hatipoğlu & Çelik, 2021)
Determine the effects of cooling on microbiological quality of lamb carcasses	Meat (1)	Carcass	Total plate count *Enterobacteriaceae* *Salmonella spp.*	50	-	(Yalçın et al., 2021)
Determine carcasses microbiological hygiene	Meat (4)	Carcass and organs	Total plate count *Enterobacteriaceae* *Salmonella spp.*	400	-	(Çetin et al., 2021)

CCP: critical control points.

2.5. Halal Food Management Related Research

2.5.1. General Overview of Study Details

The database search together with the literature reviews enabled to identify studies which are both conducted in or in collaboration with a single or with multiple food product companies and include insights on their practices, issues, challenges and management details around implementing Halal food requirements within the company. Based on the collected work, the following 3 research areas were identified within the Halal Food Management framework:

1. Successful implementation/ cultural factors (8 studies)
    - 2 interview and 4 survey studies conducted in Malaysia
    - 1 survey study in Indonesia
    - 1 survey study in India
2. Improvement studies (7 studies)
    - 6 case studies conducted in Indonesia
    - 1 case study conducted in Malaysia
3. Practices and compliance (9 studies)
    - 7 case studies conducted in Indonesia
    - 1 survey study conducted through focus group discussions in Indonesia
    - 1 survey study conducted in Malaysia

Studies have been mainly conducted in Indonesia and Malaysia. Starting from 2018 there has been a proliferation of studies conducted in Indonesia (Tables 2.8-2.12). This might be due to Indonesian regulation declared that all food in their market should be Halal certified in 2014 by LLPOM MUI, the Halal inspection agency in Indonesia, based to their prescribed Halal assurance system (HAS) HAS 23103. This was followed by a regulation in 2019, based on which the government started its enforcement, giving companies 5 years to become compliant (Anggarkasih & Resma, 2022).

While surveys are more common in Malaysia-origin studies, case-studies are so for studies conducted in Indonesia. Both countries have their own Halal food standard, which these studies use as their bases (Othman, Shaarani & Bahron, 2016; Anggarkasih & Resma, 2022).

Interestingly, no studies were encountered in the Turkish food sector context, nor companies' implementing the OIC/SMIIC 1:2019, General Requirements for Halal Food Standard. The latter is not only meant to be an overarching standard of the Halal food market to unify practices and eliminate technical barriers to trade (SMIIC, 2024; OIC, 2024), but is the standard used by the Halal Accreditation Agency of Türkiye, according to which Halal certification bodies (HCB) active in Türkiye should be accredited starting from June, 2023 (Presidency of the Republic of Türkiye, 2024; HAK, 2019). Thus, research on both Halal food management practices in Türkiye and within the OIC/SMIIC standard context would offer valuable insight into the best practices, challenges in and improvement opportunities for the sector.

2.5.2. Successful Implementation/ Cultural Factors

This set includes the studies (Table 2.8), which have been conducted either explicitly on factors affecting the implementation of Halal food management in food companies (Ahmad et al., 2017; Din & Duad, 2014) or including just some of its aspects (Ali et al., 2022; Mohamed, Rahim & Ma´aram, 2021; Khan, Haleem & Khan, 2022; Giyanti et al., 2021; Zailani et al., 2020). While the former use in-depth interviews, the latter are based on surveys aiming to understand relationships between different concepts. Among other things, these studies refer to various organizational culture aspects, to achieve better Halal food assurance (Table 2.9). Despite Halal certification, food companies have been associated with both general food integrity and direct porcine cross-contamination and Halal mislabeling scandals (Ali & Suleiman, 2017). Thus, a parallel could be drawn with food safety management and culture, that it is not just about setting requirements and rules, it is also important to take into consideration the human factor (GFSI, 2018; Jespersen et al., 2016).

One study specifically uses the term Halal culture describing it to be a type of organizational culture, defining it as *"Employees' awareness of halal practices, combined with the real things that are done"*, (Zailani et al., 2020), which could be compared with food safety culture definitions reviewed by Sharman et al., (2020). The Zailani et al.,

(2020) definition emphasizes workers awareness, which is similar rather to a food safety climate definition by De Boeck (Sharman, Wallace & Jespersen, 2020) as follows, "*Employees' (shared) perceptions of leadership, communication, commitment, resources and risk awareness concerning food safety and hygiene within their current work organization*".

Although relating their Halal culture definition with organizational culture, Zailani et al. (2020) did not actually take into consideration the vast work that has been done regarding organizational culture and with that the essence of what actually forms a culture, like defined by the Scheins (Sharman, Wallace & Jespersen, 2020) as follows, *'…espoused beliefs, values, norms and rules of behaviour that members of the culture use as a way of depicting the culture to themselves and others*', (Sharman, Wallace & Jespersen, 2020).

On the other hand, the work on defining FSC builds exactly upon this, for instance, Griffith, C. J. (Sharman, Wallace & Jespersen, 2020) defined food safety culture as follows, "*The aggregation of the prevailing, relatively constant, learned, shared attitudes, values and beliefs contributing to the hygiene behaviours used within a particular food handling environment*".

Based on these, the globally accepted FSC definition proposed by the GFSI emerged as follows: "*The shared values, beliefs and norms that affect mind-set and behaviour toward food safety in, across and throughout an organization*", (GFSI, 2018; Sharman, Wallace & Jespersen, 2020). Thus, further work is necessary around the 'Halal culture' related definition.

Zailani et al., (2020) used following items to evaluate companies´ Halal culture:

- Senior managers view halal practices as a competitive advantage;
- Make sure that halal practices are the first thought on the mind of all employees;
- Make halal practices the norm for all employees;
- Dedicated efforts to create halal practices-focused workforce;
- Make sure that all employees are vigilant toward halal practices;

Another study evaluated the following items, with which parallels could be brought with FSC dimensions (Table 2.9), to find relationships with successful Halal supply chain management (Khan, Haleem & Khan, 2022):

- Availability of skilled human resources for the Halal supply chain management system;
- Training and development of human resource for managing Halal supply chain management systems;
- Employee involvement and feeling pride for managing and adopting the Halal supply chain management system;
- Enabling Halal supply chain management through efficient capacity utilization.

Thus, currently the way culture evaluation is incorporated within the Halal food assurance concept varies.

Khan et al. (2022) and another study by Mohamed et al. (2021) found that there was no significant relationship between aspects like human resources and companies´ Halal integrity assurance. Mohamed et al. (2021) concluded that this might be because of the lack of dedicated and trained Halal teams within the companies (Mohamed, Rahim & Ma´aram, 2021). On the contrary, Ahmad et al. (2017)´s findings show that the availability and training of skilled human resources and employee involvement are critical factors in implementing Halal food management systems (Ahmad et al., 2017). Furthermore, Rejeb et al. (2021), in their review of Halal food research, also emphasized the importance of human resources that can facilitate knowledge and expertise on Halal food assurance (Rejeb et al., 2022). This is also true regarding FSC, in which effective capacity building, hiring skilled human resources, employee engagement and ownership are all important aspects of the People system dimension (GFSI, 2018).

In addition to setting up Halal policies and procedures, multiple studies emphasize aspects like management commitment and involvement, sincerity, dedication and clear intentions, as important for successful Halal food management (Ahmad et al., 2017; Din & Duad, 2014; Nawi et al., 2023; Zailani et al., 2020; Mohamed, Rahim & Ma´aram, 2021; Khan, Haleem & Khan, 2022), which are also the corner stone of the FSC Values and mission dimension (GFSI, 2018). Examples of other aspects describing this dimension are the importance of allocating resources (Ahmad et al., 2017; Khan, Haleem & Khan, 2022) and including all stakeholders, like suppliers in addition to company employees (Khan, Haleem & Khan, 2022; Mohamed, Rahim & Ma´aram, 2021; Din & Duad, 2014; Zailani et al., 2020; Ahmad et al., 2017).

Just like specified in the FSC People system dimension, Halal food assurance research also emphasizes that all responsibilities should not fall on one person to avoid silos and, regarding governance, it would benefit to have the responsible person directly report to senior management (Ahmad et al., 2017; GFSI, 2018). Other overlapping Halal food assurance and FSC aspects have been elaborated in more detail in Table 2.9, with some of the main similarities being as follows,

- People system dimension - teamwork, communication, engagement, empowerment, governance, job-specific training and competencies, incentives and rewards;
- Adaptability - like readiness for change, problem solving and crisis management;
- Consistency - like up-to-date easily implementable procedures, data management, including flow of information across the supply chain;
- Risks and hazards - like being aware of hazards and risk related to Halal food assurance and building the awareness and engagement of employees;

In conclusion, the literature review shows that research on Halal food assurance is shifting towards the importance of organizational culture. As research emphasizes the significance of food safety culture for successful food safety management (Zanin, Stedefeldt & Luning, 2021) and as it is "*No longer a matter of whether culture impacts food safety, it is a matter of how and a matter of finding and committing to the best path for improvement*", (Jespersen & Robach, 2018), Halal food management might also bring the scattered research together and take advantage of the established food safety culture definition and dimensions for a more wholesome approach of Halal and food assurance culture evaluation and improvement, especially as food safety and hygiene are an inseparable part of Halal food assurance (Neio Demirci, Soon & Wallace, 2016; Lestari et al., 2023; Raheem & Neio Demirci, 2018).

Table 2.8. Studies including successful implementation/ cultural factors regarding Halal food assurance,

Aim	Participants	Method	Findings	Source
… to identify the critical success factors of the Malaysian Halal food standard (MS1500:2009) implementation.	3 large food companies, Malaysia	Interviews with industry and authority representatives, consultants, academicians.	The identified factors include 1) Top management commitment, 2) Company policy and procedures, 3) Employee commitment, 4) Training and education, 5) Customer relations and communication, 6) Process management, 7) Sincerity, 8) Supplier commitment, 9) Technology, 10) Competent certifying body, and 11) Supportive infrastructure.	(Din & Duad, 2014)
… to identify critical factors for effective implementation of halal food management system in SMEs.	7 SME, Malaysia	- Interviews were conducted with seven informants from seven SME and 1 large food company. - Eight semi structured interviews were conducted with halal consultants and auditors from different backgrounds.	The identified factors include, top management commitment, allocating resources, halal training and education, employee attributes and management, Halal personnel empowerment, information capacity and exposure, policy and procedure, supply management, teamwork	(Ahmad et al., 2017)
…to investigate the effects of four halal orientation strategies (staffing, material, production process and storage and transportation) on	154 food companies (Halal-certified), Malaysia	Survey with a 5-point Likert scale	- halal materials and halal storage and transportation positively affect financial performance, whereas the halal production process negatively affects financial performance.	(Zailani et al., 2020)

companies' financial performance and Halal culture as the moderator.			- halal culture moderates the relationship between the production process and the financial performance of the firm.	
…to evaluate relationships between halal food supply chain and halal integrity assurance.	121 food companies (Halal-certified), Malaysia	Survey (elaborated the concepts, but not the statements used in the survey)	The halal industry with a high focus on supply chain business processes and supply chain network structure are expected to have better Halal integrity assurance.	(Mohamed, Rahim & Ma´aram, 2021)
… to investigate the drivers of the depth of halal standard implementation	83 SME food companies (Halal-certified), Indonesia	Survey (on-site) using a six-point Likert scale. - Items for the depth of halal standard implementation were developed based on HAS 23000 - The respondents had to specify their perceptions on the depth of halal standard implementation in their company (1 - no implementation at all) to 6 - full implementation).	- internal motivation and organization commitment positively affect halal standard implementation, while external pressures do not. - external pressures influence the depth of halal standard implementation through internal motivation as a mediating variable - the depth of halal standard implementation leads to the improvement of operational performance.	(Giyanti et al., 2021)
…to explore the impacts of supply chain integration on halal food supply chain integrity and, consequently, food quality.	275 Halal-certified food companies, Malaysia	Surveys with Likert scale from "not at all" to "very great extent"	The more extensive of internal integration in halal food companies, the more extensive of supplier and customer integrations can be achieved. For example, if a weak internal integration resides within a company, such as less teamwork	(Ali et al., 2022)

			and communication among the functional departments or poor internal data integration, it will be a daunting case for the company to work with suppliers and customers.	
… to identify critical success factors for effective Halal supply chain management.	216 respondents, with 104 being senior-manager level professional, India	- Literature review and experts´ inputs to identify critical factors, success indicators and sustainable performance measures of Halal supply chain management - Survey (elaborated the concepts, but not the statements used in the survey) using a 5-point Likert scale of professionals working in Halal certification systems and food and beverage industry.	Put forth factors, which were significantly related with Halal supply chain performance.	(Khan, Haleem & Khan, 2022)
… to examine the effect of knowledge and attitude on firms' commitment to Halal standard practices in a developing nation's food sector	112, Malaysia	- Survey (online) with executive officers using a five-point Likert scales - Elaborated the concepts (knowledge, attitude and commitment), but not the statements used in the survey)	- findings reflect the significant role of attitude in influencing firms' commitment to Halal standard compliance in the food sector	(Nawi et al., 2023)

SME: small and medium-sized enterprises.

Table 2.9: Comparison of success factors regarding Halal food assurance with food safety culture dimensions,

Success factors in Halal food assurance	Food safety culture dimension details **Source:** GFSI, 2018
Values and mission	
- Top management commitment and involvement (Ahmad et al., 2017; Din & Duad, 2014; Nawi et al., 2023) - Sincerity is a critical success factor in Halal standard implementation (Din & Duad, 2014). - Dedicated efforts to create halal practices-focused workforce (Zailani et al., 2020). - Having unclear intentions and lack of commitment might lead to poor implementation of the Halal food assurance system, including not properly setting up the Halal policy and trained dedicated Halal team (Mohamed, Rahim & Ma´aram, 2021). - Policies and procedures - companies need to lay out regulation and/or a policy related to halal (Ahmad et al., 2017; Din & Duad, 2014). - Management commitment and support in internal documentations Halal policy/ processes for the organization (Khan, Haleem & Khan, 2022).	Leaders develop food safety policies and standards in alignment with the company's strategic direction, but policies alone are just documents and requirements. True meaning comes when policies are translated into clear behavioural expectations for employees. A consistent, visible and credible leadership commitment to food safety and accountability is a foundational element of a food safety culture.
- Adequate support – Examples include infrastructure (e.g. facilities, equipment), tools, manpower, and prerequisite program (Ahmad et al., 2017). - Commitment from the top management for HSC-related activities through financial support (Khan, Haleem & Khan, 2022).	Proper allocation of resources, including financial, people and time, demonstrates leadership's dedication to food safety
- Selecting suppliers who are well versed in halal certification's requirements (Ahmad et al., 2017) - Conducting supplier audits… monitoring supplier is needed to ensure compliance at supplier's part (Ahmad et al., 2017)	The food safety policy statement addresses food safety ownership of staff at all organizational levels,and establishes responsibility for the food safety of products from product design across the full supply chain.

- Commitment, trust, strong coordination, collaboration and resources (including information, technology, ingredients knowledge and skills, etc) sharing among supply chain partners to provide Halal products and associated processes (Khan, Haleem & Khan, 2022; Mohamed, Rahim & Ma´aram, 2021; Din & Duad, 2014).	
People system	
- Teamwork and communication among functional departments (Ali et al., 2022). - Organizational commitment (Employee involvement, commitment, teamwork among Halal team) is important for Halal standard implementation (Giyanti et al., 2021). - Employee commitment is a critical success factor in Halal standard implementation (Din & Duad, 2014). - Management commitment and support in providing communication within the organisation about the Halal practices in supply chain (Khan, Haleem & Khan, 2022). - Departmental co-operation is important as it enables to declare the roles related to halal for each unit to facilitate halal management. (Ahmad et al., 2017). - Halal certification system requires commitment from various departments or units in the company to ensure the success of certification in halal (Othman, Shaarani & Bahron, 2016). - Lack of co-operation received from other departments and role ambiguity is a challenge in implementing halal program (Ahmad et al., 2017). - Employees might withhold important information, halal committee members might not participate (Ahmad et al., 2017).	- The maturity of an organization's food safety culture can be measured by the extent to which all stakeholders (all parties inside and outside of the company who influence the company) acknowledge shared food safety goals, assume accountability for their active role in maintaining food safety standards, and work in concert to achieve those objectives. - The traditional members of a food safety team cannot be solely responsible for an organization's food safety culture.
Make sure that halal practices are the first thought on the mind of all employees (Zailani et al., 2020).	Effective messaging is essential to successfully communicate a company's food safety expectations. Such messaging should be consistent and clear to all staff

	members, so that they understand and are regularly reminded of the company's safe food practices and overall approach to food safety.
- Articulated governance structure towards affixing accountability of non-compliance or error in the production of Halal goods (Khan, Haleem & Khan, 2022). - Make sure that all employees are vigilant toward halal practices (Zailani et al., 2020).	Food safety should be embedded within the organization's governance structure and have the appropriate profile across the whole enterprise.
- A commitment to developing employee competence will influence both the organizations' and its employees' ability to adapt to change (Zailani et al., 2020). - Adequate training given in handling halal food (Zailani et al., 2020).	Training content must be relevant to each learner's job competencies, and employees must be able to apply that learning in their work environment.
- Employees being committed, knowledgeable and empowered to act on halal and safety related issues (Ahmad et al., 2017). - Empowerment of halal executive or personnel (Ahmad et al., 2017). - To ensure that they are proficient and well equipped in handling their tasks and functions, companies need to ensure that these executives are adequately trained on halal program implementation (Ahmad et al., 2017). - Another important aspect for halal program's improvement is to give halal executives sufficient authority to make decisions and act in their work areas without prior approval from top management (Ahmad et al., 2017).	People empowerment - The extent to which people within a business have both the knowledge and authority to act will impact that organization's ability to adapt, improve and sustain its food safety culture. Employees at all levels should have the power to lead or initiate positive change.
- Halal executive also need to be given channel to directly communicate with top management on halal issues or concern (Ahmad et al., 2017).	Consider creating an independent escalation route that allows the food safety team to report directly to senior leadership rather than senior operations staff.
- The importance of incentive, reward or punishment scheme to make sure employee adhered to halal rules and regulations (Ahmad et al., 2017).	Rewards, when paired with fair and transparent recognition programs, can help management guide desired food safety behaviours. Companies can use various incentives and deterrents to achieve consistent compliance

- Adherence to the ethical standard and fair-trade practices in Halal production systems (Khan, Haleem & Khan, 2022).	As part of a company's communication program a whistle-blowing policy should be established and include the education of employees on the appropriate steps to take in communicating their ethical concerns to appropriate company personnel.
Adaptability	
- Readiness to implement innovative halal solutions. For instance, the successful change from conventional logistics operations to halal logistics operations requires the right intention (Mohamed, Rahim & Ma´aram, 2021) - Management commitment and support in providing leadership and associated environment for enabling the change management towards Halal (Khan, Haleem & Khan, 2022).	Accountability, transparent decision-making processes and sustainable deployment of change are essential, while simultaneously staying true to vision and values. The ways an organization responds to changes within the environment in which it operates will both impact, and be impacted by, its food safety culture.
- An advanced preparation in handling halal concern or crisis to be important in halal food management (Ahmad et al., 2017).	In any enterprise with a strong food safety culture, its adaptability is reflected in its skill in anticipating, preparing for and responding to change and unexpected disruptions (e.g. crisis) to ultimately survive and prosper.
- Availability of internal Halal assurance circle for problem solving/kaizen (Khan, Haleem & Khan, 2022).	Problem-solving concerns how a business responds to issues identified through measures, insights, near-misses or other events. It includes a focus on determining root cause and implementing long-term corrective and preventive actions.
Consistency	
- Establishing Halal purchasing procedure. Failure to ensure that halal executives are made aware of the in-coming material purchased could lead to inconsistency in database (Halal's authorities) and companies' inventory/ warehouse, a serious noncompliance to halal regulation (Ahmad et al., 2017). - preparing customer orders, managing production flow and the procurement process are important for effective Halal supply chain management (Mohamed, Rahim & Ma´aram, 2021).	Food safety documentation enables proper, consistent decision-making. It encompasses data (e.g. product, process and training records) and information about food safety expectations, plans and operational procedures and helps to verify consistency.

- Data integration within the company (Ali et al., 2022). - Availability of efficient flow of information across the HSC (Khan, Haleem & Khan, 2022).	Technology is seen in the context the business system to integrate functions, procedures and capabilities (Jespersen et al., 2019).
Risks and hazards	
- Halal training/education of employees, including top management and managerial staff (Ahmad et al., 2017; Din & Duad, 2014)	Basic scientific and technical information should be accessible and understandable to everyone.
- Awareness of Halal requirements and handling procedures (Zailani et al., 2020).	It is important to ensure that all employees comprehend the procedures, practices and behaviours that act as preventive control measures.
- Accessibility of information related to requirements and other supports for system implementation (Ahmad et al., 2017).	As a company, it is important to keep current on the latest industry intelligence including market incidents, changes to food safety legislation, significant new technology and analytical advances.

2.5.3. Risk Identification and Mitigation Studies

This set of studies is similar in that the researchers worked together with 1 to 4 companies using interviews, focus group discussions and/or guiding them through risk evaluation model activities (e.g., brainstorming) to identify risks and mitigation strategies within their Halal production to facilitate its better management (Table 2.10). While two studies used the HACCP approach to identify Halal control points or critical factors regarding raw materials and the production process (Lau, Jamaludin & Soon, 2016; Sucipto et al., 2022), one study just brought out justifications for each Halal critical activity specific for that production (Maonah & Saroso, 2018). The remaining studies used different models for risk analysis and mitigation (Kristanto & Kurniawati, 2023; Maman, Mahbubi & Jie, 2017; Vanany, Maarıf & Soon, 2019; Vanany et al., 2021). For example, two studies introduce the concepts of risk event, agent and mitigation and the house of risk model (Maman, Mahbubi & Jie, 2017; Kristanto & Kurniawati, 2023) and two studies from the same primary author use the Quality function deployment (QFD) model in one and the six-sigma approach in the other case (Wahyuni, Vanany & Ciptomulyono, 2018; Vanany et al., 2021).

In addition to focusing solely on risks regarding Halal production processes, some of these studies also identified risks around its management, including aspects brought out under FSC dimensions (Table 2.11). For instance, all these studies identified the need for written Halal guidelines or procedures specifying its standard operating procedures. However, as mentioned above, the policies and procedures set up by the companies remain as mere documents and requirements, if they are not *"Translated into clear behavioural expectations for employees"*, coupled with "*Accountability and a consistent, visible and credible leadership commitment*", (GFSI, 2018). This is also what some of the studies identify as a risk, e.g., lack of awareness and ownership (Maman, Mahbubi & Jie, 2017; Kristanto & Kurniawati, 2023).

All these studies included job-specific training for the frontline to improve awareness and capabilities as a risk mitigation strategy. This is especially important, because these studies were conducted in the meat or poultry sectors, where there are multiple production process-based Halal requirements. Management training per se has been mentioned only is one study for the retailers of the supply chain (Maman, Mahbubi & Jie, 2017), which is an important aspect in FSC maturity.

Two studies mention using incentives, bonuses, acknowledgement, and punishment, which is in line with the People system FSC dimension (Vanany et al., 2021; Kristanto & Kurniawati, 2023; GFSI, 2018).

One of these studies refers to the critical factors for the implementation of the Halal food management system set forth by Ahmad et al. (2017) to use in their risk analysis and mitigation approach (Vanany, Maarıf & Soon, 2019), to some extent bridging the gap between study areas 1 and 2, Halal food management implementation factors and improvement studies, respectively. Although Ahmad et al. (2017) among other factors emphasized the importance of management commitment, interestingly, they did not elaborate on the details of this subject. Thus, organizational culture aspects have been started to take into consideration even in Halal food management improvement studies, but only to some extent.

Table 2.10: Halal Food Management improvement studies,

Aim	Participants	Methods	Findings	Source
… to determine the understanding of halal concept among food production workers and to develop a generic Halal Control Point Plan for the manufacturing of processed foods	4 companies (soy sauce, frozen chicken roll, oats, coffee powder), Malaysia	- In-depth interview quality assurance staff, - Survey with in total 200 workers, - ATP swabs	- interview results were used to construct a generic Halal Control Point flowchart. - workers demonstrated understanding and a positive attitude towards halal products	(Lau, Jamaludin & Soon, 2016)
… to identify halal risk events, halal risk agents, measure halal risk level and formulate the halal risk control model (mitigation) in all stages in the beef supply chain	Feedlot, butcher and retailer, Indonesia	- HAS 23103 of LPPOM MUI as the recognized halal standard in Indonesia - focus groups with Halal auditors of LPPOM MUI - In-depth interviews with the halal expert who has the high experience of halal research - In-depth interview, direct observation, guided interview and also by focus groups with parties in the beef supply chain, such as beef feedlot practitioner, abattoir clerk and manager, transporter and also retailers	A model, which could work as a reference for halal meat auditing and reference for halal meat import procurement policy.	(Maman, Mahbubi & Jie, 2017)
…to identify critical activities regarding Halal food management	1 flavour company, Indonesia	Observations, Document review	- Constructed a production process flow and accordingly identified critical activities as prescribed in HAS	(Maonah & Saroso, 2018)

			- The study did not elaborate on observation and document review results.	
… to propose a Quality function deployment model to identify key processes and prioritize programs to improve halal food production.	1 poultry processing plant, Indonesia	- Cooperation with governmental Halal inspection agency LPPOM MUI to identify Halal requirements - Semi-structured interview with the quality manager to identify food process requirements.	The Quality function deployment was used to identify and prioritize key processes and improvement programs. This supports the company in decision-making and to allocate their resources accordingly.	(Vanany, Maarıf & Soon, 2019)
… to propose a halal-based six sigma framework that could be used to reduce halal food defects and improve compliance.	1 poultry meat production (over 500 employees), Indonesia	- Brainstorming with Halal practitioners and academicians to construct the framework - Working together with the company´s Halal six sigma project team	They identified deviations of the production process from HAS, their root causes and ways to improve the production process.	(Vanany et al., 2021)
…to identify the risks, the risk agents, and the mitigation steps and then propose a halal supply chain risk management framework for frozen food halal industries	2 frozen food companies, Indonesia	- Literature review to identify risks. - Semi-structured interviews with owners to confirm identified risks and their sources	Proposed a Halal supply chain risk management framework for frozen food industries.	(Kristanto & Kurniawati, 2023)
… to identify Halal Critical Points in materials and production processes and accordingly provide improvement suggestions.	3 small bakeries, Indonesia	- Interviews, with 10 respondents in total, 3-4 per company, including owner and production employees. - Internal audit	- Constructed a decision tree to trace the Halal status of raw materials and accordingly identified the percentage	(Sucipto et al., 2022)

			of Halal Critical Point materials. - The study did not elaborate specifically on interview and audit results.

ATP: Adenosine triphosphate; HAS: Halal assurance system; LPPOM MUI: Halal inspection agency in Indonesia.

Table 2.11: Details of risk management studies and their overlap with FSC dimensions,

Model for risk analysis and mitigation	Risk related to FSC dimensions	Risk mitigation/ improvement suggestions related to FSC dimensions
Source: Maman, Mahbubi & Jie, 2017		
Halal risk event - is an allegation of the existence of unlawful animal, or the lawful animal contaminated – or at least touched – by the non-halal animal, or the halal meat contaminated by the filth material, although it come from the cow itself. Risk agents - the fact or the condition that probably emerge the halal risk; Risk mitigation (House of risk – supply chain risk analyses model);	- Difficult to form awareness of different Halal related procedures - Halal training has not been done on a regular basis and has not yet given a significant result - The halal policy and awareness have not become a corporate culture. - The halal policy has not been effectively socialized. - Many stakeholders are not interested in Halal policies and in understanding the halal importance. - There are still many company's stakeholders who think that the halal requirement is merely a formality and the halal policy to obtain market	- Set up Halal guidelines - Conducting regular job-specific Halal training - Socialization of the Halal policy
Source: Vanany, Maarif & Soon, 2019		
Quality function deployment model: Phase 1 - identifying HAS requirements and the production process Phase 2 – identifying the relationship between HAS and set of Halal critical factors. Phase 3 – identifying relationship between potential problems of the Halal critical factors and the improvement programs	- Lack of awareness among suppliers; - Incomplete Halal procedures - Lack of evidence or supporting materials about halal procedure and certification - Lack of competencies among staff;	Improvement programs were based on critical success factors identified by Ahmad, at al. (2017), like **Supplier management** - Halal supervisor(s) to evaluate suppliers

		- Halal requirements / certification as a supplier prerequisite **Halal policy, procedures and information** - Requirement for halal policy - Revise Standard Operating Procedures **Employee capability** - Enhance information sharing and electronic traceability system - Improve employees' capability via training
Source: Vanany et al., 2021		
Six sigma framework: Phase 1 – understand the problem and clarify the scope Phase 2 – determine aspects critical to Halal Phase 3 – identify root cause and prioritize problems Phase 4 – determine feasible improvement actions Phase 5 – control of improvement sustainability; proper documentation and standardization of procedures	- no manual for Halal requirements and internal training for slaughterers	- Setting up guidelines and standard operating procedures. - Job-specific training as one of the main improvement actions **In order to maintain improvement actions, the study suggests:** - Results of the project must be communicated to all employees - Clarify new roles and tasks - Incentives for operators in Halal critical point/processes and bonuses for the best employees who make a significant contribution could be conducted in the halal improvement actions.
Source: Kristanto & Kurniawati, 2023		
Two methods are used to analyze risks: - Supply chain operations model – five processes (planning, source, production, delivery, and	- No standard operating procedure is halal - Not being discipline at work	- Making standard operating procedures of halal production

return) are used to map our existing risks, identifying risk agents, events and mitigation. - House of Risk method Step 1 – choose risk priorities Step 2 – select risk prevention efforts	- Not checking the product as it is being processed or finished, and lack of attitude - Unexpected orders from the consumer	- Doing a training to employee about halal process and good manufacturing practices periodically - Applying appreciation and punishment to workers - Suppose orders

HAS: Halal assurance system.

2.5.4. Practices and Compliance

This group of studies are similar in that they evaluate the measures the food companies take for the compliance with Halal requirements. From the identified 9 studies, there were 2 surveys from which one was conducted through focus group discussions (Lestari et al., 2023), while the other were done online (Othman, Shaarani & Bahron, 2016). The rest were single-company-based case studies (Table 2.12).

Othman et. al., (2016) evaluated variables like knowledge, assurance and commitment in food production companies, focusing on their relationship with companies' size. The Malaysian Halal food standard (MS1500:2009) was used to assemble the survey statements. However, only one example statement was given per variable within the publication, making it difficult to evaluate practices in detail. The study found that there was no statistically significant difference in Halal related knowledge between large and SME companies and that larger companies had a higher score for Halal assurance practices and commitment (Othman, Shaarani & Bahron, 2016).

Lestari et al. (2023) first associated good manufacturing practices (GMP) requirements with the Quran verses and the Thayyiban concept to establish a list of Halal GMPs. Then, this list was used in focus group discussions with SMEs´ representatives to evaluate their practices. They concluded the HGMP practices to be poor (Lestari et al., 2023).

Wahyuni et al., (2019) conducted interviews with company representatives to find out what food safety and Halal risks the companies have identified and whether they have integrated their management. However, no details were given on how the companies went about managing and integrating those risks (Wahyuni, Vanany & Ciptomulyono, 2019). The rest of the publications were similar in that they evaluated practices in a company using on-site observations based on the Halal Assurance System (HAS) requirements prescribed by the Indonesian government. 3 of these studies were conference proceedings (Dewantara et al., 2018; Al Adiat et al., 2018; Perdani, Chasanah, & Sucipto, 2018) while 3 were published in local Indonesian journals (Wulandari, Sirajuddin & Qui, 2022; Anggi & Rahayu, 2022; Yuwana et al., 2021), with one of them having only the English abstract available (Yuwana et al., 2021).

The Indonesian HAS focuses on critical activity procedures like selecting new materials, purchasing materials, inspecting incoming materials, formulating products/development of new products (Perdani, Chasanah & Sucipto, 2018). These studies found that companies either did not conduct internal audits or did not conduct them often enough. Other frequent non-conformities included lack of written documentation and management review. The case studies presented their findings in a general form of whether the companies have set up these procedures. However, they did not evaluate the detail of their content, like whether all the possible risks have been identified and addressed appropriately, leaving this as a research gap, which the current study will focus on.

Table 2.12: Studies on Halal food management – practices and compliance,

Aim	No and type of companies	Method	Findings	Source
… to assess the level of knowledge, Halal food assurance practices, and commitment	241 large and SME food production companies, Malaysia	- Survey (on-site) using a five-point Likert scales. - Presented only one example statement per variable (knowledge, Halal assurance, commitment)	Found the level of knowledge, Halal food assurance practices and commitment to be at a good level.	(Othman, Shaarani & Bahron, 2016)
… to explore food safety and Halal food risks in the companies and the integration of their risk management	2 companies, one producing meat and the other processed meat products, Indonesia 1st company: around 400 workers and no ISO 22000 standard 2nd company: 1500 workers and a ISO22000 standard	- Interviews with staff responsible for food safety and Halal food management. - Questions targeted food safety, Halal food assurance and the integration of food safety and Halal risk management.	The participants elaborated on their food safety and Halal risks and that they are managing their risks in an integrated manner. However, it was not specified how the Halal and food safety risk integration was done.	(Wahyuni, Vanany & Ciptomulyono, 2018)
… to evaluate the compliance with the Indonesian Halal assurance system requirements.	1 bakery, Indonesia No Halal certification, the company had given some effort to implement Halal food management related activities	- Interviews with 2 respondents from each division of the company, with a minimum of 2 years of experience. Total no of respondents not mentioned. - Used a check-list based on Indonesian Halal Assurance System	Identified the lack of awareness of workers regarding company´s Halal policy and lack of training and the Halal team, indicating to non-conformities regarding the Indonesian Halal Assurance System.	(Perdani, Chasanah & Sucipto, 2018) / Conference Proceeding
… to evaluate compliance with GMP, HACCP and Indonesian Halal assurance system requirements.	1 SME (not Halal certified) processed meat producer, Indonesia	- Compliance checks were made using check-lists based on GMP, HACCP and Indonesian Halal Assurance System requirements.	They found improvements were necessary regarding both HACCP and GMP requirements. As for Halal food assurance critical ingredients and processes were not	(Al Adiat et al., 2018)/ Conference Proceeding

		- Did not elaborate on whether they conducted interviews, observations, document review etc.	determined and documentation, internal audit and management review were lacking.	
… to evaluate compliance with GMP and Indonesian Halal assurance system requirements.	1 SME (not Halal certified) tofu producer, Indonesia	- Compliance checks were made using check-lists based on GMP and Indonesian Halal Assurance System requirements. - Did not elaborate on whether they conducted interviews, observations, document review etc.	Improvements were necessary regarding GMP requirements. There were non-compliances with majority of the Halal food related requirements.	(Dewantara et al., 2018) / Conference Proceeding
… … to evaluate compliance with the Indonesian Halal assurance system requirements.	1 bakery (size not specified), Indonesia Halal certified, which had been extended 2 times.	- Data collection (no details on methods) according to the Indonesian Halal Assurance System requirements. - Only the abstract of the article was in English.	They found that everything except the internal audit criteria were met.	(Yuwana et al., 2021)
… … to evaluate compliance with the Indonesian Halal assurance system requirements.	1 dairy (size not specified, Halal certified), Indonesia	- Interview, document analyses - Used a check-list based on Indonesian Halal Assurance System	Identified non-conformities, like not having a written Halal policy, no written training procedures and documented training, no management review, not routinely carrying out internal audits.	(Wulandari, Sirajuddin & Qui, 2022)
… to determine whether the raw materials used have a Halal certificate and evaluate compliance to the Indonesian	1 snack manufacturer (size not specified, Halal certified), Indonesia	- Interview, observations and document analysis	Although all raw materials were properly Halal certified, there was a lack of Halal training, team and policy.	(Anggi & Rahayu, 2022)

Halal assurance system requirements.				
… evaluated compliance with the GMP and Indonesian Halal assurance system requirements.	- focus groups with 8 government experts - 73 SME (not Halal certified) representatives, Indonesia	- Constructed and validated GMP and Halal-related evaluation check-list. - Focus groups reported implementation on a scale from 1 to 5.	-Company scores were categorized as poor.	(Lestari et al., 2023)

GMP: Good manufacturing practices; HACCP: Hazard analysis and critical control points; SME: small and medium sized enterprises.

2.6. Process Hygiene in Food Safety Culture Maturity and Halal Food Assurance Research Context

A recent systematic review on FSC emphasized the need for more empirical work to fully demonstrate the connection between FSC maturity and microbiological hygiene (Westat, Inc. & FDA Food Safety Culture Research Subgroup, 2022). Five studies, including both FSC and microbiological analysis, have been conducted in different food sectors (Table 2.13). One study, used companies´ microbiological analysis records as a part of their FSC evaluation, not conducting any actual analysis (Nyarugwe, Linnemann & Luning, 2020). Three of these studies have been conducted on a small number of solely final product samples (total of 2 - 17 samples) in food service and production businesses (Sarter & Sarter, 2012; Nyarugwe, Linnemann & Luning, 2020; Zanin et al., 2021). Two studies included samples to evaluate process environment hygiene, one in the retail markets and the other in the butcheries, with both using *Listeria monocytogenes* (Wu et al., 2020; De Boeck et al., 2016). These studies have also not used indicator organisms, like Enterobacteriaceae (EB), coliform (CF), thermotolerant coliform (ttCF) and *E. coli*, for evaluating the process environment microbiological hygiene, which are generally used for such purposes (Bourdichon, et al., 2021). Thus, there is a research gap in evaluating the process environment microbiological hygiene in the food production setting as part of FSC maturity evaluation.

To do this, different zone concepts might be used to decide upon and prioritize sampling locations, like hygiene zoning (high/medium/low), dry/wet production zones, proximity to the product (Zone 1 to 4 in ascending order of distance from the product, including food contact and non-contact surfaces) (Bourdichon et al., 2021). The importance of microorganism entrance and movement or in other words, transfer between these zones, has also been emphasized, in addition to its significance in the FSC maturity context, especially with regards to the more mature preventative stage (3M & Cornell University, 2019; Gurtler, Doyle & Kornacki, 2014).

Thus, this study used a combination of observations and microbiological analysis to explore the relationship between FSC maturity and microbiological hygiene. Observations are used, as they enable to reflect real world practices, which might lead to zone transfer, and could thus be used as a supplementary method to set the microbiological findings in perspective (Robson & McCartan, 2016). This is a novel combination in the food production environment context, as similar approach to identify possible contamination routes and risks of consumer food handling practices, has only been used in a model kitchen (Evans & Redmond, 2018; Robson & McCartan, 2016).

The combination of observations and microbiological analysis will also enable to gain further insight into Halal food assurance practices, as preventing fecal contamination from food handlers´ hands is also important from the Halal food assurance perspective, not only from a FS, but an unwanted substance perspective (Neio Demirci, Soon & Wallace, 2016; Lestari et al., 2023; Raheem & Neio Demirci, 2018). Currently, there is only one study, Lau et al., (2016) using ATP evaluation, which has used analyses within the Halal food assurance research framework. Thus, this will be the first study to apply a combination of observations and microbiological analysis in Halal certified companies.

Table 2.13: Overview of FSC studies including microbiological analysis,

Number of businesses	**Total amount of samples used per business**	**Area of testing**	**Analyzed microorganisms**	**Source**
30 food services	4	Final product	Total plate count *E. coli* *Staphylococcus aureus* *Salmonella*	(Sarter & Sarter, 2012)
3 production companies	17	Final and intermediate products	*Salmonella spp.* *E. coli* Coliforms *Staphylococcus aureus*	(Nyarugwe et al., 2018)
1 food service	2	Final product	*Coliforms* *Bacillus cereus* *Salmonella spp.* Coagulase-positive *Staphylococci*	(Zanin et al., 2021)
9 production companies	No samples	Final product analysis records	Yeast Molds Coliforms	(Nyarugwe, Linnemann & Luning, 2020)

30 retail markets	30 surfaces sampled for 6 months	Environment	*L. monocytogenes*	(Burnett et al., 2020; Wu et al., 2020)
8 butcheries	4	Final product	*L. monocytogenes* *Salmonella spp.* *E. coli O157:H7* *Enterobacteriaceae* *Staphylococcus aureus* Total plate count Lactic acid bacteria	(De Boeck et al., 2016)
	69		*E. coli*	
	5	Hands Environment	Total plate count *L. monocytogenes*	

CHAPTER III

RESEARCH METHODOLOGY

This chapter gives an overview of the research design, followed by justification and application details of the methods used in this study. The research design gives an overview of the methods used to collect data on each of the research strands. Additionally, under application of methods for FSC evaluation, its data analysis approach was described on how the findings from different methods were combined to reach conclusions on FSC maturity stages.

3.1. Research Design

To evaluate the interaction between the three research strands of this study, food safety culture (FSC), Halal food assurance (HFA) and process hygiene in food production companies, a multiple case study approach was used. Case studies might commonly be considered when studying organizations, best practices, management issues and organizational cultures (Robson & McCartan, 2016). Rather than statistical generalization, multiple case studies might enable to arrive at theoretical generalizations and with that provide context in which the companies operate, like aimed with evaluation of FSC maturity and HFA practices and provide empirical evidence into theories planned to explore in this study, like the interplay between FSC, HFA and process hygiene (Robson & McCartan, 2016). For instance, a study at a national level included 9 food production companies, assessing two variables: FSC and characteristics which could shape it (Nyarugwe, Linnemann & Luning, 2020). As the current study takes an even more in-depth approach, focusing on the interaction between three variables, 5 companies were focused on.

Figure 3.1. gives an overview of the methods used to evaluate each of the research strands. Both meta-synthesis of existing food safety and hygiene studies in food production companies in Türkiye and empirical research was used to evaluate FSC maturity in the Turkish food production context. Semi-structured interviews, survey and performance

document analysis were the main methods to empirically evaluate FSC in the companies. However, during the study, upon applying the FSC survey in the companies, a high enough participation rate was not achieved. To ensure that there is enough data for the validity of the evaluations, an additional method, focus group discussions, was included as a secondary method. Semi-structure interviews, together with management system's document review were used as the main methods to evaluate Halal food assurance management in the companies. Microbiological analysis together with observations were used as the main methods in evaluating process environment hygiene.

At the same time, the main methods of each evaluated topic enabled to collect additional data on the other topics as well (Figure 3.1, dotted lines). For instance, observations offered further insights into FSC and HFA and microbiological analysis additionally into HFA. Supplementary data for HFA was further obtained, by incorporating 1-2 additional questions regarding Halal food assurance into semi-structured interviews, survey and focus group discussion used to evaluate FSC.

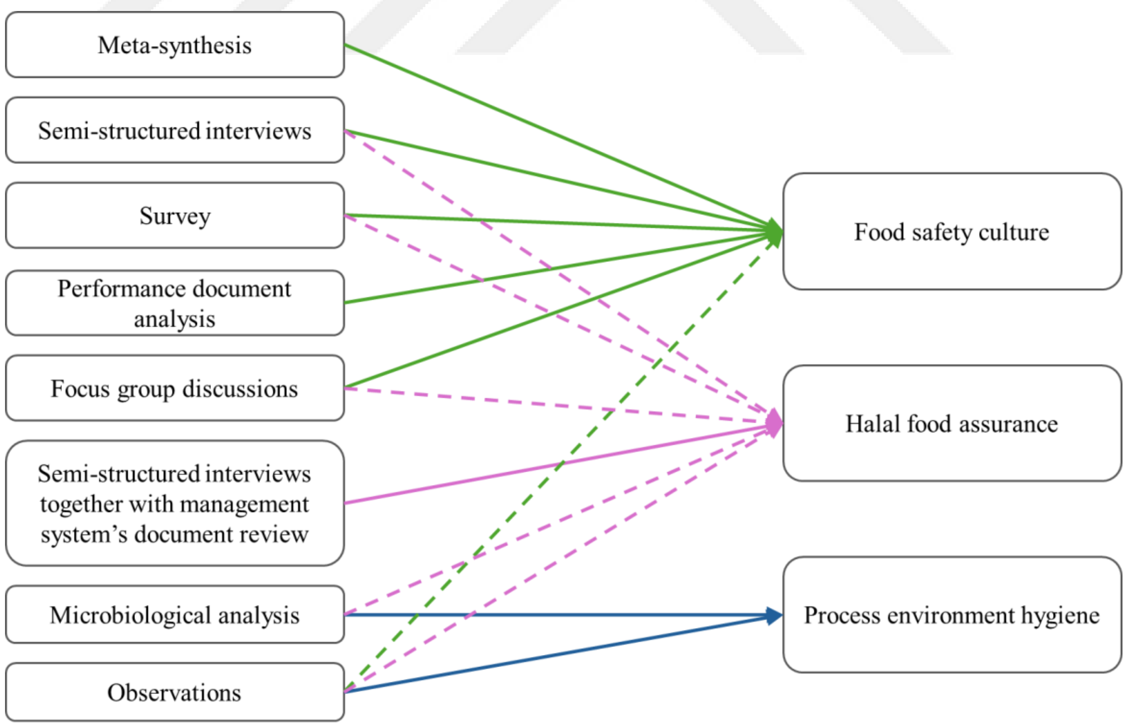


Figure 3.1: Research methodology and their corresponding research strand. Solid line – main method; dotted line – additional data gained from the method.

Source: Prepared by the researcher.

After the survey did not achieve targeted participation rates, an additional semi-structured interview was conducted to understand how the companies went about organizing the survey and analyze why their approaches might have failed. These results, together with expert advice, were used to identify actions, as improvement interventions, on how companies could adjust their approaches in organizing the survey. However, none of the companies were willing and/or able to apply these. In the end, additional data analysis was conducted to understand the reasons behind low participation rates and its connection with FSC maturity, which shaped into Chapter 4.2.

Again, Figure 3.2 depicts how, in the end, the data obtained from the chosen research methodology was shaped into different results and discussion subchapters.

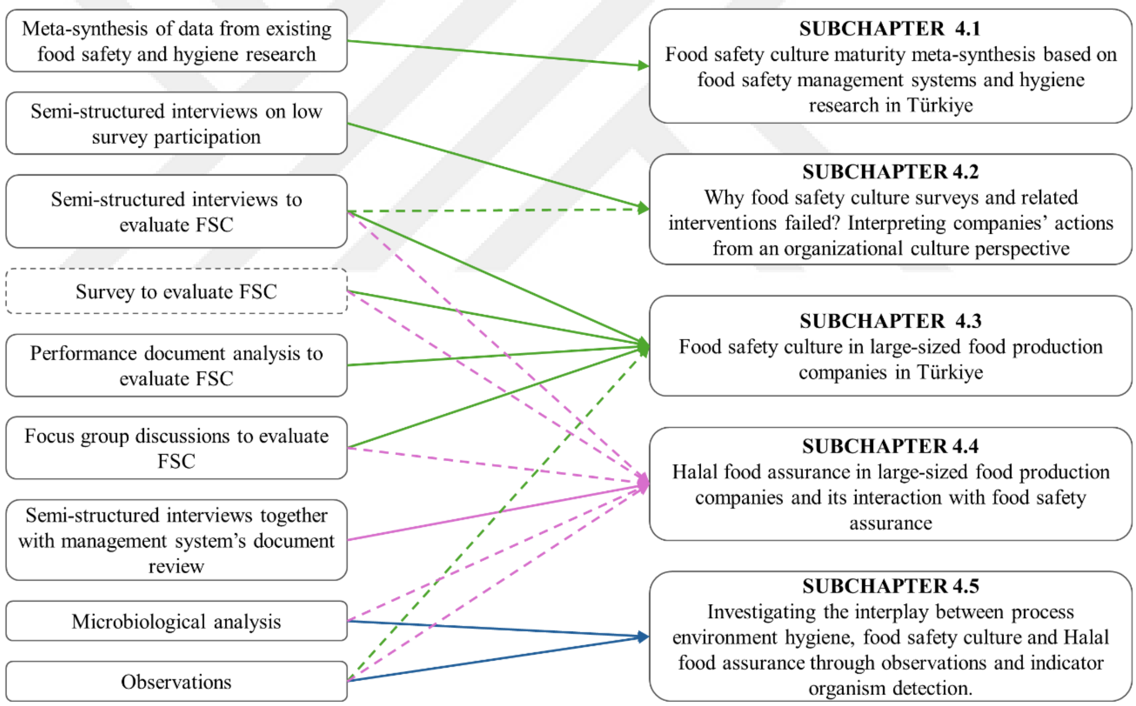


Figure 3.2: Research methodology and their corresponding outputs, as subchapters.

FSC: food safety culture.

Source: Prepared by the researcher.

3.2. Justification of the Methods

3.2.1. Food Safety Culture Evaluation

3.2.1.1. Meta-synthesis of Existing Food Safety and Hygiene Research Data

Meta-synthesis, also referred to as qualitative meta-analysis, is a non-statistical approach, in which data from studies on a topic are combined and analysed to provide novel insights into a phenomenon (Siddaway, Wood & Hedges, 2019; Robson & McCartan, 2016). As FSC, to the best of our knowledge, has not been previously researched in the Turkish food production context, first a meta-synthesis was conducted to set the baseline to companies' possible FSC maturity, using existing food safety and hygiene research conducted in food production companies in Türkiye. Meta-synthesis on FSC maturity, in addition to empirical evaluation, enabled to compare and validate findings in both cases. For instance, if FSC maturity was demonstrated to be high in some dimensions by the meta-synthesis, but not so from empirical findings or vice versa, this would indicate to a need to reevaluate the data analysis in both cases. Additionally, by analyzing existing research from a FSC perspective, meta-synthesis enabled to put forth research gaps in Turkish food safety research in each FSC dimension, accordingly, also helping to shape the FSC related data collection tools of the current research.

3.2.1.2. Food safety culture empirical data collection

To evaluate FSC, method triangulation was chosen, which is a suggested approach for food safety culture evaluation, enhancing rigor and objectivity of the research, as it enables each method´s strengths to complement other´s weaknesses (Zanin et al., 2021; Jespersen & Wallace, 2017; Robson & McCartan, 2016). While a review pointed out that semi-structured interviews are currently the most common methods used in FSC evaluations (Zanin, Stedefelt & Luning, 2021), the method combinations applied in latest FSC research are as follows,

1. monitoring data of Critical control points (CCPs) and internal audits to assess the performance of food safety management systems and food safety climate self-assessment survey of all employees (De Boeck et al., 2019);

2. microbial analysis, participatory observations, card-aided interviews to evaluate enabling conditions, which support or hinder employees executing control tasks, survey including all food employees to assess their knowledge and perceptions, storytelling to assess employees' attitudes and document analysis to assess actual food safety and hygiene practices, microbiological safety performance and equipment maintenance (Nyarugwe et al., 2018);
3. semi-structured interviews, participant observations, check-list to assess work environment, microbiological analysis and survey including all food handlers assessing leadership, communication, commitment, work pressure and normative beliefs, work environment, and management systems (Zanin et al., 2021);
4. Hygiene check-list, knowledge and attitude survey, participatory observations, food safety culture and climate survey including all food handlers (Joomun et al., 2024);
5. Survey including all employees, semi-structure interviews and performance document analysis (Jespersen & Wallace, 2017).

As food safety culture dimensions were first proposed by Jespersen, Griffiths and Wallace (2017), in a study aiming to evaluate existing culture measurement systems and suggest a simple dimensional structure to help unify the food safety culture evaluation field (Jespersen, Griffiths & Wallace, 2017), and that these dimensions (Jespersen et al, 2017) were then adapted by GFSI in preparation of the GFSI Position Paper (GFSI, 2018), becoming the globally accepted approach, this study also used their approach to method triangulation (no 5 of the above method combination's list). Although focus group discussions, which were chosen as the secondary method to compensate for the lack of data from the survey method, were not a part of that combination, it is still a method used in FSC research (Zanin, Stedefelt & Luning, 2021). Finally, as could be seen from the above combinations, observations are also one of the accepted methods in FSC evaluation and would thus help to complement the data collection in the current study.

As the FSC definition emphasizes values, beliefs and norms 'across and throughout companies' (GFSI, 2018), it is important that data would be collected from all the different hierarchical positions of the companies. This was, thus, also considered when choosing methods to evaluate FSC (Figure 3.3). Semi-structured interviews covered managerial staff, like the general/site, maintenance, production and QA managers and a frontline manager, e.g. shift/department head. The survey was meant to cover all the employees, especially the shop floor workers. However, the survey did not offer valid results due to the low participation rates in all companies, except company C5, elaborated on in the next section. Although the semi-structured interview with a frontline shift leader/ department head offered input from the shop floor, an additional method, focus group discussions, was included in the study methodology to gain a more in-depth insight and increase the validity of the results.

Although observations might also have offered FSC related data on this segment, the method was not set up to specifically focus on gaining these insights. As such, while observations were used as the main data collection tool for process environment hygiene, in case observations might have offered insight on FSC, this data was noted down separately. However, since observations had not been initially planned to examine FSC, they were not considered as a valid primary substitute to obtain data on the shop floor workers and focus groups were added to the methodology accordingly.

As for the performance document analysis, it covers the managerial approach of FS and together with this offers insight on FSC maturity as well. Thus, this method gave insight into the actions of the managers (Figure 3.3).

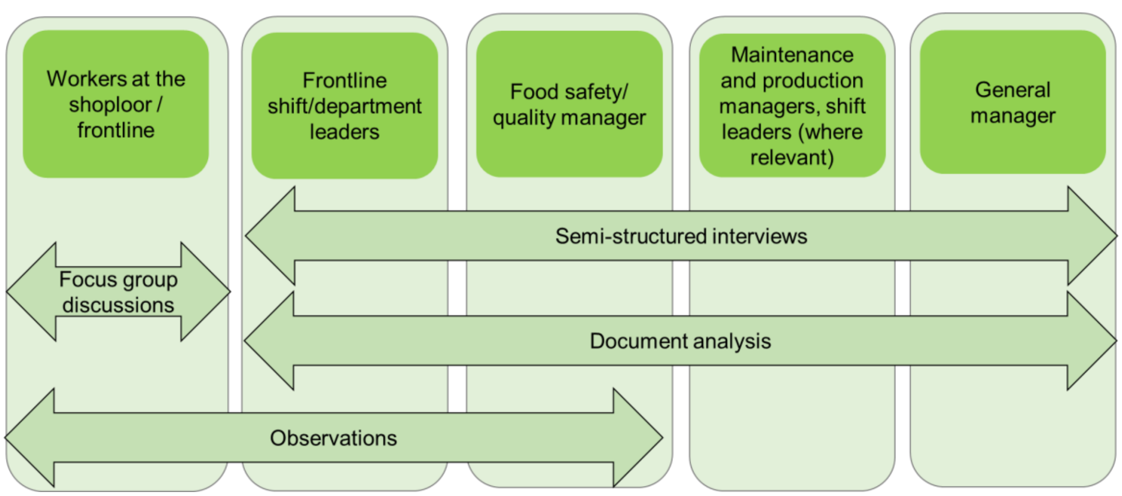


Figure 3.3: The participatory scope of FSC evaluation within companies.

Source: Prepared by the researcher.

3.2.2. Halal food assurance evaluation

Semi-structured interviews enable flexible data collection, suitable for studies investigating a phenomenon, like in this case HFA and its culture (Robson & McCartan, 2016). In addition to using it, as a method to evaluate FSC, like discussed above, it has also been used to evaluate management practices, like allergen management (Dzwolak, 2017) and together with document analysis used to evaluate HFA practices (Wulandari, Sirajuddin & Qui, 2022; Anggi & Rahayu, 2022). As such, document analysis was also used in conjunction with semi-structure interviews in this research. This not only enabled to verify the accuracy of the interview content and probe for further in-depth insights (Robson & McCartan, 2016), but to evaluate the extent Halal food management system is documented.

A 6th company (C6), a multinational enterprise, was included to pilot the semi-structured interview guide, as the company had a stringent internal Halal food standard and management system, demonstrating best practices in the field.

The novel approach of incorporating HFA questions into FSC evaluation methods, facilitated company-wide data collection, in the end enabling to make conclusions of organizational culture aspects related to Halal food assurance and its connection with food safety.

3.2.3. Process environment hygiene

The traditional approach in food safety management to evaluating process environment microbiological hygiene includes sample collection from shop floor surfaces based on different zones, like hygiene zones (high/medium/low), dry/wet production zones, zones based on the proximity to the product (Zone 1 to 4 in ascending order of distance from the product, including food contact and non-contact surfaces), followed by analysis for pathogens and/or indicator organisms (Bourdichon et al., 2021). As this study evaluated process environment hygiene in the context of FSC and HFA, it builds on the traditional approach, by combining it with observations. For a systematic approach to using observations within this context, the use of scenario analysis was explored. Thus, this section defines scenario analysis and justifies its use in both data collection and analysis. Regarding microbiological analysis, for a more effective scenario analysis, it is important to pinpoint food safety risk. Thus, the selection of indicator organisms and the additional application of their enrichment is also justified.

3.2.3.1. Scenario analysis

Scenario analysis is widely used in software design and environment change assessment, with other examples including future of teacher education and ethical issues in recreation research (Robson & McCartan, 2016; Rounsevell & Metzger, 2010). It is a specialist data collection and analysis technique to "*Identify significant events, main actors and their motivations* (note: drivers and relationships) *and are used to explore possible developments in the future* (note: storylines)", (Robson & McCartan, 2016; Rounsevell & Metzger, 2010).

Scenarios are based on key drivers and relationships between them and storylines are their qualitative components used to describe the consequences or outcomes of a scenario (Rounsevell & Metzger, 2010). In the case of food safety assurance, the presence of microbial contamination, behavior and working conditions are the drivers, as these might lead to (various relationships on how) increased food safety risk (storyline of consequences). Relevant literature was used to identify relationships and any additional drives (elaborated in the methods' application section), which guided both observations and the related scenario analysis (Figure 3.4). To properly identify microorganism related drivers, an investigative sampling approach was used, together with analyzing samples for multiple indicator organisms for their presence. The data collected on drivers, together with knowledge of their relationships, enabled to connect the drivers and construct storylines of food safety risk.

This approach to process environment sampling and data analysis also enabled to gain insight to post-process contamination potential. Post-process contamination, also referred to as recontamination, is an important causative factor in foodborne outbreaks. It is the final product contamination from the processing environment after the kill step to eliminate pathogens with no subsequent pathogen elimination step (ICMSF, 2018; 3M & Cornell University, 2019; Mota et al., 2021; Kornacki, 2010). As such, this approach enabled to identify routes, through which the final products might get contaminated and aspects increasing this risk.

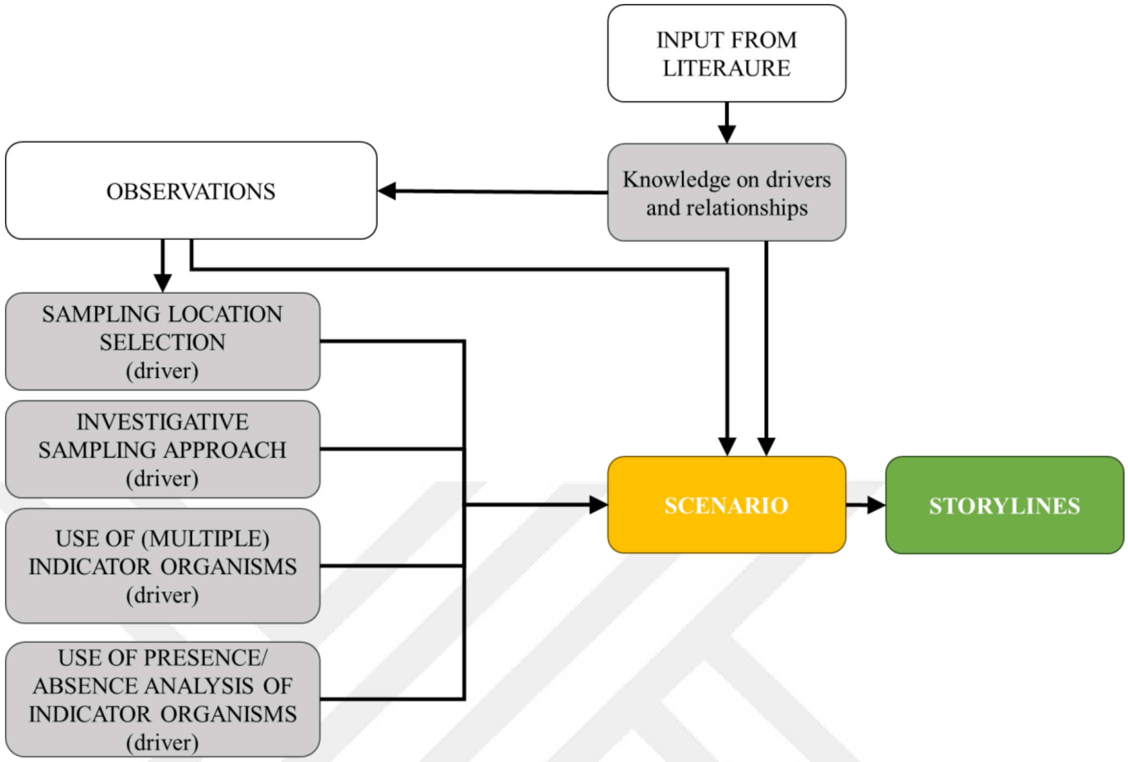


Figure 3.4: Process environment hygiene evaluation approach.

Source: Prepared by the researcher.

Regarding HFA, as food safety and hygiene are closely tied with it, the scenario analysis approach enabled to give insight into both hygiene practices and microbiological risk in a Halal food-certified setting. Additionally, as fecal contamination in the HFA context would mean contamination with an unwanted substance (Neio Demirci, Soon & Wallace, 2016; Lestari et al., 2023; Raheem & Neio Demirci, 2018), observations enabled to pinpoint its possibilities. Although this study used multiple indicator organisms, including *E. coli*, which is currently the best option for this purpose, it does not explicitly indicate fecal contamination (da Silva et al., 2019). Thus, observations enabled to more accurately interpret positive *E. coli* results. For instance, its presence right after using the toilet would indicate a high probability of the contamination being of fecal origin.

3.2.3.2. Selection of indicator organisms

Analysis of both indicator organisms and pathogens might be used by companies to evaluate process environment hygiene (Bourdichon et al., 2021). '*Indicator organisms are the organisms used as a sign of quality or hygienic status in food, water, or the* *environment*', (Batt & Tortorello, 2014). This section justifies the selection behind analyzing the process environment microbiological samples for multiple indicator organisms, instead of pathogens or just one or two specific indicator organisms.

Pathogen sampling is considered as a useful tool to evaluate product safety. However, if pathogens are not detected in a specific location, at a specific time, it does not mean that they are not in the production environment. It just means that the higher the number of negative samples, the higher the probability that pathogens are not present in the production environment (ICMSF, 2011). Furthermore, since the prevalence of pathogens in the production environment in general is low, measuring them will not give detailed enough data to decide upon the microbiological performance of the production environment, including possible contamination sources and its overall hygienic condition (Bourdichon et al., 2021; Zwietering et al., 2016; 3M & Cornell University, 2019; Nascimento et al., 2015). For example, Zacharski, et al., (2018) detected neither Listeria spp. nor Salmonella during 2 years of taking up to 3468 samples from the process environment of a dairy products´ production facility (Zacharski, 2018). Thus, indicator organisms will be focused on in this study.

Recent research shows that *Enterobacteriaceae* (EB), in addition to having greater resistance to environmental conditions, also compasses a broader range of microorganisms, including some pathogens, compared to coliforms. This makes EB a more effective indicator for post-process contamination (Baylis et al., 2011; Martin et al., 2016; Tortorello, 2003). The European Union´s legislation EC No 2073/2005 on microbiological criteria for food also uses EB instead of coliforms to indicate process hygiene (European Commission, 2005). It has also proven useful in identifying contamination sources in the processing environment compared to other indicators, like coliforms and thermotolerant coliforms (Nascimento et al., 2015). Despite this, both EB and coliforms are still used in different countries and sectors as hygiene indicators for process monitoring (Craven et al., 2021; 3M & Cornell University, 2019). For example, from the literature review in Chapter 2 on the studies conducted in Türkiye, it became apparent that the studies focusing on process environment hygiene, used a selection of

EB, coliforms, thermotolerant coliform (ttCF) (referred to in the studies with the out-dated term faecal coliforms) and *E. coli*.

Thus, this study used *Enterobacteriaceae,* coliforms, thermotolerant coliforms and *E. coli* as indicator organisms, which further enabled the following,

- to validate the results. For instance, if *E. coli* is present, the other indicator groups should be as well. If *Enterobacteriaceae* is absent the other groups should be as well.
- to better understand the profile of the contamination. For instance, having all the groups present indicates the presence of a higher variety of microorganisms and possibly to a wider extent in contamination and with that higher food safety risk.
- to identify fecal contamination with a higher probability, as *E. coli* is currently the best option for this purpose (da Silva, et al., 2019).

3.2.3.3. Use of indicator organism enrichment

After swabbing the surfaces in the processing environment, samples are either directly analyzed (also referred to in this study as the count conditions or enumeration) or subjected to enrichment, which provides appropriate conditions for sub-lethally injured or viable but nonculturable microorganisms allowing their repair and recovery or in other words their resuscitation, after which they could proliferate (Mackey, 2014). In this case, instead of a quantitative cell count, a present/absent result is obtained. While enrichment is common for pathogen analysis, directly analyzing the sample is so for indicator organism analysis. However, this study expands on the existing literature and analytical methods, developing an analysis protocol for indicator organism enrichment and applying this approach in addition to direct sample analysis (count conditions), as this approach, together with observations, enabled to more accurately identify microorganism related risks as drivers and combine these with relationships in the scenario analysis. For instance, the presence of both microorganisms (driver obtained through laboratory analysis) and favorable conditions (driver obtained through observations), like residual moisture, in the process environment might lead to microorganism resuscitation and growth (relationship), increasing food safety related risks (storyline).

Other reasons justifying indicator organism enrichment are as follows:

1. Injured microorganisms cause concern for food safety not just because they are hard to detect, but also that under favorable conditions (e.g. residual moisture) they can resuscitate and start functioning normally being capable of causing disease (Taneja, Kaushik & Juneja, 2023; Wu, 2008). For example, the indicator organism, *Enterobacteriaceae,* is able to survive in low-moisture conditions for an extended time and might resuscitate and even proliferate under favorable conditions within the production environment (Gurtler, Doyle & Kornacki, 2014; Finn et al., 2013; Wu, 2008).

2. Mossel (1985) himself' the author of the Violet Red Bile Glucose (VRBG) and Violet Red Bile Lactose (VRBL) agars to evaluate *Enterobacteriaceae* and *coliforms*, directly stated that *"Obviously these media should never be used immediately"*, emphasizing that *Enterobacteriaceae* and *coliforms*, as a rule, have been injured and as a result have difficulty growing under selective conditions that these media provide (in other words the currently used widespread pour-plate methods), needing resuscitation beforehand (Mossel, 1985). It has again been emphasized by Wu (2008), that, interestingly, many commonly used microbiological analysis methods do not include the resuscitation step, which might lead to false-negatives and the underestimation of the contamination rate (Mossel, 1985; de Boer, 1998; Wu, 2008).

3. The generally accepted approach for indicator organism analysis in the food production setting might not serve the aim to identify and prevent risk. For instance, Baylis et al. (2011) elaborated that enumeration methods (count conditions) are prevalent, because food companies include microbiological limits in their product and/or raw material specifications, thus needing quantifiable results (Baylis et al., 2011). Food companies might set these limits, however, if the analytical methodology used is not sensitive enough, this will lead to false-negatives and/or underestimating the microbiological load. For example, the EC 2073/2005 regulation has set the limits for the food groups using the *Enterobacteriaceae* colony-count method between 10 to 100 cfu/g or ml (Figure 3.5), however the ISO21528-2 (for detection) standard clearly states that the *"Technique is intended to be used when the number of colonies sought is expected to be more than 100 per millilitre or per gram of the test sample"*. As such, the suggested analysis method does

not match the sensitivity dictated by the regulatory limits. The situation demonstrated inconsistencies, which could lead to deficiencies in microbiological process control in food production facilities. A similar situation was also reported by Jozic et al. (2019) for bathwater, where due to changes in the reference method, it was recommended to be used for samples with bacterial numbers well below the limits suggested in the European directive, leading the author to question the use of the method under the scope of the directive (Jozić et al., 2019; European Union, 2006). Thus, the currently suggested enumeration methods might not be sensitive enough to properly identify food safety risk.

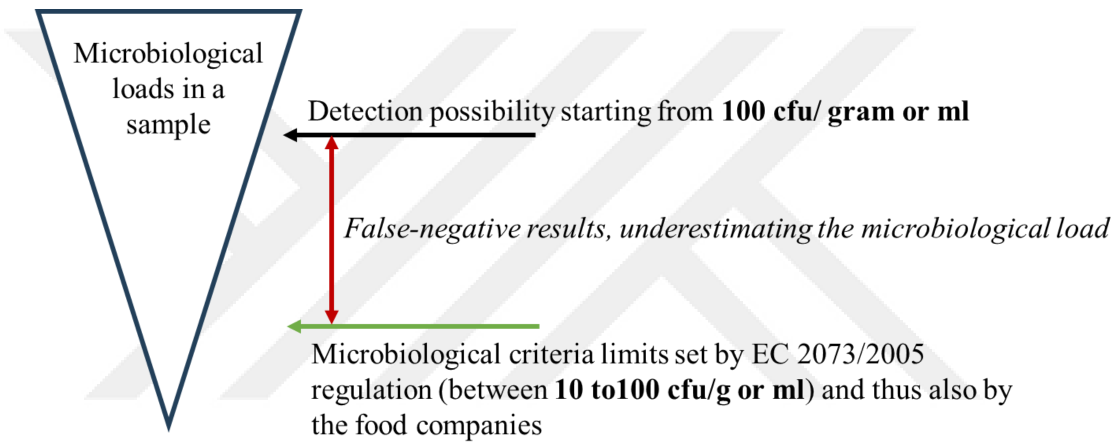


Figure 3.5: The inconsistencies in EC 2073/2005 regulation between microbiological criteria and method detection limits. cfu: colony forming units.

Source: Prepared by the researcher based on ISO, 2017; European Commission, 2015.

4. Indicator organisms’ enrichment is already discussed in existing literature and included in validated methods:

The European Union´s legislation EC No 2073/2005 on microbiological criteria for food suggests ISO21528-2 as a reference method to analyze *Enterobacteriaceae* for process hygiene control, which is a colony-count or in other words enumeration technique. Only for food groups meant for infant consumption, the regulation prescribes ISO21528-1 for the detection of EB (Table 3.1) (European Commission, 2005). Thus, the more sensitive detection methods giving the presence/absence results, are commonly prescribed for high-risk foods (Baylis et al., 2011).

Regarding *E. coli*, the EC No 2073/2005 suggests either ISO16649-1 or 2 as reference methods for all the food groups, except fishery products for which part 3 of the standard is suggested (Table 3.1). It writes in the introduction of the standards that ISO16649-1 and 3 should be preferred, in case the sample is suspected to contain injured cells. Methods in Part 1 and 3 include resuscitation steps in a non-selective agar, while Part 2 includes an optional resuscitation step during incubation in the Tryptone-Bile-X-Glucuronate (TBX) agar (Table 3.1). For example, the Public Health England standard for enumerating the *E. coli* with the TBX medium basing their approach on the ISO16649-2 standard, for consistency, made the above-mentioned resuscitation obligatory (Public Health England, 2014).

Furthermore, a study showed significantly higher numbers of *E. coli* obtained with the Part 3 method, using the 24-hour resuscitation/enrichment in a non-selective media, compared to Part 2 (Table 3.1), which uses direct plating and incubating at both 37^{o}C and 44 ^{o}C (Rubini et al., 2023). This shows that if low counts or injured cells of *E. coli* are expected to be present and the aim is to detect its presence/absence, the enrichment approach should be preferred.

Table 3.1: Details for microbiological analysis methods, food groups and regulatory limits specified in regulation EC No 2073,

Method name	**Method details**			**Food groups (limits) Source:** European Commission, 2005
	Part	**Analysis approach**	**Analysis protocol**	
ISO 21528 -Horizontal method for the detection and enumeration of *Enterobacteriaceae* Colony-count technique (ISO, 2017)	Part 1 – Detection of *Enterobacteriaceae*	Enrichment	- Enrichment in BPW - Incubation 37^{o}C ± 1 ^{o}C for 18 ± 2h - streak of loopful on the VRBG agar	Dried infant formula, follow-up formula and dried dietary foods for special medical purposes intended for infants below six months of age (Not detected in 10g of sample)
	Part 2 – Colony-count technique	Detection	- Direct plating of the sample on VRBG agar	-Carcasses - Pasteurized liquid dairy products (-10 cfu/ml) - Milk and whey powder, ice Cream and frozen dairy desserts, egg products (10-100 cfu/g or ml)
ISO16649:2001 - Horizontal method for the enumeration of beta - glucuronidase positive *Escherichia coli* (ISO, 2015)	Part 1 - Colony-count technique at 44 ° C using membranes and 5-bromo-4-chloro-3-indolyl beta-D-glucuronide	Enumeration with resuscitation	- Resuscitation in minerals modified glutamate agar. - Incubation 4 ± 1h at 37^{o}C - place membrane on TBX agar and incubate	- Minced meat, mechanically separated meat (50-500 cfu/g) - Meat preparations (500 to 5000 cfu/g or cm2) - Cheese from milk or whey which has undergone heat treatment, butter, cream, precut fruits and
	Part 2 - Colony-count technique at 44 degrees C using 5-bromo-4-chloro-	Enumeration with possible resuscitation	- Direct plating of the sample on TBX agar	

	3-indolyl beta-D-glucuronide	during incubation	- If stressed are suspected, incubation for 4±1h at 37 ºC, followed by 44 ºC for 21±3h	vegetables, unpasteurized fruit and vegetable juices (100-1000cfu/g)
	Part 3 - Detection and Most Probable Number Technique Using 5-Bromo-4-Chloro-3-Indolyl-ß-D-Glucuronide	Detection with enrichment – 1 tube	- Resuscitation in minerals modified glutamate agar. - Incubation 24 ± 2h at 37±1 ºC - streak with a loop on TBX agar	Shelled and shucked products of cooked crustaceans and molluscan shellfish (1-10 MPN/g)
		Enumeration with enrichment – 3 to 5 tubes		

VRBG agar: violet red bile glucose agar; TBX agar: tryptone Bile X-glucuronide agar.

The Bacteriological Analytical Manual published by the FDA, among other sources (da Silva et al., 2019; FDA, 2023), also suggest using resuscitation if necessary for the coliform colony-count method, yet again, leaving the decision to the food production companies. The question is whether food production companies have enough competency to make this decision. Companies with a low FSC maturity, might doubt the need for microorganism testing at all (3M & Cornell University, 2019) or prefer not to obtain positives, being biased toward the method giving lower counts. For instance, in the investigation of an outbreak caused by Peanut Corporation of America in 2009, sickening 691 and killing 46 people, it was found that the company retested samples to get a negative result for *Salmonella* spp. (Powell, Jacob & Chapman, 2011). Companies might also choose the method according to price, availability of consumables or previous experience with a particular method and with that ultimately leading to questionable microbiological process control results.

3.2.3.4. Investigative sampling

Routine sampling, where results might be tied to key performance indicators (KPI) or trend analysis, requires comparable bacterial counts and with that a standard area to be swabbed. As it is important to identify microbiological risk as a driver in the scenario analysis context, the current study takes an investigation sampling approach, in which case larger and/or irregular surfaces are used to identify problematic areas (Bourdichon et al., 2021; Kornacki, 2010). In this case, the results should be presented as detected/not detected per swab, instead of CFU per cm^2 (Public Health England, 2017).

3.3. Application of Methods

3.3.1. Company Recruitment

Initial criteria for company selection were as follows,

- having a Halal food certificate and being a medium (50-250 workers)/large (over 250 workers) sized company (KOSGEB, 2023), to enable comparison of the companies;
- being located in or near the Istanbul province of the Marmara region in Turkey, to enable face-to-face data collection from the companies.

Companies were found through Halal certification bodies' webpages, which had lists of their Halal certified companies, OIC Halal Expo and personal network. First, the background and purpose of the study was explained to the companies´ representatives by phone, through an online meeting or visiting the company on-site. These representatives included the quality manager and/or chief, general manager and/or factory manager and/or an employee from human resources.

In the end, purposive convenience sampling was used, and 5 large-sized food production companies were chosen, based on companies´ willingness/possibilities to participate and to allocate enough time in their work schedules for the research activities. The 6th company (C6) was a multinational enterprise, which was included (Table 3.2) for piloting the Halal food assurance semi-structured interview method, as the company had a stringent internal Halal food standard and management systems. The results were also used in Subchapter 4.4 as a benchmark for comparison of companies' Halal food assurance practices.

The production facilities were in the Marmara and Ege regions of Türkiye and from various food sectors, including meat, poultry, confectionary, powder and baked goods. The significance of the sample in the Turkish context reflects from three companies being among the biggest food production companies in Türkiye (ISO500, 2023), in addition to one of the companies being a public company, offering a strong foundation for the multiple case study approach on making theoretical generalizations.

After obtaining the agreement from companies to participate, the authorized signatories signed the informed consent form on behalf of the company, followed by signing multilateral non-disclosure agreement (NDA). As this study used a previously validated

FSC survey (Jespersen et al., 2016; Jespersen, MacLaurin & Vlerick, 2017), which is the private property of Dr Jespersen, she provided the NDA (as her company property, an example was not shared in the Appendix) and was one of the signees, together with Istanbul Sabahattin Zaim and the participating companies´ representatives. Within the scope of this agreement, two parties, Dr Jespersen and the companies, disclosed confidential information and all three parties were responsible for protecting it. To make sure the identities of the companies would not be revealed, their names and some details were not elaborated on, in addition to not adding the NDAs to the appendix of this study.

Data was collected between November 2022 and July 2024. According to the extent of companies´ willingness to participate the type of data was collected as shown in Table 3.2. Companies were given abbreviations C1-C6, which will the used throughout the rest of the study. Exceptions to applying all the planned methods were in C2 and C4. Microbiological analysis could not be conducted, and semi-structure interviews were conducted online in C2 due to travel constraints. Performance document analysis could not be conducted in C4 due to structural changes in the company preventing them from sharing their documented data. Focus group discussions could also not be conducted in C4, as by the time it was decided to incorporate these among research activities, structural changes at the company had started preventing us from conducting any additional data collection. Despite this, the semi-structured interviews with the shift leader and maintenance manager who are both frontline leaders, will still be enable to obtain insights from the frontline. Focus group discussions were not conducted in C5, as the survey participation rates were the satisfactory threshold.

Table 3.2: Participating companies and the type of data collected from them,

Data collection	C1	C2	C3	C4	C5	C6
Food safety culture						
Semi-structure interviews	+	+*	+	+	+	-
Food safety culture survey	+	+	+	+	+	-
Performance document analyses	+	+	+	-	+	-
Focus group discussions	+	+	+	-	-	-
Semi-structured interviews on low survey participation (online)	+	+	+	+	+	-
Halal food assurance						
Semi-structures interviews, together with management system's document review	+	+*	+	+	+	+
Microbiological hygiene						
Observations	+	+	+	+	+	-
Microbiological analyses	+	-	+	+	+	-

*: data collection took place online; +/-: Applied/ not applied; C1-6: participating company codes; **Source**: Prepared by the researcher.

3.3.2. Food safety culture evaluation

3.3.2.1. Meta-synthesis of existing food safety and hygiene research data

Studies on food safety and hygiene in food production companies in Türkiye were collected, based on the criteria described in section 2.2. Descriptions of FSC dimensions and their maturity stages in GFSI´s FSC *Position Paper* and Jespersen et al. (2019)'s work (GFSI, 2018; Jespersen et al., 2019) were used to compare the content of the data collected from the studies, enabling to group this data under relevant FSC dimensions. Jespersen et al., (2019)'s FSC maturity model is also brought out in Appendix 9. Then, the data under each dimension was compared with each other, putting forth their similarities and differences, and with the descriptions of FSC maturity stages, ultimately, enabling to make conclusion on the FSC maturity stages regarding each dimension.

3.3.2.2. Semi-structured interviews and focus group discussions

Guides for semi-structured interviews (Appendix 1) and focus group discussions (Appendix 2) were constructed based on literature (Jespersen et al., 2016; Jespersen et al., 2019; GFSI, 2018) and the initial insights and research gaps put forth by food safety studies' meta-synthesis, presented in Subchapter 4.1. These guides also included additional questions regarding Halal food assurance on whether and how Halal food certification has had an impact on participants' work, like

1. Do you need to pay attention to anything regarding halal food?
2. Have you been involved in the halal certification process in any way?

This is how these semi-structured interviews and focus group discussions relate to the data collection on HFA and is thus one of the novel parts of this work.

Interviews were conducted face-to-face with only the interviewer and the interviewee(s) present. The participants at each company are specified in Table 3.3. In one company, the interviews were conducted online through Microsoft Teams. In the three biggest companies (C2, C4 and C5) the GM was either unavailable or not easily reachable to organize an interview. As companies had different structures and sizes, positions interviewed varied. For instance, while C1, C3 and C4 only had a quality assurance (QA) department, additionally C2 and C5 had separate departments/positions, in which people were specifically responsible for quality management systems. In this study, the latter were referred to as quality management assurance (QMA) responsibles.

Permission was obtained to record the interview. Interviews lasted between 45-75 minutes.

Table 3.3: Participants of the semi-structured interviews,

Position	**C1**	**C2**	**C3**	**C4**	**C5**
General manager (GM)	+	-	+	-	-
Operations director (OD)					+
Factory/site manager (FM)				+	
Production manager (PM)	+	+	+	+	+
Quality and research and development (R&D) manager	+	+		+	+
Quality manager/ chief (QM/QC)			+	+	
Quality management assurance (QMA) responsible	+	+			+
Shift manager (SM)	+	+		+	
Technical/maintenance manager (TM)	+	+	+	+	+

Grey colour: positions do not exist in these companies; '-': position exists, but it was not possible to conduct interviews with that position.
Source: Prepared by the researcher.

While two companies were able to organize a focus group discussion in a group, the third company organized short 15-20 minutes separate interviews with the relevant staff, as they were not able to separate a group of workers all at once, without causing issues in the production process (Table 3.4).

Table 3.4: Focus group discussion participatory details,

C1	C2	C3
1 group discussion – 8 participants, including frontline staff, supervisors and technicians.	3 focus group discussions, with department operators, team leaders and line workers	5 individual interviews, including frontline staff and supervisors

C1, 2, 3: participating company codes.
Source: Prepared by the researcher.

3.3.2.3. Company performance document analysis

A general list with topics on both FSC and Halal food management was created (Appendix 3) and shared with the companies, according to which the company representatives could identify the types of documents the company owned, relevant to the topics, and discussions that they were willing to share. Companies sent electronic copies of relevant documents or in case they were not willing to share these directly, documents were reviewed on-site.

3.3.2.4. Data analysis of semi-structured interviews, focus group discussions and performance documents

Based on the guidance of FSC maturity model v2 (Jespersen et al., 2019) and GFSI's *Position Paper* (GFSI, 2018), data from semi-structure interviews, focus group discussions and performance documents, offering insights into FSC dimensions, Value and mission, People system, Adaptability, Consistency and Risks and hazards, indicating to values, belief and norms were collected under these dimension headings into a Word document (Figure 3.6, step 1) (Appendix 7).

Afterwards, data under the same dimensions was combined (Figure 3.6, step 2), which enabled to put forth the similarities and differences between companies (Appendix 8). This data was compared against food safety culture maturity model version 2 (Jespersen et al., 2019) (also reproduced in Appendix 9) and Competency Model's stages (as discussed below) to make inferences on companies' FSC maturity discussed in Subchapter 4.3.

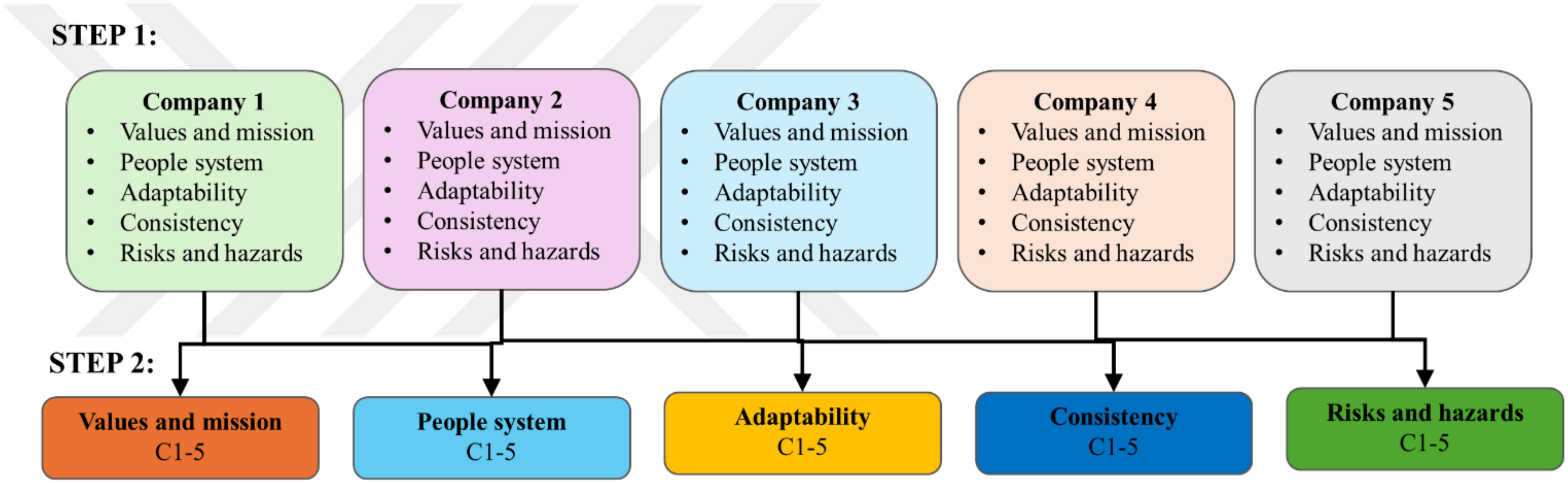


Figure 3.6: Food safety culture data evaluation steps. C1-5: participating company codes.

Source: Prepared by the researcher.

As the FSC maturity model describes a progressive improvement of beliefs, values and norms towards a learning culture specific to food safety (Jespersen et al., 2019; GFSI, 2018; The British Standards Institution, 2023), it is a learning process in itself and could thus also be interpretable through the Competence Model, which was discussed in detail in Chapter 2, section 2.3.2. Although not mentioned explicitly, the model is also embedded into the GFSI Position Paper, as it highlights the need to look for evidence of "unconscious competence" (stage 4 of the Competence Model) to judge food safety´s value for the company (GFSI, 2018, p. 53).

Thus, to simplify making inferences on FSC maturity stages, this study suggests a novel approach to FSC data analysis based on the Competence Model. It offers a set of principles to guide decision making on culture related findings, regarding both food safety and Halal food assurance. While the literature review (Chapter 2, section 2.3.2.) described how values, beliefs and norms are formed in companies from the Competence Model perspective (Figure 3.7. yellow arrows), its stages could also be used in alignment with the FSC maturity stages 1-5 (Figure 3.7, green arrows). Namely, the 'consciously incompetent' stage demonstrates the start of learning, which could also reflect organizational learning. This is in line with the 'Know' stage 3 of FSC maturity, as companies become aware of the need to change and start identifying and implementing more effective, long-term solutions. For instance, the norms, values and beliefs below describe the different learning processes companies could go through in maturing their FSC (GFSI, 2018; Jespersen et al., 2019; Alliance to Stop Foodborne Illness, 2023),

- that senior management being involved for more than problem solving (e.g. messaging, role modelling, Gemba walks) (Values and mission dimension);
- that QA/QMA being a mediator/coach, rather than a governance body, rewarding and recognizing desired behaviors at different levels, like daily, monthly, quarterly, annually and all departments contributing to FS, including support functions, in addition to QA/QMA and production (People system dimension);
- involving the frontline in problem solving and making improvements and using change management strategies (Adaptability dimension).
- obtaining data from both leading and lagging indicators to improve company practices (Consistency dimension);

- routinely verifying hazard awareness to determine the risks behind daily practices (Risks and hazards dimension).

FSC maturity stage 3 being in line with the Competence Model stage 2, leaves FSC stages 1 and 2 aligned with the Competence Model stage 1, unconsciously incompetent. To interpret FSC stages 1 and 2 in this context, the confidence and understanding matrix described in the GFSI *Position Paper* could be used (GFSI, 2018). For instance, the company having low understanding, but high confidence in their current state and solutions would describe the 'Doubt', stage 1 of FSC maturity, which prevents the start of the learning process altogether, while a 'lower' confidence, described by Toman Chamorro-Premuzic in the *Harvard Business Review Emotional Intelligence* series, would lead to more open-to-learning mindset (Chamorro-Premuzic, 2019). While the latter would enable transition from being unconsciously incompetent (stage 1 of the Competence Model) to consciously incompetent (stage 2 of the Competence Model) upon raising awareness, the former would prevent that.

Furthermore, this progress in awareness and practices might be made at a personal level, but to do that at the organizational level, it is important to engage a critical mass of employees (Anderson & Ackerman Anderson, 2010). Thus, when analyzing FSC evaluation data, it is important to distinguish between individual and company-wide learning to pinpoint the actual stage of FSC maturity. To do this, it is important to collect data from different positions across the company, which was discussed above under the methods' justification section. Namely, if data from different positions demonstrates different values, beliefs and norms, it could be inferred that these reflect personal learning, rather than organizational. On the opposite, similar reports from different positions would indicate to values, beliefs and norms at an organizational level.

FSC maturity stage intervals, like 1-2 and 2-3, 3-4, 4-5, in addition to whole numbers, like 1, 2, 3, 4 and 5 were used. This kind of presentation of the results also enabled to better rank the companies and through that highlight maturity stage differences when comparing companies. When calculating the overall score for a dimension, the averages of intervals were used.

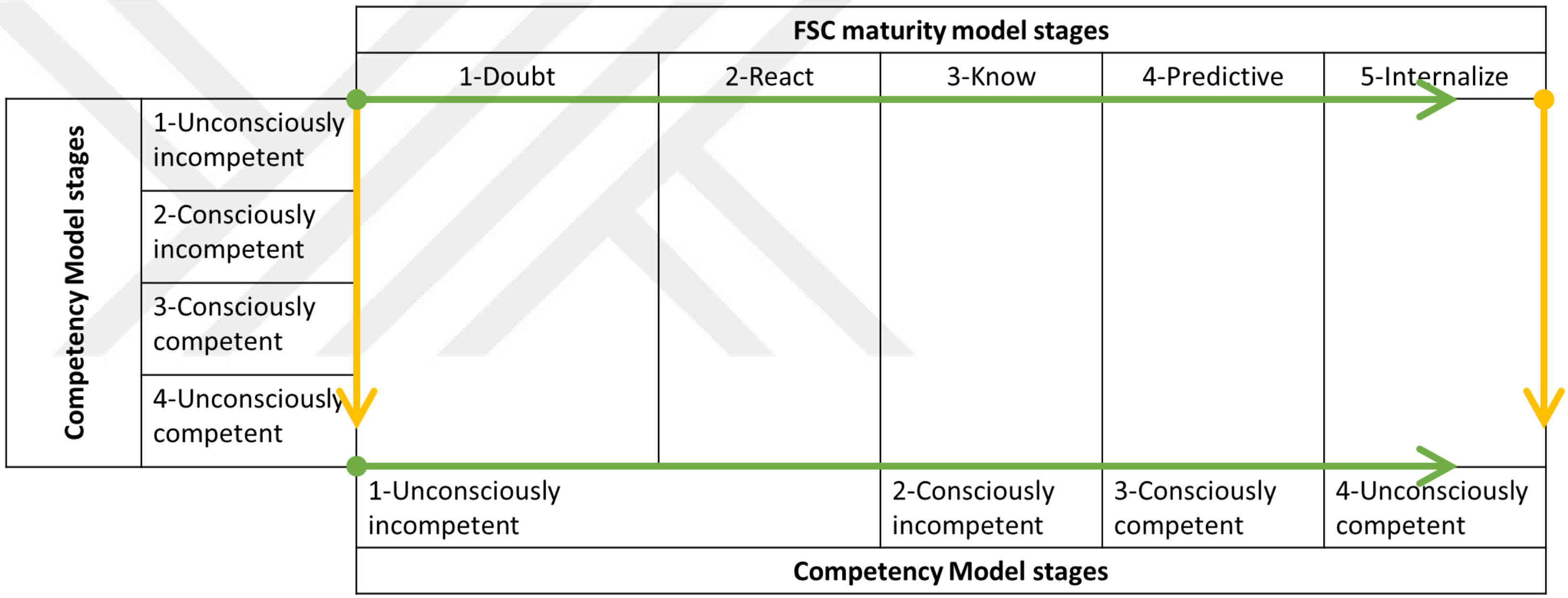


Figure 3.7: FSC maturity stages in line with their corresponding Competence Model stages. FSC: food safety culture; Yellow arrows: formation of organizational norms; Green arrows: maturation of FSC.

Source: Prepared by the researcher.

3.3.2.5. Survey

Jespersen et al., (2016), using an approach of pin-pointed behaviors, developed and validated a FSC survey (Jespersen et al., 2016). She kindly gave permission to use the most up to date version of the survey questions, on the condition that they would remain confidential (Jespersen et al., 2016; Jespersen et al., 2019; GFSI, 2018). Some examples of the original FSC evaluation statements are as follows,

- I immediately remove food safety issues by myself to avoid negative consequences for my team and myself (People system dimension, stage 1 maturity).
- I always have to manage negative consequences when a food safety problem occurs (People system dimension, stage 1 maturity).
- I take action daily to let anybody know when they go over and beyond for food safety (People system dimension, stage 5 maturity).
- I minimum monthly check in with functional - and business leaders to ensure food safety is built into their business plans (People system dimension, stage 5 maturity) (Jespersen et al., 2016).

The survey consisted of 3 sections:

1. Participant demographic data, including questions on age, education, work experience, nationality and perception of Halal certification and production (Appendix 4). The latter is how the survey relates to the data collection on HFA and is thus one of the novel parts of this work. The additional questions regarding Halal were as follows,
    - Does your company have a Halal certificate?
    - In your opinion, does your company produce Halal food products?
2. FSC evaluation statements using a 5-point Likert scale, with each point in the scale representing a maturity stage, e.g., 1 is equal to the doubt stage and 5 to the internalize stage in the FSC maturity model. The work around formulating the survey statements is based on determining pin-point behaviors characteristic for maturity stage 5.
3. Social desirability statements using a 5-point Likert scale, (1) Not at all like me, (2) Not like me, (3) Neutral, (4) Like me, (5) Just like me, which are used to modify the FSC maturity score obtained through statements in the second section. These quantify the tendency of employees to answer questions in a way that will be

viewed favorable by others or in other words the degree to which employees put their words into action (Jespersen, MacLaurin & Vlerick, 2017).

The survey was set up electronically using Microsoft Forms, which could be accessed by participants through computers or mobile phones using an internet link or QR code. The links and QR codes were shared with companies´ food safety/quality responsible who in turn shared these with the rest of the staff. A survey introduction text was also shared with the food safety/quality responsible, which they could use in their communications regarding the survey with the rest of the company. They were encouraged to send out emails and messages within the company to communicate the survey, to print posters with QR codes and hang them in areas with high staff movement and include other managers to both support with the survey execution and communicate it to their teams. The targeted participation rate of the survey was 60% of all the workers in a company, including 60% participation rate of all the departments of the company.

Before starting the surveys in the companies, their food safety/quality responsible of each company reviewed the survey statements of whether these were clearly understandable. This review step was also requested by the companies to verify that the content of the survey was suitable for them.

Survey data was analysed by obtaining the Excel output from Microsoft Forms, modifying its format according to Dr Lone Jespersen´s team´s feedback and forwarding it to them for analysis. The Jespersen et al. (2016) method is used commercially with large numbers of companies and so has a proprietary program/algorithm to analyse the results. As part of the collaboration, it was agreed that the results would be put through this standard analysis program/algorithm, which also considers section 3 of the survey on social desirability.

a) Pilot of the translation

All the sections were translated into Turkish and back translated to English. Back-translations of sections 2 and 3 were reviewed by Dr Jespersen´s team, that there would not be a loss in meaning. Finally, the questions and statements were modified where necessary according to their feedback.

The Turkish translation of the survey was also pilot tested in 4 micro companies, with 2 to 15 employees, during which the researcher was in the same area enabling the respondents to ask questions, request clarifications and provide feedback. As a result, slight Turkish language modifications were made.

Jespersen et al. (2017) published section 3 of the survey as a separate study on social desirability and its impact on participants' replies in a FSC related survey, including all the survey questions of this part of the survey (Jespersen, MacLaurin & Vlerick, 2017). The Turkish translations used in this study are brought out in Appendix 5, in case future research in Türkiye would like to benefit from them.

During pilot testing of translations, it also became apparent that when the respondents "did not know" whether a certain pin-pointed behaviour was applicable for their company, they chose the 3rd option of "Neither agree of disagree", which on the other hand represents the 3rd maturity stage. This kind of choice, in turn, leads to a higher maturity score, because if a respondent is "not aware" of a certain pin-pointed behavior this indicates to the doubt stage in the FSC maturity model or in other words to (1) on the Likert scale. Thus, together with Dr Jespersen, it was decided that it would be appropriate to have the point (1) of "Strongly disagree" on the Likert scale supplemented with "I do not know", resulting in the option of "Strongly disagree/ I do not know" under point (1). Furthermore, a previous study using the same survey highlighted that the survey led to more mature FSC results, compared to semi-structured interviews (Jespersen & Wallace, 2017). Thus, this study also explored whether this modification might impact the gap between the survey and interview results, since upon "not being aware of statement" the participants should choose (1) instead of (3), leading to a lower score.

3.3.3. Exploring low survey participation rates

3.3.3.1. Participation rates

In all 5 companies (8 factories) total survey participation rates were below the targeted 60% threshold, ranging between 6-53% (Table 3.5). The participation rates are also presented in separate categories, including Quality Assurance (QA) and R&D, frontline teams, and other support functions (OSF). The latter two could be described as follows:

Frontline teams - workers, who´s everyday work takes place on the shop floor, like production, maintenance and cleaning;

Other support functions (OSF) - supporting departments, whose everyday work does not take place on the shop floor, including departments like storage, logistics, distribution, planning, purchasing, H&R, finance.

Table 3.5: Food safety culture survey participation rates,

Company no	**C1**	**C2**	**C3**	**C4**	**C5**
Frontline teams, %	2	7	19	19	62
Other support functions (OSF), %	11	43	24	37	34
QA, R&D, %	43	75	65	100	90
Total participation, %	6	15	24	26	53

C1-5: participating company codes; QA: quality assurance department; R&D: research and development department.
Source: Prepared by the researcher.

C5 had the highest total (53%) and frontline (62%) participation rates, with the latter being the only category to exceed the 60% participation threshold compared to all the other companies. However, the company did not reach this goal in OSF (34%) and total participation rates (53%). C1-4, being far from the participation threshold, the frontline participation rates were as low as 20%. C1 had the lowest participation rates in all categories, with even less than 50% of the QA team participating (Table 3.5).

3.3.3.2. Intervention

Companies with low participation rates were offered to conduct the survey again, after modifications to their organizational approach. These modifications were determined using Dr Lone Jespersen and Prof Dr Carol A. Wallace expert advice:

1. Organize a meeting with both the general manager (GM) and quality manager (QM) to explain:
    - the importance of the survey with regards to collecting data from the frontline.
    - getting the GM involved together with other managers to communicate the survey.
2. Share a draft communication plan which was translated into Turkish (private property of Dr Lone Jespersen and thus not attached to the thesis), giving a tangible example of expected communication routes.

These suggestions were shared with C1, 2 and 3 via online or face-to-face meetings. C4 was excluded since the QM left the company, due to which the company was unable to participate in the project any further. In the end, all three QMs did not go forward with the suggestions and thus an additional round of the survey was not possible. Thus, due to low participation rates, the validity of the data gained from the surveys remained questionable and was not included in the FSC results and discussion in Subchapter 4.3.

c) Semi-structured interview on low survey participation

To better understand the reasons behind low participation rates, additional semi-structured interviews were conducted to gathered data on how companies organized their surveys (e.g. who were responsible and how they communicated it, in other words behavioral artifacts). An interview guide was prepared, containing a narrative part to let the interviewees describe the process without leading them and two parts with probing questions on details around organizing the survey in general and then more specifically about communicating the survey to the frontline:

1. Narrative part: Could you describe how your company went about organizing the survey?
2. Probing questions for general background:
    - Have you received any feedback regarding the survey?
    - What did you do to communicate the survey?
    - Did you ask anybody to help with organizing/ communicating the survey?
    - Did you keep track of whether the people you asked to communicate the survey actually did what was expected from them?
    - Did you share survey participation rates? How? With whom?
3. Probing questions focusing on the frontline:
    - Have you received any feedback from the frontline regarding the survey?
    - How was the survey communicated to the frontline?
    - Have you investigated the reasons why frontline did not participate in the survey?

The semi-structured interviews lasted between 20-30 minutes. Interviews were recorded and transcribed. Based on the data from the transcripts, behavioral artifacts were identified and gathered under relevant themes. Additionally, observations from the survey organizational process and related correspondence offered supporting data (Figure 3.8).

3.3.3.3. Data analysis

To interpret the collected data, in parallel, literature was reviewed on behavior models, national macro culture impact on organizational culture, and management principles (e.g. trust building, breaking silos, working towards collaboration). The analysis design is depicted in Figure 3.8. In the end, these lead to the formation of a conceptual framework for interpreting artifacts and espoused values and beliefs based on behavioral science concepts and basic underlying assumptions stemming from national culture. As such, this part is extending research on FSC and offering a novel contribution.

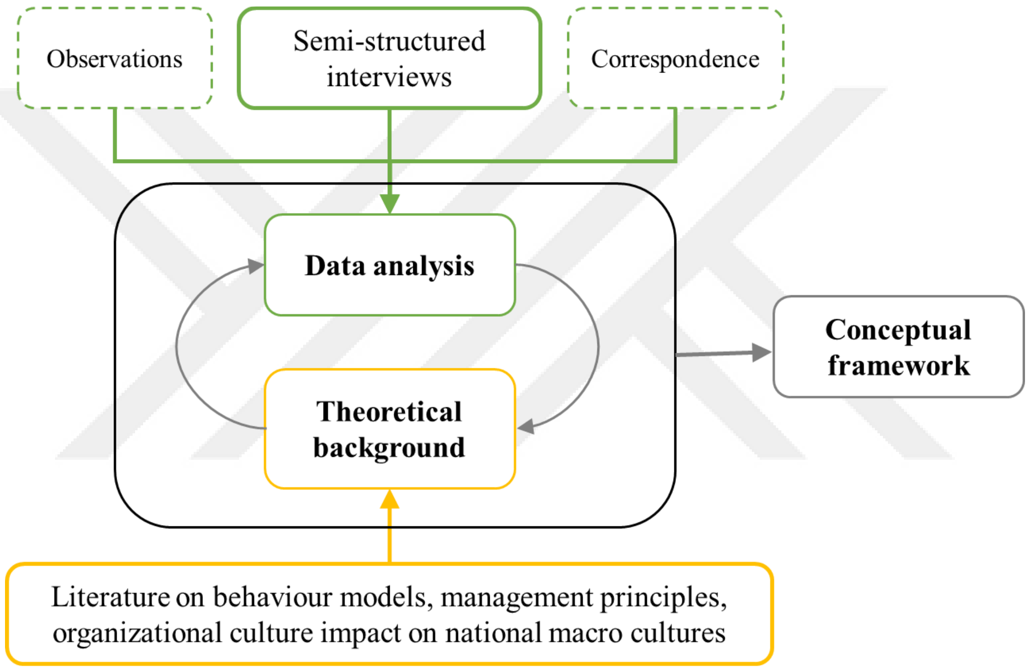


Figure 3.8: Design of analysis. Solid green line: main data collection method. Dotted green line: complimentary data collection methods.

Source: Prepared by the researcher.

3.3.4. Halal food management evaluation

3.3.4.1. Document analysis

Document analysis was conducted. A general list with topics on both food safety culture and Halal food management was created (Appendix 3) and shared with the companies, according to which the company representatives could identify the types of documents the company owned and were willing to share. Companies sent electronic copies of relevant documents or in case they were not willing to share these directly, documents were reviewed on-site. Furthermore, during semi-structured interviews the participants were asked to open relevant documents for a more in-depth investigation into companies' HFA practices, which is elaborated in the section below.

3.3.4.2. Semi-structure interviews to evaluate Halal food assurance management system

Semi-structure interviews were conducted with the companies' staff responsible for Halal certification between September 2022 and April 2023. A two-in-one interview and document review guide was developed for this purpose. In addition to interview questions, it highlights areas where companies might have relevant documents, guiding the interviewer to probe (Appendix 6).

To set up the interview guide, Halal food standards, published by the Organisation of Islamic Cooperation´s (OIC) (SMIIC, 2019), by Malaysian Standards (Standards Malaysia, 2019) and the Republic of Indonesia (LPPOM MUI, 2023) were used. For a more pin-pointed identification of risks, other sources were used from related disciplines in the food sector and translated into the Halal context. These sources include:

- A tool to diagnose context riskiness in the view of food safety activities (Luning et al., 2011)
- Allergen management code of practice (CAC, 2020) and assessment sheet (Dzwolak, 2017)
- Organic production management (EC, 2018)
- Food safety culture related documents (GFSI, 2018; Jespersen et al., 2016)

a) Pilot study of the interview guide

To verify the relevance of the topics in the guide and that all relevant topics had been included, interviews were conducted with the 2 Halal committee representatives of C6. These interviews were conducted in 3 sessions, each lasting up to 2 hours. The company had their own Halal food management system standard combining requirements from different Halal food standards and management systems. The company also had a team to audit their factories´ Halal practices. The interviewees had responsibilities in setting up the initial version of the internal standard and revising it, and accordingly auditing company´s food production factories and setting up a database describing materials (including raw materials, maintenance oils, cleaning chemicals etc.) and their possible risks associated with Halal food assurance.

The initial guide was used to interview the Halal committee representatives. Details emerging from the interviews were added to the guide as either main or probing questions. The final version of the guide includes the following sections:

Section 1 - An introduction to explain the details around the interview to the participant;

Section 2 - Questions regarding the Halal certification process and Halal certification body´s activities;

Section 3 - Narrative part to let the interviewee describe their Halal management practices, which helps to set the scene and pin-point topics for further probing (Robson & McCartan, 2016);

Sections 4 – 9 are about Halal food management system details, including

- Topics around supplier management, like the certification bodies that the suppliers use, their certification scope and procedures around first-time supplier approval (section 4);
- Topics around incoming materials´ risk analysis and managing Halal certificates (section 5);
- Topics around material reception, like certificate and contamination monitoring procedures (section 6);
- Topics around the involvement of other departments, like purchasing, logistics, product development (section 7);

- Topics around Halal food requirements regarding the production, including hygiene, pest and waste control and whether they have in place any measures to prevent contamination, including from subcontractors, visitors (section 8);
- Topics around the company having Halal food related documentation (like policies, procedures, handbook), Halal team, management review and training (section 9).

Since the food production facilities might be either dedicated (all products certified) or non-dedicated (some products not included in the certification scope), additional questions were included for the latter on how they go about preventing cross-contamination (Appendix 6, Section 10).

During the interviews, the sequence of sections and topics was changed depending on the flow of the interview and document analysis. The main questions were carefully worded that they would not lead the interviewee and encourage a particular answer (Robson & McCartan, 2016). To avoid leading the interviewee, probing questions were used only when the interviewee referred to a certain topic. For the same reason, topics on Halal policy and handbook, Halal team and training were purposely placed last in the guide. The latter also enables to see whether the participants mention these topics during the interview, giving insight to their relevance within the company´s Halal food management scope. The interviews with the person responsible for Halal certification lasted between 1.5 and 2.5 hours. A break was included, if necessary.

Voice records were transcribed either manually or by using an AI-based transcription software (Cockatoo Inc; www.cockatoo.com). Transcripts were analysed in parallel with the voice recordings to double check the transcripts for errors. The data from different companies was gathered under relevant themes in Excel, enabling to compare the findings.

3.3.4.3. Semi-structured interviews to evaluate Halal certification bodies' accreditation impact

After the initial data collection (September 2022 and April 2023), there was a change in regulation that starting from June 2023 only Halal certificates (HCs) issued by Halal certification bodies (HCB) which had been accredited by the Halal Accreditation Agency of the Republic of Türkiye were valid in Türkiye (Presidency of the Republic of Türkiye, 2024). To gain insight into its impact on companies' HFA practices and to what extent the initial data still reflects current practices, an additional semi-structure interview was conducted. Based on the main HFA activities an interview guide was constructed, with the following questions:

- Did your HCB's accreditation affect your practices around Halal food? How?
- Did the accreditation affect how your company conducts training/ laboratory analyses, identifies high-risk ingredients/ analyses risks, types of documents and information demanded from suppliers and related communications and documentation around Halal food assurance? How?
- Did the accreditation affect practices regarding food safety and hygiene?
- Did your HCB's accreditation simplify Halal food assurance for your company or make it more complex?

Interviews were conducted with the same responsible staff with whom the initial interviews were conducted. These were conducted either face-to-face or online, lasted around 30 minutes and were recorded. As the extent of changes was small, the data was gathered in a table under each company presented in Chapter 4.5.

3.3.5. Process environment hygiene

3.3.5.1. Scenario analysis

Literature was reviewed to establish drivers and the relationships between them, in the context of food safety assurance, for scenario analysis;

1. Behavior and working conditions (driver) might lead to microorganism entrance and movement into production or in other words transfer (relationship) between different zones (driver), like hygiene zones (high/medium/low), dry/wet production zones, zones based on the proximity to the product (Zone 1 to 4 in ascending order of distance from the product, including food contact and non-contact surfaces), resulting in product contamination (relationship) and with that a possible food safety hazard (relationship) (Bourdichon et al., 2021; 3M & Cornell University, 2019; Gurtler, Doyle & Kornacki, 2014).
2. Behavior and working conditions (driver) might lead to (relationship) the presence of indicator microorganisms and moisture (driver) (3M & Cornell University, 2019).
3. Presence of indicator microorganisms (driver) and residual moisture (driver) might lead to their resuscitation and/or proliferation (relationship), resulting in a food

safety hazard (relationship) (Gurtler, Doyle & Kornacki, 2014; Finn et al., 2013; Wu, 2008; Taneja, Kaushik & Juneja, 2023)

4. Residual moisture (driver) increases the level of touch-contact associated bacterial transfer (relationship) (Patrick, Findon & Miller, 1997).

The identified drivers were used to guide observations, which in turn guided the process of selecting sampling locations (Figure 3.9). Like this, the data collected on the drivers, in conjunction with relationships between them, were used to construct storylines highlighting the possible consequences or in other words the food safety risk (Figure 3.9).

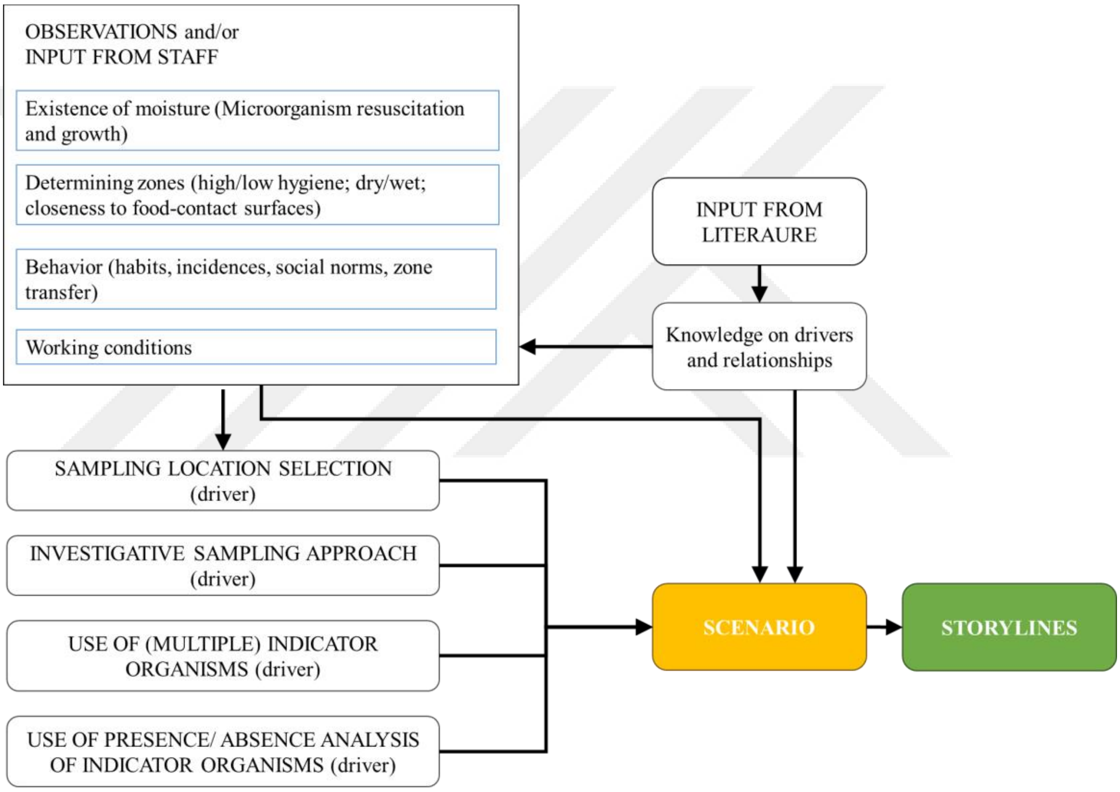


Figure 3.9: Scenario analysis framework.

Source: Prepared by the researcher.

3.3.5.2. Observation methodology

Observations were conducted as 'observer-as-participant', in which the status of the researcher was known and where the researcher does not take part in the activities (Robson & McCartan, 2016). The conducted observations were also 'focused observations', as they were carried out within a pre-determined theoretical (scenario) framework (Figure 3.9), leading to a greater focus of specific aspects in a setting, such as the drivers (Robson & McCartan, 2016). Thus, data was collected through observations to identify zones, existence of moisture and people´s behavior, including habits, instances, and social norms, leading to movement between different zones up to the open product (Figure 3.9). Additionally, the escorting staff were asked to elaborate on zones, rules, and common practices. All comments and conversations between employees or employees making direct contact were considered as data. Quick notes were taken as “memory sparks” to aid writing out the full record as soon as possible after the observations (Robson & McCartan, 2016).

Observations were performed on the shop floor and together with collecting the microbiological samples lasted between 2-3 hours. In each company one or two employees, who were either a part of the food safety/quality team and/or supervisors, were appointed to escort and assist the sampling process.

3.3.5.3. Microbiological sampling

a) Materials for sample collection

- Pre-moistened sterile cotton swabs in 10ml Butterfield´s phosphate dilution water (DiaTek Diagnostic, Türkiye)
- Sponges in 10ml Letheen Broth (3M Health Care, USA)

b) Process environment surfaces

Based on the observations, samples were collected from locations where contamination between Zones and growth within the production environment is most probable. Independent of the size, same type of surfaces in the same location, being the same transition vectors, were considered as one location. For example,

- Both left- and right-hand railings of production line crossover stairs were considered as one sampling location. Other, same type of railings across the room was another sampling location.
- The 3 metal bars in a turnstile of a hygiene barrier were considered as one sampling location. The same area of another hygiene barrier was a separate sampling location.
- The handles of mechanically movable equipment, used for the same purpose in the same area (e.g. containers for dough transfer or forklifts) were considered as one sampling location. Same type of equipment in a different area, although used for

the same purpose were considered as separate locations, because, it might have become contaminated due to different reasons, like a forklift being used to bring raw materials to the processing area from the depo as a “one-time” incident.

- Since palettes already have a large area to swab, one palette was considered as one sampling site.

If there was an opportunity to observe how employees touch these sampling locations, the swabbing would be adjusted accordingly. For example,

- Employees holding the railings of the crossover stairs from their ends, might indicate to a habit, resulting in this area being a more probable transition vector.
- To pass the hygiene barriers, employees pulled the metal bars of the turnstile back. Many did so from the end of the bar. That is why care was taken to swab this area more rigorously.
- While the employees were washing their hands they leaned against the sink with the front part of their clothing. Thus, especially the front or side part of the sink, depending on which side they touch, was sampled. Back of the sink, for example, was not sampled.

c) Hands and clothes

Hands were swabbed starting in the following order including the wrists: 1. back of the left hand; 2. back of the right hand; 3. palm of the left hands; 4. palm of the right hand. After steps 1, 2 and 3, the swab tip was rigorously shaken within the liquid in the swab tube. The hand areas, which are commonly missed during disinfection, were especially focused on (Figure 3.10, yellow circles).

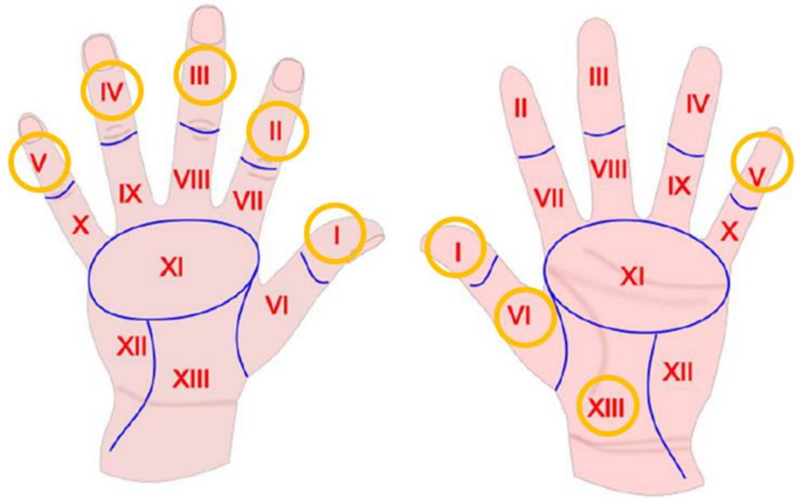


Figure 3.10: The hand areas, the back and palm surfaces, which are commonly missed during disinfection. Left hand: back of the hand; Right hand: palm of the hand; Yellow circles: areas commonly missed when disinfecting hands; Roman numerals: area numbers investigated by the original study.

Source: Gniadek et al., 2021

Clothing was swabbed by opening the swab tube and instructing the workers to take the swab tip and rub it up and down against their clothing, between the chest and ankles and at the forearms.

d) Sample collection and storage

Swab and sponge samples were collected from 4 of the 5 food production companies (Table 3.6). Samples were not collected from C2, due to the company's location, making it not possible to conduct all data collection on-site. Samples were collected with cotton swabs and sponge sticks. Swabs were used for hands, clothing and smaller surfaces, e.g. handles, utensils, and crates. Sponges were used for bigger surfaces, like sinks, palettes, railings, curtains, floors and doors.

On each swab tube and plastic sponge bag, the location details were written. After collecting the samples, they were transported within 2-4 hours to a refrigerator at 4 – 6 degrees. The samples were analysed within 24 hours after their collection.

Tabel 3.6: Overview of collected samples,

Locations	**C1**	**C3**	**C4**	**C5**
Hands	7	8	10	5
Clothes	6	8	10	6
Surface samples – swab (e.g. handles, utensils, and crates)	3	10	8	6

Surface samples – sponge (e.g. sinks, palettes, railings, curtains, floors and doors)	6	10	10	12
Total number of samples taken	22	36	38	29

C1, C3, C4, C5: participating company codes.
Source: Prepared by the researcher.

3.3.5.4. Survey with frontline

Before or after swabbing hands and clothing of frontline workers, a small survey was conducted with them to obtain related background information:

- Gender? Gloves or no gloves? Position?
- For how long have you been working for the company?
- For how many days have you been wearing the current clothing?
- For how many hours have you been working?
- How long has it been since you last washed your hands/changed gloves?
- What surfaces have you touched after washing hands/changing gloves?
- When was the last time you participated in hygiene training?

Responses were recorded right away in writing on the survey guide. Additionally, on the shop floor, questions regarding companies' process environment microbiological evaluation were also asked to the accompanying responsible staff, enabling them to point out significant sampling locations and other details:

- Are microbiological analyses conducted in the company? How?
- How are sampling locations chosen?
- Are workers' hands/clothing sampled?
- What are the consequences in case samples from hands are positive?

3.3.5.5. Microbiological sample analysis

a) Materials for microbiological analyses

Materials for Buffered peptone water:

- Peptone (enzymatic digest of casein) (Biokar Diagnostics, France)
- Sodium chloride (NaCl) (Merck & Co., USA)
- Disodium phosphate / anhydrous disodium hydrogen phosphate (Na_2HPO_4) (Merck & Co., USA)
- Potassium phosphate monobasic / Potassium dihydrogen phosphate (KH_2PO_4) (Merck & Co., USA)

Materials for microbiological analysis:

- Plate Count Agar (Biokar Diagnostics, France)
- Violet Red Bile Glucose Agar (Biokar Diagnostics, France)
- Violet Red Bile Lactose Agar (Biokar Diagnostics, France)
- Tryptone-Bile-X-Glucuronate Agar (Biokar Diagnostics, France)
- Escherichia coli ATCC 8739 strain (American Type Culture Collection, USA)

b) Sample preparation

The details of each sampling location were recorded to Excel from the swab tubes and sponge bags and each location was assigned a sample number. The sample numbers were marked on the cover of each centrifuge tube with a permanent marker. Samples were then emptied into these sterile centrifuge tubes to facilitate sample distribution to enrichment media and petri dishes.

Samples were analysed for the presence and absence of *Enterobacteriaceae* (EB), coliforms (CF), thermotolerant coliforms (ttCF) and *E. coli* indicator microorganism groups using three different sample preparation approaches. Samples from all 6 factories were both directly plated and incubated in buffered peptone water (BPW) for 18h enrichment before plating (Figure 3.11).

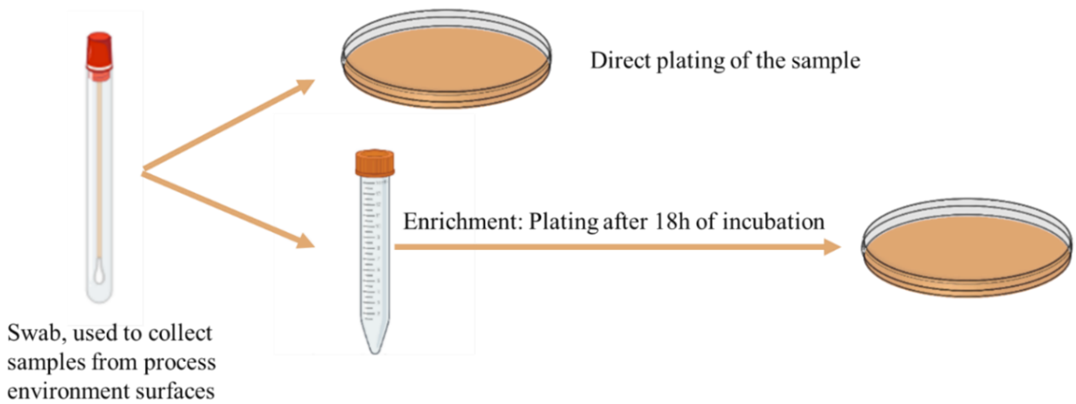


Figure 3.11: Microbiological analysis approaches.

Source: Prepared by the researcher.

If a sample had to be analysed again using protocol modification or for confirmation purposes, it was done as soon as possible or on the following day at the latest. Between analyses, samples were stored in the fridge and care was taken to keep them out of the fridge for as short time as possible during analysis to prevent microorganism resuscitation and growth.

c) Direct plating of the sample

Each sample was analysed for EB, CF, ttCF and *E. coli* indicator groups. Agar preparation, plating and incubation details are brought out in Table 3.7. The aim of using direct plating as in the colony-count method was not to count colonies per se, but to compare results with and without enrichment. Furthermore, dilutions and parallels were not used as originally prescribed in methods brought out in Table 3.7. As highlighted in the PHE method F8, published by the UK´s government agency Public Health England (PHE), parallel analysis is especially important for official and formal samples, however not essential when evaluating microbiological hygiene in general, as is the case in this study.

As for the incubation temperature, since both 35°C and 37°C could be used for coliform incubation (Corry, Curtis & Baird, 2012), 37°C was chosen for the sake of simplicity.

Table 3.7: Microbiological analysis details,

Target indicator group; *Method*	**Agars**	**Agar preparation**	**Plating method**	**Incubation temperature and time**
Enterobacteriaceae *ISO 21528-2:2017/ APHA 9.62:2015*	Violet Red Bile Glucose Agar (VRBG)	Reconstitution: 39.5g/l Sterilization: Bring to boil Media held at: 44-47 ^{o}C	Pour plate double-layer, using 15ml+5ml agar	37 ± 1 °C for 24 ± 2 hours maximum
Coliforms *ISO 4832:2006*	Violet Red Bile Lactose Agar (VRBL)	Reconstitution: 38.5g/l Sterilization: Boil for 2 minutes Media held at: 44-47 ^{o}C	Pour plate double-layer, using 12ml+4ml agar	37 ± 1 °C for 24 ± 2 hours maximum
Thermotolerant coliforms *ISO 4832:2006*	Violet Red Bile Agar Lactose (VRBL)	Reconstitution: 38.5g/l Sterilization: Boil for 2 minutes Media held at: 44-47 ^{o}C	Pour plate double-layer, using 12ml+4ml agar	44 ± 1 °C for 24 ± 2 hours maximum
E. coli *ISO 16649-2:2015/ PHE method F8*	Tryptone Bile X-glucuronide	Reconstitution: 30.6g/l Sterilization:	Pour plate, using 15 ml of agar	Incubate at 37 ± 1°C for 4 ± 1 h and then at 44 ±

	(TBX) Agar	15min at 121 ^{o}C Media held at: 44-47 ^{o}C	1°C for 21 ± 3 h. The total incubation time must not be longer than 24 h.

Source: ISO, 2006, 2015 and 2017

d) Enrichment

From the targeted indicator groups, only EB had a validated method for its detection using pour plating (ISO 21528-1:2017) (ISO, 2017). It included incubation of a sample in Buffered Peptone Water (BPW) at 37^{o}C for 18±2h as a non-selective enrichment before pour-plating. BPW has also been used by Dr Rapallini, M. from Wageningen University, who presented the same enrichment method for the detection of *E. coli* using TBX agar (Rapallini, 2024). Regarding coliforms, a study successfully used BPW for coliform resuscitation incubating the samples in BPW at 37^{o}C for 3h using 96-well microtiter plates (Wu, 2008). Craven et al. (2021), who took surface samples from food production companies, also used BPW incubating at 37^{o}C for 16h for the enrichment of both EB and coliform before further analysis (Craven et al., 2021).

Therefore, the following enrichment approach was used for all the targeted indicator groups (EB, CF, ttCF and *E. coli)* before plating:

1. BPW was prepared according to the details in Table 3.8.
2. 9ml BPW was pipetted into 15ml centrifuge tubes, which were then closed and sterilized in an autoclave at 121C for 15 min.
3. 1 ml of each sample was pipetted into separate sterilized BPW centrifuge tubes.
4. The centrifuge tubes were incubated at 37 °C for 18 h ± 2 h for enrichment.

Table 3.8: Buffered peptone water preparation details,

Composition	**Amount per 500ml of solution**	**Instructions**	**Sterilization**
Peptone (enzymatic digest of casein)	5.0 g	Measured 9 ml of reagent into plastic centrifuge tubes.	121^{o}C for 15 minutes.
Sodium chloride (NaCl)	2.5 g		
Disodium phosphate / anhydrous disodium hydrogen phosphate (Na2HPO4)	1.79 g		

Potassium phosphate monobasic / Potassium dihydrogen phosphate (KH2PO4)	0.75 g
Distilled water	0.5 l

Source: ISO, 2017

e) Confirmation

It has been reported that in addition to bacteria from the EB and CF groups, other bacteria might also grow colonies with similar morphologies on the VRBG and VRBL agars (Baylis et al., 2011; Silbernagel & Lindberg, 2002; Ramos & Nascimento, 2020; Mercuri & Cox, 1979; Mossel, Mengerink & Scholts, 1962). In some cases, CF colonies may be red as expected but lack the typical purple halo or be smaller than 0.5mm in diameter, which are common criteria for their identification (Jones, Gibson & Cheng, 1966). Thus, confirmation tests are prescribed in some EB and CF analysis methods (da Silva et al., 2019; Baylis et al., 2011). On the other hand, the standards released by the American Public Health Association (APHA) and Association of Official Agricultural Chemists (AOAC) to either enumerate or detect EB (APHA 9.62 and 9.61 and AOAC 2003.1, respectively), do not require confirmation tests (da Silva et al., 2019). When conformation tests are not used, “presumptive” EB and CF results are obtained (da Silva et al., 2019).

It is also reported that confirmation tests might be carried out “if necessary”, depending on the purpose of sampling (Corry, Curtis & Baird, 2012; Baylis et al., 2011; van Schothorst & Oosterom, 1984). Interestingly, while some studies, analysing EB and CF from surfaces in food businesses, directly refer to relevant methodology standards (Djekic et al., 2016; Jacxsens et al., 2009), other studies bring out analyses details until the incubation, not mentioning confirmation tests or reasons behind omitting them (Ipek & Zorba, 2018; Nascimento et al., 2015; Lahou et al., 2012; Temelli et al., 2006). Craven et al. (2021), on the other hand, also did not use confirmation tests for enumeration emphasizing that upon monitoring, omitting these is a common practice in the industry.

As Hartman, et al. (1960), who studied the selectivity of the agars in question, said *“When simplicity of analysis is sacrificed, as it must be in confirmation of coliform type or determination of coagulase reaction, then the import of the information obtained should justify the effort expended.”* (Hartman, 1960). Since this study does not evaluate growth trends, but aims to identify risks in conjunction with observations, the additional data obtained with confirmation tests would not justify sacrificing simplicity and increasing the cost of analysis. Thus, the current study did not include confirmation test and presented the results as "presumptive".

However, in addition to the above discussion on colony morphologies, especially regarding the nuance that some non-EB and non-CF indicator group microorganisms could have similar colony morphologies (Baylis et al., 2011; Silbernagel & Lindberg, 2002; Ramos & Nascimento, 2020; Mercuri & Cox, 1979; Mossel, Mengerink & Scholts, 1962), it was decided to visually evaluate colony morphologies before deciding upon their presence. Visual selection is also commonly done in their standard methods, as characteristic colonies are chosen for confirmation based on their visual appearance (ISO, 2006; ISO, 2017). Thus, an *E. coli* strain was plated with the VRBG and VRBL agars to obtain characteristic colony visuals, which could be used later on, when evaluating colonies on sample plates. While from one side, this might lead to false negatives, as some CF colonies might not exhibit a typical visual, as discussed above (Jones, Gibson & Cheng, 1966), from the other, it enables to take a slightly more stringent approach for presenting 'present' results. *E. coli* was chosen for the visuals, as this study also focused on identifying faecal contamination, for which *E. coli* is currently the best option (da Silva et al., 2019). Depending on the research focus, future studies could also consider using other strains for this purpose.

f) Analysis with the E. coli strain

The *Escherichia coli* ATCC 8739 strain (American Type Culture Collection) was used. With a loop, *E. coli* colonies were rubbed onto a swab, which was placed back into its tube containing 10 ml Butterfield´s phosphate dilution. The tube was mixed by both inverting it 3 times and using the Vortex for at least 20 seconds. Serial dilutions were made up to 10^{-3}. Each dilution of the sample was plated was plated with the different agars (VRBG, VRBL and TBX), using four different methods: pour plate with overlay, pour plate, spread plate and finally spreading the sample with a loop on the agar, like described in ISO21528-1:2017 for enumeration of EB (ISO, 2017). TBX agar was analyzed for informative purposes, as it was the first time for the PhD researcher to work with the agar. All agars showed growth of the *E. coli* (ATCC 8739) strain. Visuals were obtained, including plates with high bacterial density (Figure 3.12), of colonies within the agar and colonies on the agar (Figure 3.13).

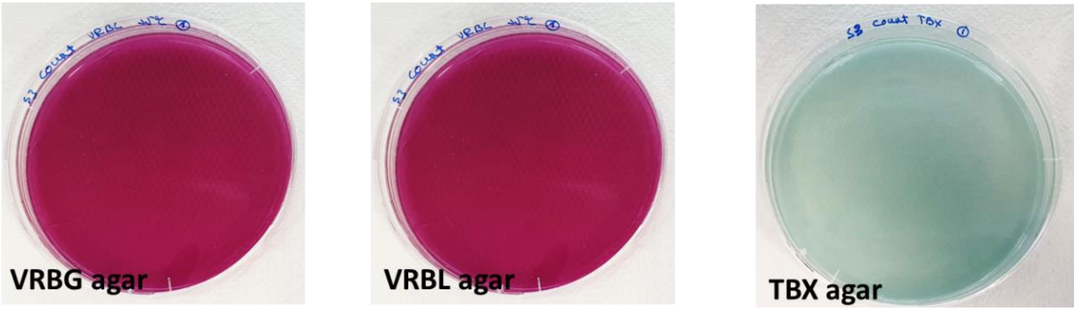


Figure 3.12: Results with *E. coli* strains of high target microorganism density. VRBG: Violet Red Bile Glucose agar; VRBL: Violet Red Bile Lactose agar; TBX: Tryptone Bile X-glucuronide agar.

Source: Prepared by the researcher.

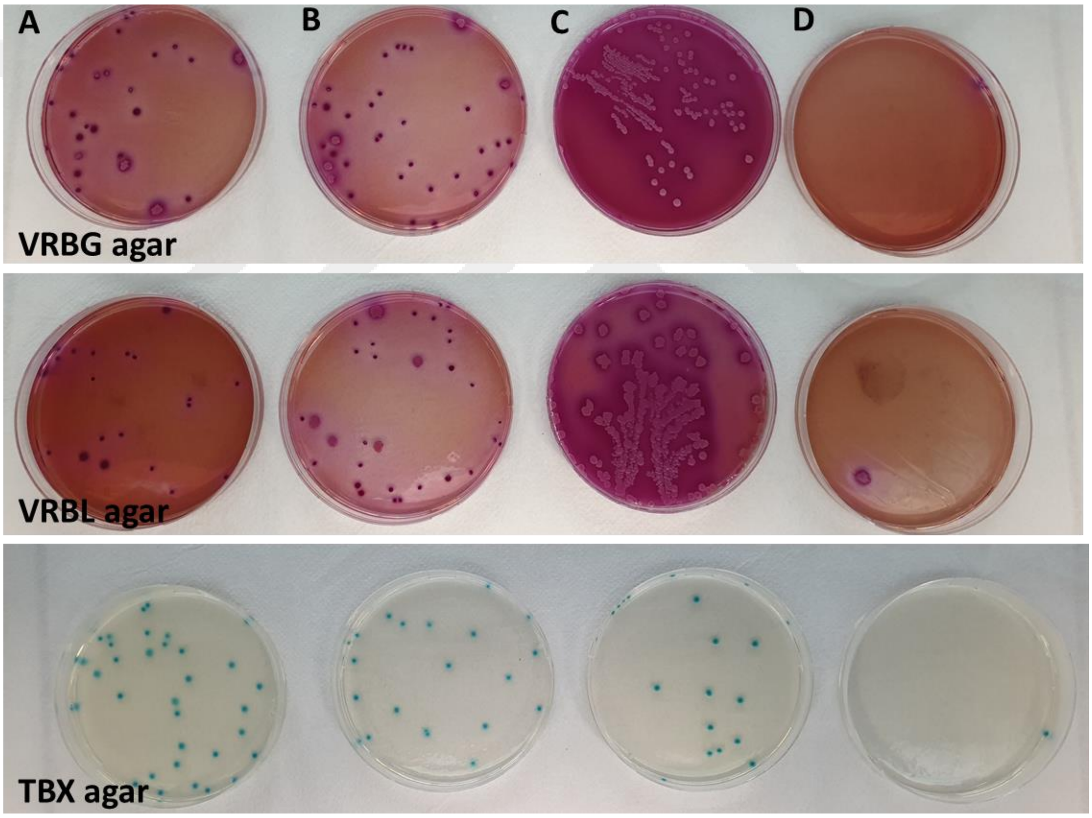


Figure 3.13: Results with *E. coli* strains of low target microorganism density and different plating methods. A: pour plate with overlay; B: pour plate; C: spread plate; D: streaking with a loop on agar. VRBG: Violet Red Bile Glucose agar; VRBL: Violet Red Bile Lactose agar; TBX: Tryptone Bile X-glucuronide agar.

Source: Prepared by the researcher.

g) Analysis protocol modifications - E. coli

As seen on Figure 3.13, streaking with a loop on the agar might not show growth, unlike with the pour plate technique, which is recommended in case of low bacterial density (da Silva et al., 2019). This is especially important for *E. coli*, which is a more specific indicator group and thus more difficult to detect compared to EB and CF. Therefore, for *E. coli* detection 1ml of the enriched sample was used with pour plate, just like specified in its corresponding enumeration standard (ISO 16649-2:2001) to increase the probability of detection. Example results could be seen in Figure 3.14, where direct plating gave an absent result, while enriched samples gave a present result. In sample A, the *E. coli* density was high, while sample B showed the growth of two colonies in the enriched sample.

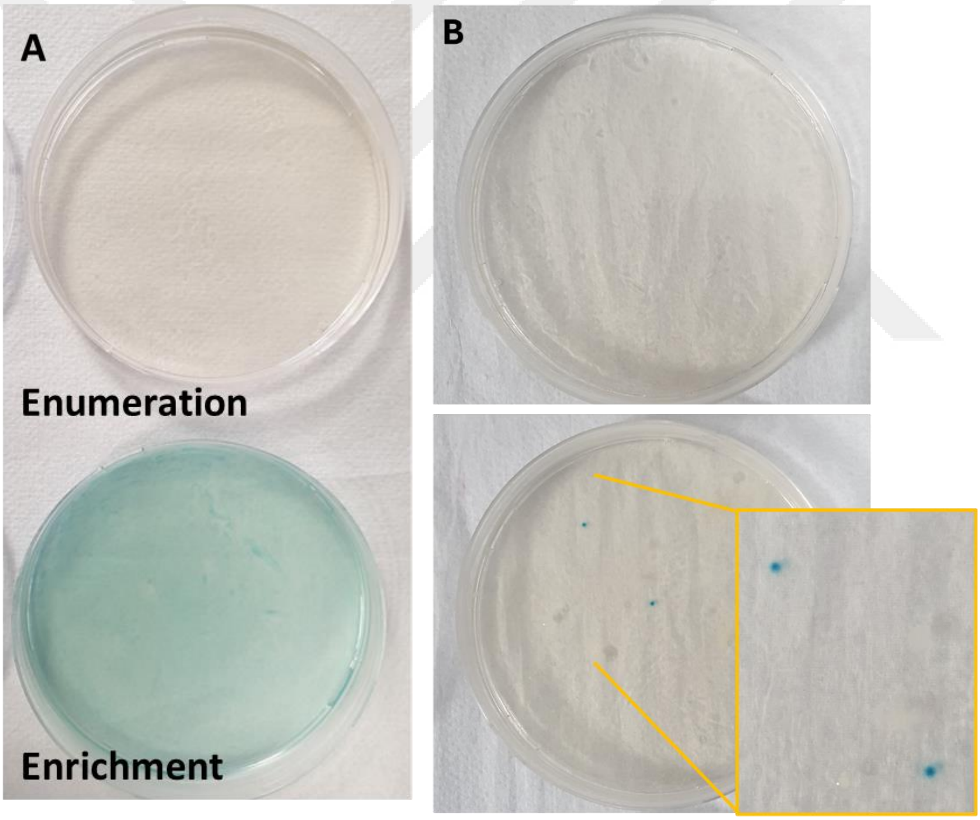


Figure 3.14: Example of *E. coli* results from direct plating and enrichment. A: sample from Company 1 (C1); B: samples from Company 4 (C4).
Source: Prepared by the researcher.

Of the 187 samples analysed from 4 companies in total, 22 samples were positive for *E. coli*. 11 samples were positive for both non-enriched and enriched samples and 6 samples were positive only for enriched samples (Table 3.9). However, the impact of enrichment remains questionable, because *E. coli* was present in 5 non-enriched samples, while their enriched versions were absent. This might be because the number of *E. coli* colonies was low in the initial sample of 10 ml and no *E. coli* was taken up when pipetting 1 ml of sample to 9ml of BPW for enrichment. However, this might be subjected to further research in the future. Since characteristic *E. coli* colonies were identified in all present cases (whether obtained through count or enrichment conditions), all present results were considered in the scenario analysis.

Tabel 3.9: *E. coli* results overview from 5 companies,

Results		Number of samples
Direct plating	**Enrichment**	
present	present	11
absent	present	6
present	absent	5

Source: Prepared by the researcher.

h) Analysis protocol modifications – EB, CF and ttCF

Yellow/orange overgrowth was witnessed on some sample's VRBG and VRBL agars incubated at both 37°C and 44°C for both non-enriched and enriched samples. In non-enriched samples, overgrowth was also witnessed for some sponge samples, which might be due to the inherently larger surface areas swabbed with the sponge, picking up more background flora than the conventional swab. To capture the characteristic plate visuals (Figure 2.5 and 2.6), different plating techniques, smaller sample amounts in conjunction with monitoring the plates at different incubation times were used.

While streaking agar with a loop is a common practice for enriched samples, pour-plating with overlay using the same agar is so for colony-count methods (da Silva et al., 2019). Overlay has been proven to improve the specificity of the media, by suppressing non-fermenting Gram-negative bacteria and background flora, in addition to encouraging fermentation of glucose (Baylis et al., 2011; Corry, Curtis & Baird, 2012). For example, Jones et al. (1966) used overlay after streaking the sample on the VRBL agar for CF detection (Jones, Gibson & Cheng, 1966). As could be seen from Figure 3.15, both the plating technique and sample amounts had an impact on overgrowth. Characteristic colonies became visible using a loopful (about ~0.01ml) of sample together with the pour plate with overlay method (Figure 3.15, B), compared to streaking the sample on the agar (Figure 3.15, C) or using 0.1ml of sample with pour plate and overlay (Figure 3.15, A). Thus, the pour plate technique, with a smaller sample amount enabled to reveal the positive result.

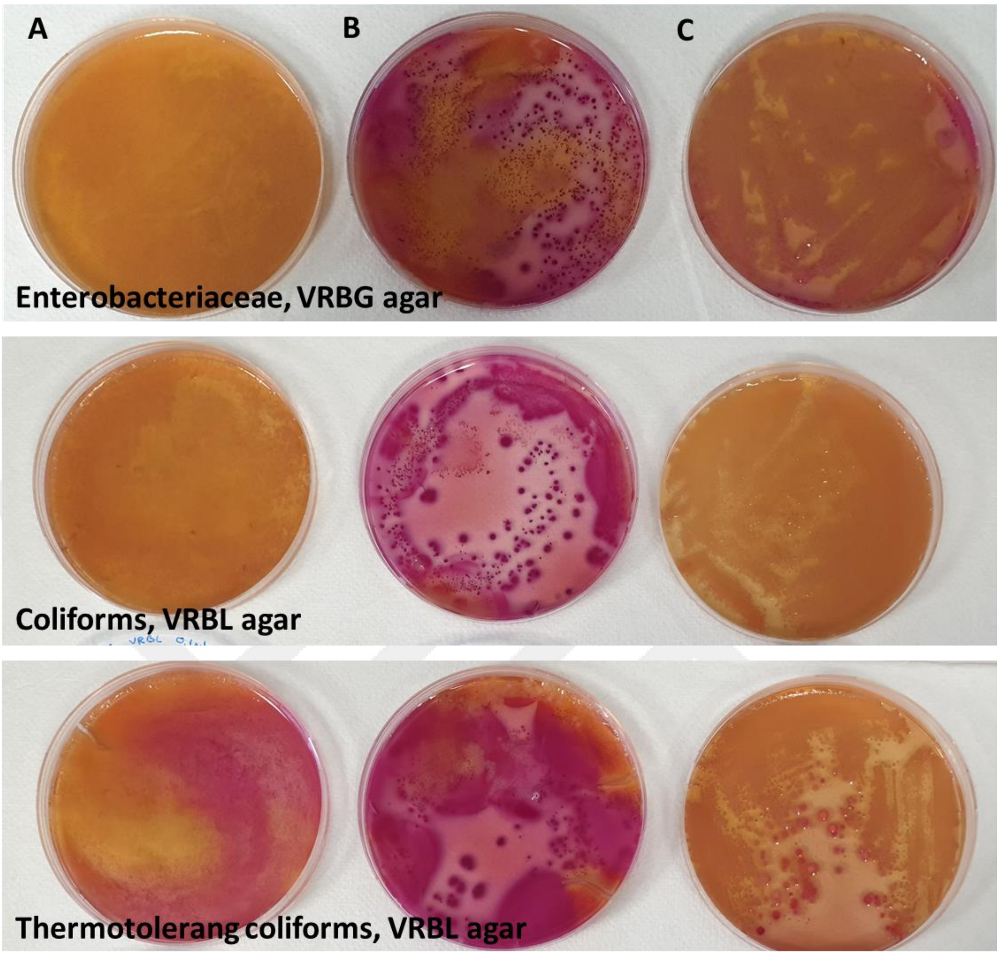


Figure 3.15: Enriched sample from Company 4 (C4). A: 0,1ml sample using pour plate with overlay; B: loop on petri using pour plate with overlay; C: loop on agar, VRBG: Violet Red Bile Glucose agar; VRBL: Violet Red Bile Lactose agar.
Source: Prepared by the researcher.

Regarding sample amounts, the results in Figure 3.15 were from a sample, which showed growth and overgrowth even when enrichment (count conditions) was not used, meaning that the original samples already included a lot of targeted microorganisms and background flora. Thus, to increase the probability of detection multiple loopfuls were applied: 3 loopfuls (3xl). However, even when analyzing samples from C1 in this manned, only one swab sample showed growth, 10 of the remaining 14 enriched swab samples had no growth and the 4 samples had 1 to 9 colonies (Figure 3.16). When the samples were analyzed again using 1ml of sample,

- the latter 4 samples had characteristic colonies in samples 1 and 2, giving a present results, while complete overgrowth was observed in samples 3 and 4, leaving the results ambiguous and were thus accepted as negative (Figure 3.16);
- 5 of the 10 negative samples gave a present result without overgrowth, while 5 remained absent and as such regarded as a negative result.

The higher overgrowth rate in the previous company (C4), might have been because various powdered ingredients were used in this production environment, leading to higher amounts of the background flora. The negative results in the second company (C1) stemming from smaller sample size, might have been due to lower surface contamination rates compared to C4. Thus, the optimal sample amount might change according to companies.

Furthermore, optimal sample amount could be combined with optimal incubation times. For instance, a shorter incubation time together with the right amount of sample enabled to capture the presence of target microorganisms before overgrowth (Figures 3.17 and 3.18). Thus, to overcome the overgrowth challenge, it was important to strike a balance between incubation times and different sample amounts.

In the end, the microbiological analyses plates with clearly visible red/purple colonies were used to compare with the visuals of the characteristic colonies demonstrated in Figure 3.12 and 3.13, which were then accordingly recorded as results to be used in the scenario analysis.

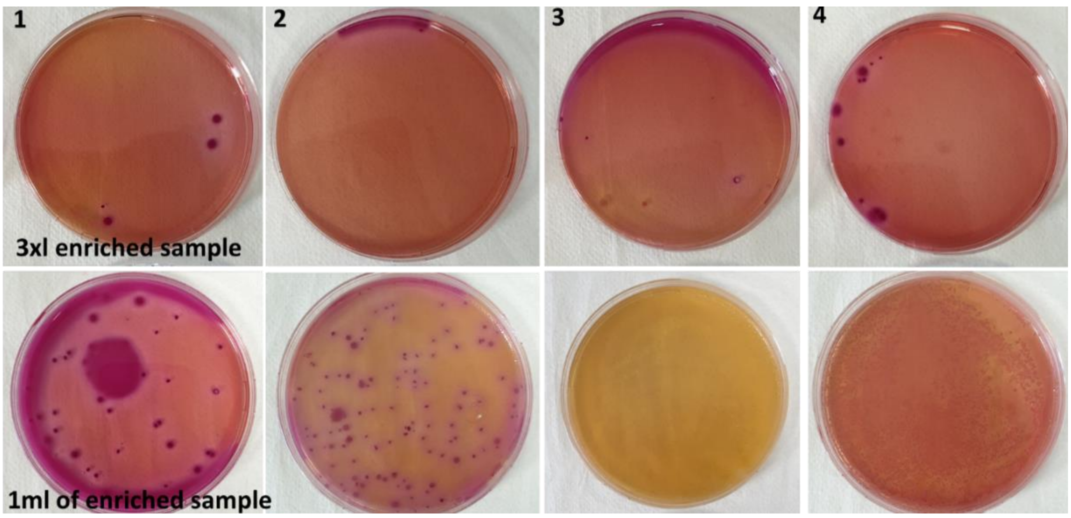


Figure 3.16: Example samples from Company 1(C1), using both 3xl and 1ml enriched samples on VRBG agar. 3xl: 3 loopfuls of enriched sample was used.
Source: Prepared by the researcher.

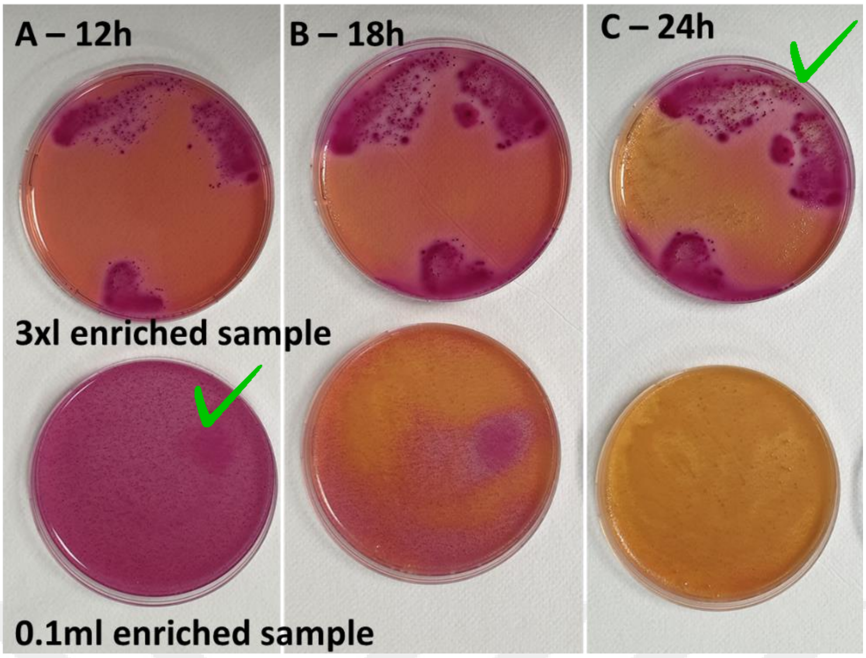


Figure 3.17: Example samples number 1 from Company 4 (C4). VRBG agar. A, B, C:12h, 18h and 24h incubation, respectively. 3xl: 3 loopfuls of enriched sample was used.

Source: Prepared by the researcher.

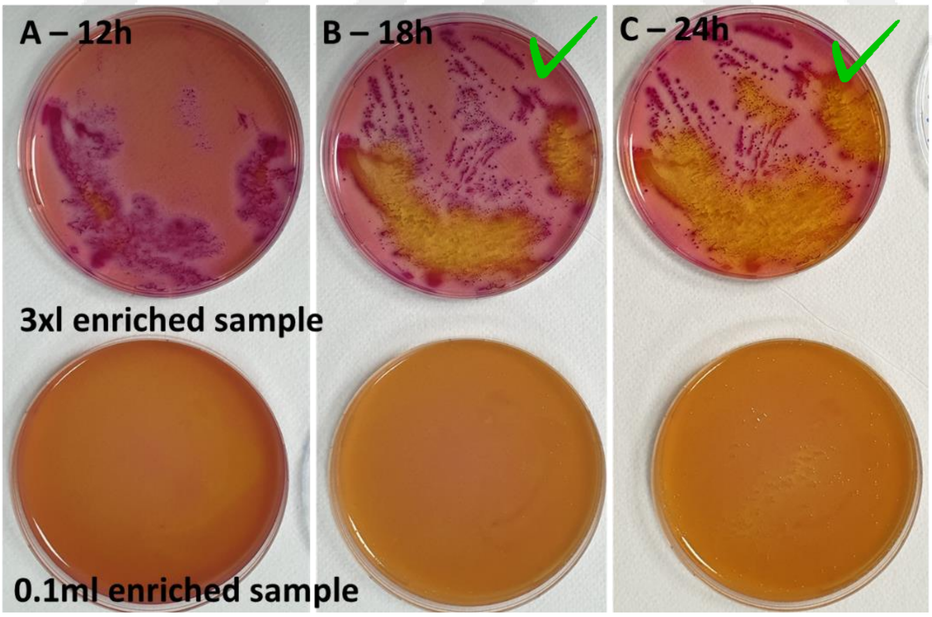


Figure 3.18: Example samples number 2 from Company 4 (C4). VRBG agar. A, B, C:12h, 18h and 24h incubation, respectively. 3xl: 3 loopfuls of enriched sample was used.

Source: Prepared by the researcher.

CHAPTER IV

RESULTS AND DISCUSSION

In this study, it was aimed to evaluate food safety culture (FSC), Halal food assurance (HFA) and process hygiene and their interactions, using a multiple case study and a mixed-methods approach in 5 food production companies in Türkiye. First, a meta-synthesis was presented in Subchapter 4.1., which analysed the existing research data, putting forth new and initial results regarding FSC maturity in food production companies in Türkiye. This is followed by Subchapter 4.2. on issues, which emerged during FSC evaluation, exploring the possible reasons behind these. Then, Subchapters 4.3., 4.4. and 4.5. present the empirical findings on FSC, HFA and process hygiene, accordingly. Interactions between the three research strands were elaborated under relevant Subchapters 4.4. and 4.5.

4.1. Food Safety Culture Maturity Meta-synthesis Based on Food Safety Management and Hygiene Research in Türkiye

While this subchapter presents new findings on food production companies' food safety culture (FSC) maturity based on existing research, Subchapter 4.3. puts forth new empirical evidence, based on data collected from the participating companies. Like this, both subchapters serve the aim to gain a better understanding of food safety culture maturity in large-sized food production companies in Türkiye (Chapter 1, Figure 1.1). As such, this subchapter analyzed results in existing food safety management and hygiene studies conducted in food production companies, not only putting forth existing findings and research gaps in each FSC dimension, but advancing current research in this area, by analyzing this data from a FSC maturity perspective, thus presenting the first insights into companies' maturity stages. The meta-synthesis results are grouped and presented under FSC dimensions, which are based on Jespersen et al., (2019)' work and GFSI's *Positioning Paper*. Table 4.1 includes a short overview of findings from the studies, FSC related insights and research gaps.

Table 4.1: Overview of research findings and related FSC insights and research gaps,

Findings	Food safety culture insights	Research gaps
Vision and Mission		
Food safety does not tend to be one of the business priorities (Karaman et al., 2012; Azak, 2011; Gül Özdoğan, 2009). Aspects like decreased consumer complaints, increased product quality and compliance with legislation are the main perceived benefits of food safety management systems (FSMS), instead of food safety (Karaman et al., 2012; Demirbas & Karagözlü, 2007; Dilek & Üçüncü, 2022).	- Food safety is not perceived as a priority, as companies fail to see its benefit, as external pressure (like compliance with legislation and consumer complaints) drive food safety. - Lack of understanding between quality and food safety.	There is no research on whether and how companies set food safety and their indicators among business priorities.
People		
Employees´ active role in FSMS is interpreted as having them fill out forms (Dilek & Üçüncü, 2022). In the FSMS implementation process, everything is organized by the quality and food safety team (Dilek & Üçüncü, 2022). The majority stated that the responsibility to implement FSMS is not on one person (Karaman et al., 2012). Monitoring specified in the HACCP plan is done by the quality and safety team (Hakizimana & Gürbüz, 2019; Altınbaş Özdemir & Kurultay, 2013; Erfa & Taşan, 2007; Küçüktezcan & Dağlıoğlu, 2010; Bayraktar & Gürbüz, 2020; Karadal & Ova, 2020). In just some cases these responsibilities were divided among the relevant	The results show a tendency towards silos. Some companies have the do-it-yourself approach by the quality team, paving the way to silos. Some companies are aware of the need to involve staff and seem to give an effort towards more cross-functional team cooperation.	Further research is necessary into how engagement and team-work are perceived and to what extent work takes place in silos vs. having cross-functional activities.

production personnel (Ekici & Turgay, 2016; Bülbül & Üçüncü, 2020; Günşen, Eseceli & Atan, 2019; Sav & Bilgin, 2018).		
Only one study included details on consequences in case hygiene rules were not followed (Özbay Doğu & Akolaş, 2013).	Some companies might be aware of the need for consequence systems to influence behaviour.	Further research is necessary into whether and what kind of reward, recognition and consequence systems companies have in place for food safety issues.
The majority of companies were found to provide food safety related training (Bozbey & Güneş, 2021; Kök, 2009; Ali Gürbüz & Yılmaz, 2021; Erkeç & Bilgin, 2020; Karaman, 2012). Most of the companies did not offer food safety related training to temporary workers (Karaman, 2012). SMEs provide less training less frequently compared to larger companies, at the same time being aware that they need more training (Karaman, 2012). Most of the employees felt that they need more training (Erkan, 2018). Management and supervisor food safety training is not common practice. However, around half of the companies realized that they need educator training (Karaman, 2012).	Food safety training might not be conducted. There is little recognition that training for different populations of the company is necessary. Capacity building, like trainers training is limited.	Further up-to-date research should be conducted on what kind of training systems are in place and what levels of the company does it include.
Companies explained both '*What'*, needs to be done and '*Why'*, (Dilek & Üçüncü, 2022).	Some companies seem to be aware that training material should go beyond rules, the '*What'*, focusing on risk concepts and their consequences, the '*Why'*.	There is no research into training style, material content, and efficiency.

Companies might use internal and external training, with some companies also using support from governments and universities (Kök, 2009).	Different sources of training might indicate to higher commitment, however it does not necessarily indicate to better food safety practices, if the training material are not company and area specific.	
Adaptability		
High cost, inadequacy of the workforce, extra workload and low adaptability of the workforce are the main challenges in implementing FSMS (Karaman et al., 2012; Demirbas & Karagözlü, 2007; Karaman, 2012; Dilek & Üçüncü, 2022; Gül Özdoğan, 2009; Erkan, 2018; Azak, 2011; Ali Gürbüz & Yılmaz, 2021).	Companies may need to improve their change management and problem-solving skills and work on their readiness to change.	There is no research into whether, how and to what extent companies have overcome challenges in managing food safety.
Managers´ long experience combined with a low level of education is suggested to impact companies´ practices (Çalışkan, 2019; Karaman et al., 2012).		
Companies use consultancy services when establishing FSMS (Gül Özdoğan, 2009; Bozbey & Güneş, 2021; Azak, 2011; Dilek & Üçüncü, 2022; Erkan, 2018; Aytekin, 2017).	Some companies showed commitment and gave an effort to overcome challenges by investing in and learning from consultancy services.	There is no research into how effective these consultancy services are in helping to set up company specific FSMS.
Consistency		
Managers realized technology was important to improve food safety practices (Karaman et al., 2012).	Technology and updating documents are somewhat recognised as important in the food safety context.	Further research is needed to understand to what extent and in which cases companies buy and adopt technology
Companies updated food safety documentation once or twice a year (Kök, 2009).		Further research is needed on whether food safety documentation includes all the necessary information to eliminate the need to rely on one person,

		whether it is accessible, and easily understandable and whether its contents are applicable to allow employees at all levels to properly engage with it.
For continuous improvement, companies are having meetings with staff responsible for food safety, evaluating and setting new objectives, correcting mistakes and making improvements (Dilek & Üçüncü, 2022).	Companies use a “project management” rather than “organizational learning” approach.	More research is needed on how companies go about continuous improvement regarding food safety. There is no research on how companies conduct root-cause analysis and performance measurement, including what kind of leading and lagging indicators they use.
Risks and hazards		
Managers had opinions on what they could do themselves to help improve food safety (Karaman et al., 2012).	Knowing what they should do, does not necessarily mean that they have taken or mean to take action.	Further research is necessary into how, to what extent and under which circumstances do companies try to understand and act on risk; Further research is necessary into how to improve managers´ food safety awareness;
While most companies stated that they knew and followed up with food safety legislation, some companies did not (Azak, 2011; Gül Özdoğan, 2009).	Food safety awareness of managers and company representatives could be improved.	
Some managers and company representatives did not know some basic food safety related definitions, concepts, and abbreviations (Bozbey & Güneş, 2021; Erkan, 2018; Ali Gürbüz & Yılmaz, 2021).		
A study found that the higher the education level of the manager, the higher the tendency to pay premiums to provide high-quality milk (Demirbaş & Karagözlü, 2008).	In some cases, risks are understood and acted upon without external pressure.	Further research is necessary into what extent companies take ownership of the supply chain.
Pathogens were identified in both ISO 22000-certified and non-certified companies (Yörük & Güner, 2017).	Research results are ambiguous on the effectiveness of the ISO22000 FSMS.	There is no research into whether and how food safety certification, especially national ones

A company was found to properly implement ISO 22000 requirements, with just a few minor improvements necessary (Çevik & Özpınar, 2019).		like HACCP and ISO 22000, contributes to companies´ hazard and risk awareness.
Behavioural factors were not considered when determining the likelihood of hazards within the HACCP systems (Günşen, Eseceli, & Atan, 2019; Karadal & Ova, 2020; Bülbül & Üçüncü, 2020).	There is a lack of awareness regarding the impact of human factors on the likelihood of hazards.	There is no research into to what extent behavioural aspects are used by food production companies to determine the likelihood of hazards within the HACCP system.

FSMS: food safety management systems; HACCP: Hazard analysis and critical control points; SME: small medium-sized enterprises.

4.1.1. Values and Mission

The Values and mission dimension of food safety culture includes aspects like companies´ values regarding food safety, leadership commitment, setting food safety responsibilities and establishing trust between employees (GFSI, 2018; Jespersen et al., 2019). It was found that aspects like decreased consumer complaints, increased product quality and compliance with legislation are the main perceived benefits of FSMS (Karaman et al., 2012; Demirbas & Karagözlü, 2007; Dilek & Üçüncü, 2022; Erkan, 2018; Gül Özdoğan, 2009; Azak, 2011). Both lack of understanding between quality and food safety and emphasizing external pressures (like compliance with legislation and consumer complaints) are signs of FSC maturity at stages 1 and/or 2 (GFSI, 2018; Jespersen et al., 2019).

Regarding barriers to implementing food safety systems, among others, companies brought out that food safety is not a business priority and that there is a lack of management support (Karaman et al., 2012; Gül Özdoğan, 2009; Azak, 2011). Food safety is not perceived as a priority as companies fail to see the benefit or importance of food safety. The latter is also apparent from companies emphasizing external pressures as benefits, as highlighted above. Thus, in these cases it is already self-evident that food safety is not perceived as a priority, indicating to a maturity level of 1 (GFSI, 2018; Jespersen et al., 2019)

4.1.2. People System

4.1.2.1. Working in Silos

The people dimension of food safety culture includes aspects like communication within the company, reward and consequence systems and approaches to dividing responsibility, leading either towards silos or employee engagement (GFSI, 2018; Jespersen et al., 2019). In one study using in-depth interviews and structured data analysis, 3 companies´ food safety and quality managers were asked about the role of workers within the FSMS and how they are preparing workers for these roles. All stated that each worker has an active role within the FSMS, meaning that workers should submit completed forms within their area of responsibility (Dilek & Üçüncü, 2022). These findings indicate that companies are aware of the need to involve the staff, rather than having specific people or departments be solely responsible. However, reducing food safety engagement to filling forms, directs people to work in silos rather than take a team approach and does not support a work environment where workers would take interest in others´ food safety practices reinforcing them to abide (GFSI, 2018; Jespersen et al., 2019).

Another answer from a company representative gives further insight into how people might work in silos, namely, stating that everything was organized by the company´s engineers to obtain the FSMS certification and that in some cases they are the ones conducting the controls and filling in the forms (Dilek & Üçüncü, 2022). This is also consistent with the findings from studies focusing on establishing HACCP system documentation in a food production company. Namely, the food safety and quality teams were responsible for monitoring aspects of HACCP plans, like physical contamination from production and cleaning equipment, the occurrence of wounds on the hands of the employees, the amount of food additives added, final product package integrity, storage temperature and critical control points like cooking length and temperature. Another example was that they had to record the number of employees of the line, line speed and lighting condition to prevent contamination with foreign materials during olive packaging (Hakizimana & Gürbüz, 2019; Altınbaş Özdemir & Kurultay, 2013; Erfa & Taşan, 2007; Küçüktezcan & Dağlıoğlu, 2010; Bayraktar & Gürbüz, 2020; Karadal & Ova, 2020). However, there were also studies in which these kind of monitoring responsibilities were divided among the relevant production personnel (Ekici & Turgay, 2016; Bülbül & Üçüncü, 2020; Günşen, Eseceli & Atan, 2019; Sav & Bilgin, 2018). If the companies have a low FSC maturity, then it would make sense to have more qualified personnel (which the quality and safety team presumably are), check these kinds of process aspects, since the production personnel might not have the necessary skills. In this case, an appropriate education and training plan should be in place to equip workers with these kinds of capabilities, until they are ready to engage and take up responsibilities at that level (GFSI, 2018). However, if the above-mentioned is a constant practice, this indicates that the food safety and quality team are keeping all the responsibility to themselves, rather than enabling food safety to be a shared responsibility, creating silos. A limitation of the ISO 22000 and HACCP establishment case studies is that none so far have evaluated to what extent and how successfully these were implemented.

On the other hand, in another study of 28 companies, majority of the quality managers stated that in their company the responsibility was not on solely themselves. However, it remains unclear in what regards and to what extent other staff were engaged (Karaman et al., 2012). Because as could be seen from the previous study, active participation might be perceived as being responsible for filling out forms (Dilek & Üçüncü, 2022). Thus, further research is necessary into what extent work takes place in silos vs. having cross-function activities. In a mature FSC, food safety is a shared effort (GFSI, 2018). Therefore, the do-it-yourself approach by the quality team indicates to little effort in the direction of cross-functional team cooperation and with that to a maturity stage between 1 and 2 (GFSI, 2018; Jespersen et al., 2019).

4.1.2.2. Consequence Systems (Positive and Negative)

In one study on establishing a HACCP system, the procedures included disciplinary instructions in case of hygiene-related non-compliances, like the cleanliness of work clothes, smoking and walking outside with work clothes, and insisting on being non-compliant. It included having verbal to written warnings, suspension from work or a cut in wages (Özbay Doğu & Akolaş, 2013; Özbay Doğu & Akolaş, 2015). This shows that they focus on negative consequences to induce behavior change, indicating to a level 1 FSC maturity stage. However, further research is necessary into whether and what kind of reward, recognition and consequence systems companies have in place for food safety issues. This is important since rather than knowledge, consequences are the more effective behavioral influencers (GFSI, 2018).

4.1.2.3. Training and Capacity Building

A few studies included questions on whether companies provide food safety training (Bozbey & Güneş, 2021; Kök, 2009; Ali Gürbüz & Yılmaz, 2021; Erkeç & Bilgin, 2020; Karaman, 2012) however, only two studies went into more detail by also inquiring about the training approach and needs, employees who receive training and barriers to offering training to all employees (Karaman, 2012; Kök, 2009). The majority of companies were found to provide food safety related training (Bozbey & Güneş, 2021; Kök, 2009; Ali Gürbüz & Yılmaz, 2021; Erkeç & Bilgin, 2020; Karaman, 2012). A higher ratio of SMEs was found not training their staff compared to larger companies (Karaman, 2012; Kök, 2009). It was also found that SMEs conducted training less frequently (Kök, 2009). However, most SMEs also stated that they need more food safety and hygiene training (Karaman, 2012), showing awareness regarding their deficiencies on the topic.

Even though companies might state that they train employees, it does not necessarily mean that they offer training to all employees or that enough effective training has been given. Namely, one study conducted a survey with the production staff of the participating companies. There was a question on whether the employees felt they have had enough training. The study concluded that over 90% of the employees were trained, but when employees were asked whether they feel the need for more food safety related education and training, over 90% stated that they did (Erkan, 2018).

On the other hands, it is also not the frequency that makes an impact, but rather the content, personalization, and different approaches, like coaching and mentoring (GFSI, 2018). Thus, indicating to conducting 'food safety training' does not necessarily mean that it has been effective. Therefore, SMEs might have less frequent training, but if food safety is constantly on the agenda and there are follow-up activities after training, this will make a greater impact all in all (GFSI, 2018). However, there is no research into training style, material content, and efficiency, to be able to make any conclusion on companies' training approach. There are just a few aspects in the existing studies, which might shed some light on the topic. Namely, to overcome the difficulty of workers adapting when establishing a FSMS, a company suggested defining responsibilities for each employee and use training to making sure they understand the usefulness of the changes (Dilek & Üçüncü, 2022). This shows that these companies realize the importance of explaining "*Why*" these responsibilities are important, rather than just sticking with telling the workers "*What*" should be done (Dilek & Üçüncü, 2022), indicating a stage 2 maturity where training materials go beyond rules, focusing also on consequences (GFSI, 2018; Jespersen et al., 2019).

It was also found that companies used both internal and external training, with some, especially larger ones, also getting support from governments and universities (Kök, 2009). Using multiple sources for training might indicate to higher commitment, however it does not necessarily indicate to better food safety practices, especially if the training material are not company and area specific (GFSI, 2018). Thus, further research is necessary to make conclusion on their efficiency.

Another study found that a vast majority of companies do not offer training to temporary workers, but rather focus on training permanent workers. This indicates to a maturity level of 1, in which case either no training or limited onboarding training is provided (GFSI, 2018; Jespersen et al., 2019). The same study was also the only one, which elaborated on management and supervisor training. It became apparent that only 20% of the management had any food safety and hygiene training, with SMEs practically not conducting any management training at all. Regarding supervisors, nearly 80% of companies did not offer them food safety training (Karaman, 2012). However, in the GFSI´s FSC *Position Paper* supervisors are one of the 3 groups, together with senior management and frontline staff, in the education and training maturity model, emphasizing the importance of their training. They have significant roles in maturing FSC, because just like senior management, supervisors influence other employees (GFSI, 2018).

Furthermore, it is also important to improve capabilities like trainer skills (GFSI, 2018). However, only this one study asked whether the companies thought they needed educator training and found that around half, from which over half were SMEs, thought it to be strongly necessary (Karaman, 2012). Although the author interpreted these results as low enthusiasm towards this kind of training, it also indicates that around half of the companies have focused on their food safety to an extent where they start realizing the areas where they are lacking and need to improve. Despite this further research is required on how companies go about capacity building.

4.1.3. Adaptability

The Adaptability dimension of food safety culture includes aspects to evaluate companies´ ability to manage and drive change and innovation. Being able to overcome the challenges accompanying change is a fundamental part of being able to adapt, as is being ready to change (GFSI, 2018; Jespersen et al., 2019). High cost, inadequacy and low adaptability of the workforce and extra workload are perceived by companies as the main challenges in implementing food safety management systems (Karaman et al., 2012; Demirbas & Karagözlü, 2007; Karaman, 2012; Dilek & Üçüncü, 2022; Gül Özdoğan, 2009; Erkan, 2018; Azak, 2011; Ali Gürbüz & Yılmaz, 2021). Here the companies directly admit their low ability to adapt. Although they emphasized the low adaptability of the workforce, it is up to the company to analyse the needed change and build the capabilities of the workforce accordingly (GFSI, 2018; Jespersen et al., 2019).

Two studies highlighted that despite the managers having a low level of food safety training, some of them said that due to their experience in the sector they have enough knowledge on the topic (Bars & Akbay, 2013; Bars & Akbay, 2016). However, another two studies indicated that despite managers or owners having many years of experience in the field, sometimes even from childhood, combined with their low level of education, they were less prone to apply quality control systems at the process stage, do routine analysis, attend training and education and improve hygiene practices (Çalışkan, 2019; Karaman et al., 2012). These are signs of both low risk awareness and complacency, which impair change, indicating to maturity stage of 1 or 2 (GFSI, 2018; Jespersen et al., 2019).

Although, there is no research into whether, how and to what extent Turkish food production companies have overcome the above-mentioned difficulties and barriers, using consultancy services might be one approach companies use. Namely, studies indicate that around half or more of the companies participating in various studies used consultancy services to establish FSMS (Gül Özdoğan, 2009; Bozbey & Güneş, 2021; Azak, 2011; Dilek & Üçüncü, 2022; Erkan, 2018; Aytekin, 2017). While this also gives some insight into these companies´ commitment to food safety, with regards to willingness to invest, the studies did not elaborate on the impact on the consultancy services in finding sustainable solutions.

4.1.4. Consistency

The Consistency dimension of food safety culture includes aspects to evaluate companies´ approach to investing and using technology, measuring performance, engaging with documentation and problem-solving around food safety (GFSI, 2018; Jespersen et al., 2019). A study brought out that managers realized that technology was important to help themselves improve food safety practices (Karaman et al., 2012), showing that they place value on technology, indicating to a maturity stage of 2 (Jespersen et al., 2019). However, further research is needed to understand to what extent and in which cases companies buy and adopt technology.

Regarding food safety documentation, a study of 25 companies found that these companies were updating their Food Safety Handbook once or twice a year, with SMEs showing the tendency to update less frequently (Kök, 2009). Although updated documentation is an important part of a mature food safety culture, other aspects should be considered as well. Namely, whether the documentation includes all the necessary information to eliminate the need to rely on one person, whether it is accessible, easily understandable and whether its contents are applicable to allow employees at all levels to properly engage with it (GFSI, 2018).

Only one study asked participants about what they do for continuous improvement in the food safety context. The participants replied that they are having meetings with employees responsible for food safety, evaluating and setting new objectives, correcting mistakes, and making improvements (Dilek & Üçüncü, 2022). These findings do not give enough insight to whether the companies emphasize the “plan, do, check, act” cycle, highlighted by Jespersen et al. (2019), on the checking, focusing on immediate results and expecting to find working solutions from the start, indicating to a stage 2 maturity or instead of just checking, they use this part of the cycle to study and improve, focusing on constant effort, indicating to a stage 4 maturity (Jespersen, et al., 2019). Furthermore, they did not mention evaluating food safety performance within this context, showing that the respondents did not relate these two concepts, although it is the cornerstone of continuous improvement (GFSI, 2018; Jespersen et al., 2019). Finally, no research refers to performance measurements, including what kind of leading (proactive) and lagging (reactive) indicators are used by the companies (GFSI, 2018). Thus, more research is necessary to understand how companies go about continuous improvement and performance measurements.

4.1.5. Risks and Hazards

The risks and awareness dimension of food safety culture focuses on under what conditions companies give an effort to understand and act on food safety hazards and risks (GFSI, 2018; Jespersen et al., 2019). Regarding the latter, some studies collected managers´ opinions on how they could help themselves improve food safety. The main replies were to routinely conduct hygiene checks (96.4%), implement basic hygiene procedures (92.9%), insure only good products were bought (89.3%), and follow new developments and technology (85.7%) (Karaman et al., 2012). This indicates that the managers are to some extent aware of food safety aspects, but so far have lacked the initiative to put these into practice. This gap between knowledge and practice might also suggest that they are aware of „*What*", to do, but lack the understanding of „*Why*", these things are important, leading to both low food safety awareness and commitment (GFSI, 2018).

Other studies asked company representatives for food safety and HACCP definitions, meanings of abbreviations like HACCP, TSE, and ISO and to name inspecting organizations (Bozbey & Güneş, 2021; Erkan, 2018; Ali Gürbüz & Yılmaz, 2021). Most of the company representatives could not answer one or the other, indicating to a low level of food safety awareness. Since it was not specified what positions were held by the company representatives completing the survey, it is difficult to make any certain conclusions on the appropriateness of their food safety awareness. However, some of these terms, like HACCP and inspection organizations should resonate throughout the organization, especially since both are mandatory by law since 2008 (Ministry of Agriculture and Forestry, 2008). The low awareness might suggest that these topics do not have an active role in companies´ daily activities or that people work in silos if the survey was filled out by another person than the one responsible for food safety. Therefore, in future surveys, it would be useful to specify the position of the person filling in the survey.

Most companies stated that they know and follow up with the legislation, while others stated that they either know it to some extent or not at all and do not follow up with updates to legislation (Azak, 2011; Gül Özdoğan, 2009). Especially, the latter suggests that food safety is impacted by external pressure, like inspections and enforcement measures, indicating to low FSC maturity (GFSI, 2018; Jespersen et al., 2019). Furthermore, if companies are not interested in food safety legislation, this might also explain why they are not familiar with the above-mentioned terms. Regarding the companies which know and follow up with legislation, more data is necessary on to what extent they put these into practice. On the other hand, a study found that the higher the education level of the manager, the higher the tendency to pay premiums to provide high-quality milk (Demirbaş & Karagözlü, 2008). Since paying premiums is not mandatory by law, setting up this kind of reward system for the supplier shows that risks are understood and acted upon without external pressure, indicating a stage 3 FSC maturity (GFSI, 2018; Jespersen et al., 2019).

Although it might be expected that companies owning a food safety management certification might have higher food safety risks and hazards awareness, it is worrisome that a study highlighted that pathogens were identified in both ISO 22000 certified and non-certified companies (Yörük & Güner, 2017). On the other hand, a study evaluating the implementation of ISO 22000 in a company, concluded that the company properly implemented the requirements, with just a few minor improvements necessary (Çevik & Özpınar, 2019). Therefore, research is needed on whether and how food safety certification, especially national ones like HACCP and ISO 22000, contributes to companies´ hazard and risk awareness. Especially since, the accreditation of the certification bodies against these standards is not mandatory by law, which might lead to variation in certification practices across the certification bodies (Türk Akreditasyon Kurumu, 2017).

Some recent case studies on establishing a HACCP system, have indicated that behavioural factors were not considered when determining the likelihood of hazards. The likelihood was defined as occurrence per week, month and year (Günşen, Eseceli & Atan, 2019; Karadal & Ova, 2020; Bülbül & Üçüncü, 2020). Since these HACCP systems were constructed in collaboration with food production companies, they give insights into both companies´ and researchers´ approaches to the topic. Namely, that there is a lack of awareness regarding the impact of the human factor on the likelihood of hazards, leading to a higher likelihood of some hazards occurring (GFSI, 2018).

Although existing research on food safety in food production companies in Türkiye gives valuable insights into food safety management and its culture aspects, multiple research gaps were identified. While most insights were gained on topics like people working in silos, lack of training and a low level of food safety awareness, research was completely absent on food safety performance measures, training approaches and their effectiveness. Based on the existing data, the FSC maturity was mostly rated to be at the stages 1 and/or 2, however further empirical research on food safety culture is necessary to enable food production companies to pin-point challenges and work towards improvement.

4.2. Why Food Safety Culture Surveys and Related Interventions Failed? Interpretations From the Turkish Organizational Culture Perspective

This part of the research emerged due to companies not being able to successfully see through the FSC survey, in other words, to get a high enough participation rate of their companies' employees, despite the guidance and intervention suggestions offered through this study. The additional data collected from companies on how they went about organizing their surveys (artifacts; the concept elaborated in section 2.3.1.) was interpreted through behavioral models and Turkish national organizational culture tendencies, in search of explanations for the low participation rates and lack of interest/ability to implement interventions suggested by this study. This, in the end led to the formation of a conceptual framework.

First, the behavioral artifacts from semi-structured interviews on how companies went about organizing their FSC surveys were presented (Figure 4.3), followed by section 4.2.1. establishing the theoretical background, including behavioral models, their relationships with FSC and national organizational culture dimensions, with a focus on Türkiye, which were used as the bases to analyze the data presented in Figure 4.3 (section 4.2.2). The relationships between different concepts, enabling to better comprehend possible reasons behind companies' actions related to the FSC survey process, was in the end depicted as a conceptual framework (section 4.2.3.).

Table 4.2: Data on behavioral artifacts on companies organizing the FSC evaluation survey,

Themes and their codes	**Company codes**				
	C1	C2	C3	C4	C5
Providing means					
Time and/or computer					✓
Expecting workers to find time and means to enter the survey by themselves.	✓	✓	✓	✓	
Communicating the survey					
Written announcements and reminders (e.g. email, poster, phone messages)	✓	✓	✓	✓	✓
Communicated the survey in a training to the frontline **before** its start**.**			✓		
Communicated the survey in a training to frontline leaders and operators **before** its start. Asking help from them in advocating the survey.		✓			
Organizing a seminar for the frontline leaders on the survey details **before** it's start that they could see through the survey.					✓

Asking for help with increasing survey participation from managers/team leaders – **after** the start of the survey.		✓	✓		✓
Responsibility distribution					
Got the senior manager´s support, which was communicated in team meetings.			✓		✓
Responsibility for seeing through the survey was given to managers/team leaders (production, not in other support functions (OSF))					✓
Responsibility to communicate the survey was on the quality assurance team	✓	✓	✓	✓	✓(OSF)
Consequence management					
Following up on what the managers/team leaders have done to help with the survey participation rates					
Providing one-time feedback (verbal or written) on participation rates		✓	✓		✓
Verbal and written reminders after the start of the survey	✓	✓	✓	✓	✓
Additional details					
Right before and during the survey, the production and factory managers were preparing to quit.			✓		
High frontline turnover	✓	✓	✓	✓	✓
Lack of qualified employees				✓	
Had expectations of higher participation rates.	✓	✓	✓	✓	✓
Organized the survey previously and had difficulty in obtaining participation rates	✓		✓		

FSC: Food safety culture; C1-5: participating company codes; OSF: other support functions.
Source: Prepared by the researcher.

4.2.1. Conceptual Framework: the Theoretical Background

This theoretical background will first give an overview of some foundational principles of behavior change, followed by a discussion on the impact of Turkish national culture on organization culture, which will then be used to put the findings into context in the next section.

4.2.1.1. Change Management

To bring about change, such as getting employees to collaborate in organizing the survey or getting them involved, companies might use a supply-push or a demand-pull approach. In the former "*A group has something it wants others to do*", compared to the latter, in which the leader(s) work toward influencing people, like earning their trust, listening, educating, coaching, involving, setting consequences like rewards and feedback mechanisms, recognizing and encouraging progress, resulting in people "*Wanting to do something"*, (Braksick, 2007). This is also described as a learned capability to exert influence (demand-pull) rather than power (supply-push), enabling

“*To gain commitment from colleagues over whom they have no authority”*, (Gardner & Matviak, 2022). Thus, whether the companies used a supply-push or a demand-pull could help to better understand reasons behind low participation rates of the FSC survey.

Senge (2006)´s work adds an extra layer to this by describing, reinforcing and balancing processes during change initiatives. Advocating change initiatives, whether through a supply-push or a demand-pull, are the reinforcing processes, which are inevitably faced with balancing processes or limiting factors also called resistance (Senge, 2006). While Senge, (2006) describes these processes as a reinforcing and balancing loop, Wallaert, (2019) describes behavior as a result of competing pressures, in which promoting pressures (reinforcing processes) increase, while inhibiting pressures (balancing processes/ limiting factors) decrease the likelihood of a behavior (Wallaert, 2019). Although, he used this in the context of product/service development, the underlying principles are the same with Senge´s work. Both describe contrasting forces impacting behavioral change.

Both also highlight that when driving change, there is a natural tendency to focus on reinforcing processes / promoting pressures, however, to change the behavior of a system the solution lies in identifying and addressing the limiting factors/ inhibiting pressure or in other words the source of resistance (Wallaert, 2019; Senge, 2006). Senge, (2006) also emphasized an important nuance that after eliminating or decreasing one limiting factor, others will eventually surface. Thus, a skillful leader should always focus on identifying and finding solutions for these factors (Senge, 2006), just as Anderson and Ackerman Anderson, (2010) stated that “*Resistance is not to be feared but expected*”, (Anderson & Ackerman Anderson, 2010).

As the described concepts are also a part of behavioral science, companies’ approaches also give insight to their FSC maturity. What is more, improving FSC is ultimately about shifting from a “must do” to a “want to do” for all employees (Alliance to Stop Foodborne Illness, 2023), which reflects the concepts of supply-push and demand-pull and eliminating limiting factors/inhibiting pressures, again enabling to make conclusions on FSC maturity (Figure 4.2).

FSC maturity model stages				
1-Doubt	2-React	3-Know	4-Predictive	5-Internalize
SUPPLY-PUSH				DEMAND-PULL
1-Unconsciously incompetent		2-Consciously incompetent	3-Consciously competent	4-Unconsciously competent
Competency Model stages				

Figure 4.2: Behavioral science concepts in the context of FSC maturity stages. FSC: food safety culture.

Source: Prepared by the researcher.

Limiting factors/inhibiting pressures could take the form of limited resources, implicit goals and/or existing norms or in other words, the basic assumptions of the existing organizational culture (Senge, 2006; Wallaert, 2019; Schein & Schein, 2017). As organizational cultures are closely impacted by national macro cultures (Schein & Schein, 2017), analyzing the Turkish organizational culture might give insight into basic assumptions, which impacted the FSC survey organizational processes and ultimately the participation rates.

4.2.1.2. National Culture

Geert Hofstede and Erin Meyer are among two of the renowned cross-cultural researchers, who also provide online country work culture evaluation tools (Hofstede Insights Oy, 2024; Meyer, 2023). Both discuss national culture impact on company cultures, related problems and solutions. The current study will in turn take this work as a foundation to explore national culture´s impact on FSC.

As elaborated in the literature review (Chapter 2, section 2.3.1.), culture is formed as problems are solved around cultural elements of external adaptation and internal integration. Schein and Schein (2017) emphasize three cultural elements under these categories, which form the overarching foundation of organizational culture, namely authority (*how you treat the boss*), trust and openness (*how you treat each other*) and rewards and punishment (*how you know whether you are doing things right or not).* Furthermore, when describing the impact of national macro cultures on organizational culture, Schein and Schein (2017) highlight two national culture dimensions from the work of Geert Hofstede, which are especially relevant to organizational culture analysis: power distance and individualism vs collectivism (Schein & Schein, 2017). As these are directly related with the solutions around the above-mentioned cultural elements of authority (power distance) and trust and openness (individualism vs collectivism), these national culture dimensions impact the core of the organizational culture.

Both the Schein and Schein (2017)’s cultural elements and Hofstede´s national culture dimensions, are also reflected in Erin Meyer´s work, who’s work on power distance is greatly influenced by Hofstede´s research (Meyer, 2014). However, Meyer´s work is based on more specific pinpoint behaviors compared to the latter, making it easier to distinguish between different national culture nuances (Table 4.2). For example, comparing the dimension descriptions, the power distance dimension reflects the leading dimension, while individualism vs collectivism dimension reflects aspects of trusting, communicating, evaluating and disagreeing dimensions.

A closer look at their country culture evaluation of Türkiye regarding these dimensions reveals that their conclusions are also consistent with each other. For example, both describe the significance of hierarchy, concluding Türkiye´s national culture to have high power distance according to Hofstede and hierarchical leading tendencies according to Meyer. Also, both describe the importance of relationships and the possible harm of public conflict and negative feedback to these relationships, concluding Türkiye´s national culture to have collectivism tendencies according to the former and relationship-based trust building and avoiding conflict and direct feedback tendencies according to the latter (Table 4.2).

Table 4.3: National organizational culture descriptions related to Türkiye,

Cultural elements	**Results of Hofstede´s work Source:** Hofstede Insights Oy, 2024	**Results of Meyer´s work Source:** Meyer, 2023
Authority (importance of hierarchical levels and the extent of establishing psychological safety)	**High power distance**: Hierarchical superiors, often inaccessible, the ideal boss is a father figure. Power is centralized and managers rely on their bosses and on rules. Employees expect to be told what to do. Control is expected and attitude towards managers is formal. Information flow is selective. Do not expect to be included	**Hierarchical leading:** The ideal distance between a boss and a subordinate is high. The best boss is a strong director who leads from the front. Status is important. Organizational structures are multilayered and fixed. Communication follows set hierarchical lines.

	in the decision-making process.	
Trust and openness (rules around work relationships, e.g. what to call each other, how much personal life to share, how much emotion to display, whom to ask for help and around what issues, how open to be in communicating)	**Collectivism**: This means that the "We" is important, group members are expected to look after each other in exchange for loyalty. The relationship always has priority over task fulfillment. Time must be invested initially to establish a relationship of trust.	**Relationship-based trusting:** Trust is built through sharing emails, evening drinks, and visits at the coffee machine. Work relationships build up slowly over the long term. I've seen who you are at a deep level, I've shared personal time with you, I know others well who trust you, I trust you.
	Collectivism: Communication and feedback are always indirect and open conflicts are avoided.	**Disagreeing - Avoiding conflict:** Disagreement and debate are negative for the team or organization. Open confrontation is inappropriate and will break group harmony or negatively impact the relationship. **Evaluating - Indirect negative feedback:** Negative feedback to a colleague is provided softly, subtly, diplomatically. Positive messages are used to wrap negative ones. Qualifying descriptors are often used when criticizing. Criticism is given only in private. **Communicating - High-context:** Messages are both spoken and read between the lines. Messages are often implied but not plainly expressed.

As Meyer´s work enables to distinguish between the nuances of the trust and openness cultural element in a more detailed manner, the basic assumptions described in her work were used for further data interpretation (Meyer, 2023). Her county culture map shows that Türkiye has distinct national organizational culture tendencies, as in all dimensions Türkiye leans toward the right side of the scales, with the hierarchical leading style and relationship-based trusting being the dominant features (Figure 4.3). As especially the latter two directly influence the solutions around authority and trust and openness cultural elements, this further indicates that the Turkish national organizational culture might have a significant impact on aspects around organizing the FSC survey and its involvement. It might also shed light on some of the basic underlying assumptions around FSC maturity.

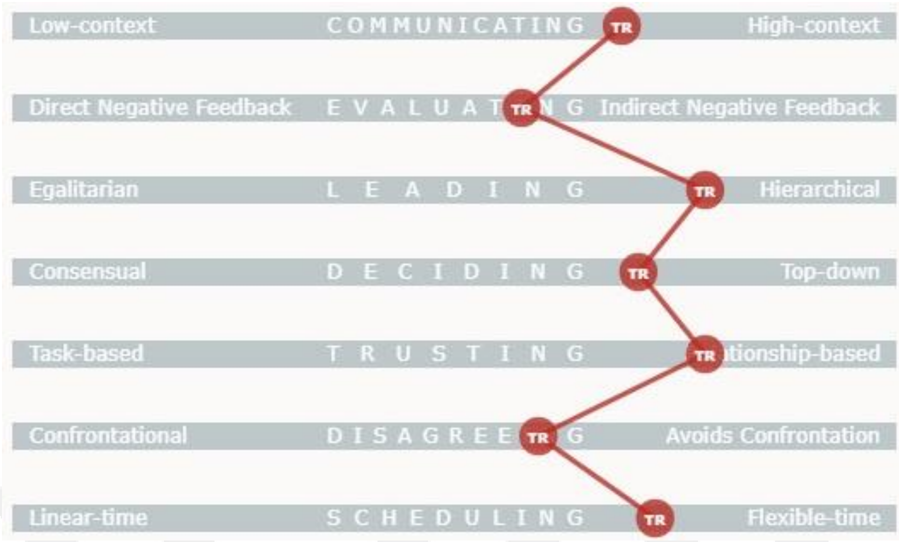


Figure 4.3: The culture map of Türkiye (Meyer, 2023).

Source: Meyer, 2023

4.2.2. Conceptual Framework: Data Analysis

The work on national culture norms of Türkiye in conjunction with behavioral change principles were used to interpret the behavioral artifacts of how companies went about organizing the survey (Table 4.3).

4.2.2.1. Tangible Limiting Factors/Inhibiting Pressures

The limiting factors/inhibiting pressures could be interpreted as tangible, like lack of resources and intangible like organizational culture norms (Table 4.4). While C1-4 did not address the tangible limiting factors/ inhibiting pressures and expected the frontline to fill in the survey during their lunch and/or shorter break times, C5 was the only one to address this. However, only for the production part, not for the OSF. At the start of organising the survey the senior manager decided to allocate resources like people (the frontline supervisors) to see through the survey and time and computers for the frontline to participate in the survey.

In contrast to C5, C3 decided to allocate resources, as a possible solution, after seeing the low participation rates. While C3 showed a reactive approach of *"… invest if we must"* indicating to a stage 2 FSC maturity in the Values and mission dimension, C5 was aware of the need and took action before an issue occurred indicating to a stage 3 maturity (Jespersen et al., 2019).

Further to the resources allocated by C5, as per hierarchical leading tendencies the frontline supervisors might not be inclined to share their space and belongings, like computers, table, chair, which in turn might lead to ill feelings towards the survey, impacting their intention to get involved, like participating and advocating others to participate. This was also reflected in the following observation:

During a capability building session for the frontline supervisors to be able to see through the survey, when the QMA said that they were expected to allocate their computers, some of the frontline supervisors, surprised, asked whether they had understood correctly and some suggested to obtain separate computers or tables for this purpose. After the QMA announced that the decision had already been made by the operations director (OD), the frontline supervisors did not offer further input.

Although, the OD shows readiness to invest and act upfront, the approach might have had unintended negative consequences and thus be a limiting factor/inhibiting pressure in obtaining the targeted survey participation rates.

Table 4.4: Inhibiting pressures/ limiting factors and aspects of demand-pull,

Limiting factors	**Companies´ approach based on the collected data of this study**
Tangible limiting factors	
Lack of antecedents, like resources (e.g. access to the survey, necessary skills, time (Braksick, 2007; Wallaert, 2019, Senge, 2006).	Only C5 allocated resources like time, computer, people (for production, not for OSF).
Intangible limiting factors	
As bottom-up initiative is not expected per hierarchical leading tendencies, workers might not understand the need or take initiative to participate in the survey. (Meyer, 2023)	Only C2, C3 and C5 explained the importance of the survey to the frontline before the survey, also enabling them to ask questions. However, none of the companies created an opportunity for the frontline to ask questions at their convenience.
Workers might not ask questions and share barriers to participating, due to hierarchical leading and/ or high context communicating tendencies. (Meyer, 2023)	

Aspects leading to demand-pull	
Antecedents like the responsible staff having the necessary level of intimacy/ relationships to get people to collaborate in organizing the survey (Braksik, 2007; Meyer, 2014).	C2 invited frontline leaders to collaborate on getting the word out on the survey, but they did not show initiative. Companies' FSC evaluation data should also be considered on whether they encourage collaboration.
Antecedents, like organizing communication through leaders, due hierarchical leading tendencies or through people with good relationships, due to relationship-based trust building tendencies, as they might function as <u>influencers</u> (Braksik, 2007; Meyer, 2014). These aspects might also be used to set <u>consequences</u>, like leaders following up, announcing participation rates and rewarding and recognizing departments for high participation (Braksik, 2007; Meyer, 2014).	C1-C4 did not use leaders to communicate the survey. C5 used frontline leaders to see through the survey. The QA / QMA were the main communicators of the survey. If they have not established good relationships as per relationship-based trusting or they do not have the necessary authority as per hierarchical leading cultural tendencies, their communication might not be influential. What is more, it might be considered disrespectful if another manager directly requests something from other managers´ team members as hierarchical leading in turn damaging relationships and with that trust (Meyer, 2014; Meyer, 2023).
Direct verbal communication is more effective compared to written communication, as per relationship-based trust building and high-context communication (Meyer, 2023).	All companies communicated mainly in writing, with limited verbal communication.

C1-5: participating company codes. QA: Quality assurance department; QMA: Quality management assurance responsible; OSF: other support functions.

4.2.2.2. Demand-pull Approach to Change

National culture tendencies could also help to better understand possible intangible limiting factors/inhibiting pressures and aspects creating a demand-pull (Table 4.4). The two distinctive Turkish national culture characteristics highlight that leaders (as per hierarchical leading tendencies) and/or people with good relationships (as per relationship-based trust building tendencies) could have an influential impact on others (Meyer, 2014) and are thus important in creating a demand-pull. A parallel might be drawn with influencers defined by the GFSI: "*A person or group with the ability to affect the behaviour, opinions or actions of others*", (GFSI, 2018).

As influencers, the QA/QMA in C1-4 took lead in communicating the survey throughout the company and in C5 with the OSF, as production was decided to organize everything by themselves. Only in C3 and C5 did they give an effort to involve the senior managers, which was done to brainstorm how to organize the survey (stage 2-3 in Values and mission dimension). However, the fact that both the production and factory managers were about to quit C3, might have had an overall negative impact on the process.

The quality manager (QMs) in C1 and C4 communicated the survey only in writing (e.g. email, poster, messages). From the start, C1 said they would like to skip any communications, not to waste time and directly send out an email with the link at the start of the survey (FSC maturity stage 1-2 in Adaptability dimension). C4, on the other hand, had planned communication before the start of the survey, but were not able to realize due to lack of key technical staff. So, they opted to communicate the survey just through email. Thus, C1 and C4 did not use verbal communication, which might have been effective in creating a demand-pull.

The QMA in C2, QM in C3 and QMA in C5 communicated the survey verbally before its start, encouraging the frontline and their leaders to participate and creating an opportunity for them to ask questions. The QM in C3 introduced the survey in a training session to all of the frontline, asking everyone to participate, whereas the QMA in C2 did that with the frontline leaders, additionally asking for their help in communicating the survey, who were skeptical about its usefulness and were not inclined to collaborate (stage 1-2 in People system dimension). This is especially noteworthy, as C2 was the only company who incentivized collaboration by having both individual and team based KPIs.

Furthermore C2, C3 and C5 directly addressed the frontline and/or their leaders regarding the survey, leaving out the middle management. Especially, C5 had the most contrasting case of lack of communication. While QA/QMAs in C1-4 solely took the lead in communicating the survey throughout the company (Figure 4.4 A), QMA in C5 gave an effort to do that through the OD (stage 2-3 in Adaptability dimension for using behavioral tactics) (Figure 4.4 B, yellow outline). With the direct subordinate managers present, the OD decided that their frontline team leaders should allocate their time and computers to have the frontline participate in the survey. Interestingly, the managers, who had witnessed the decision of the senior manager, had not clearly forwarded this to the frontline team leaders, as the necessity for them to allocate their time and computers came as a surprise during the capability building session with the

QMA, during which the QMA had to point out that the decision to do that has already been made by the GM (Figure 4.4 B, orange outline). That even the FS related decisions, which should be communicated down the hierarchical cascade, are left to the QMA to communicate, is a sign of low involvement and of the QMA being considered as the main responsible behind food safety (stage 1-2 in People system dimension). The team leaders ended up calling frontline workers one-by-one to their offices to complete the survey, giving survey participation a more compulsory tone.

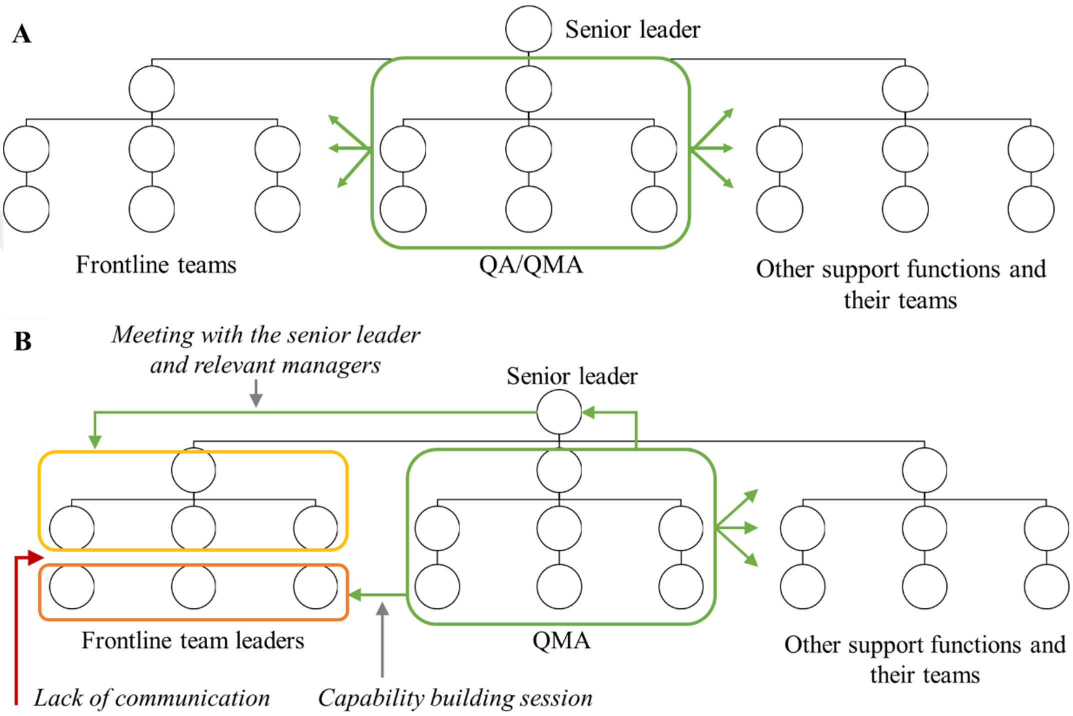


Figure 4.4: Communication patterns between different positions in the companies. A: at C1-4, the QA/QMA department´s supply-push through the organizational cascade. B: at C5, the QMA department´s supply-push through the organizational cascade. QA: Quality assurance department; QMAs: Quality management assurance responsible.

Source: Prepared by the researcher.

In all cases, no pre-survey communication was organized for the OSF. Just C1, C2 and C3 had the marketing department design posters to share the survey QR code in a visually effective way. Furthermore, C5 assumed that since the OSF staff have computers, emails, and telephones ready at hand and can more easily allocate time compared to the frontline, that their participation would not be a problem. However, their participation in the survey was not so much limited by tangible, but the intangible limiting factors/inhibiting pressures. The OSF employees thought the survey notification email was sent to them by mistake and they were not meant to participate, as it was about FS. In C3, as well, the QM expressed confusion of the OSF staff to why they were expected to participate, as they are not related to FS. Thus, already, the low participation rates and the lack of communication with the OSF is in itself a sign of siloed work regarding food safety (FSC maturity stage 2 in People system dimension). However, many OSF directly have a role in decreasing food safety risks, in addition to all of them with the potential to contribute with their wide range of competencies individually or in cross-functional teams (GFSI, 2018).

While creating an opportunity to ask questions by communicating face-to-face with the frontline before the start of the survey might have been expected to have an impact in overcoming limiting factors/inhibiting pressures and creating a demand-pull (Tabel 4.4), looking at the low participation rates, the impact remained low. This might have multiple reasons:

- As the Turkish company culture has hierarchical leading tendencies, it is not common to ask input top-down or give it bottom-up. The latter might not necessarily be out of fear, but respect (Meyer, 2014; Meyer, 2023). Thus, the frontline might not understand the need or see the use in bottom-up input, especially if the learning/consequences history has proven that when they do report or make suggestions nothing will change anyway (Braksick, 2007). An example could be brought from a focus group discussion in C3 (Subchapter 4.3), where an operator said that his suggestions on allergen issues had not been taken into consideration. He felt especially strong about this, because he and his family have had difficult times due to allergens from some foods. Now, when the QA/QMA or other leaders invite everyone to participate in the survey, its impact would be questionable.
- Just encouraging people to give input is not enough, another aspect impacting learning/consequences history, is the extent psychological safety has been established. "*Psychological safety exists when people feel their workplace is an environment where they can speak up, offer ideas, and ask questions without fear of being punished or embarrassed* (note: negative consequences history)" (Edmondson, 2019). If not managed well, it is common for people with lower hierarchical status to feel less psychologically safe in the presence of members

with higher status (Edmondson, 2019). However, the stronger the hierarchical leading tendencies/power distance the more responsibility falls on the leaders, as they determine the psychological safety foundation of their teams (Schein & Schein, 2019). Thus, while having team leaders/managers directly communicating the survey might exert more influence as per hierarchical leading tendencies, a consequences history leading to poor psychological safety of the team would diminish this influence. In this case, if the QA/QMA has established a better consequence history, they might be a better choice as communicators. If not, again their influence would be questionable.

- If the QA department has not built necessary relationships or worse, have a negative consequences history, they could also not be considered as influencers. This is especially important since relationship-based trust building tendencies have an impact throughout the company, as "I know others well who trust you, I trust you" (Meyer, 2023) could also work in reverse as "I know others well who do not trust you, so I do not trust you", resulting in low company-wide involvement and interest in the activities of the QA/QMA department. To some extent this might be the case with all participating companies, as it was found in FSC evaluations (Subchapter 4.3, section 4.3.5.) that the role of the QAs/QMA was to control, followed by negative consequences, resulting in a poor relationship foundation. For instance, C1 explicitly brought out their distrust of frontline workers, while C3 reflected conflicts between QA and production related departments, indicating the QA might not be the best choice for communicators.
- Although QMs and QMA are the leaders of specific departments, they are not the direct leaders of frontline staff. Not only would they have a lower impact compared to direct leaders, but as per hierarchical leading tendencies it might be considered disrespectful if another manager directly requests something from other managers´ team members, as communication is expected to follow a hierarchical line (Meyer, 2014). If the right tone has not been set from the start by the direct superiors, like explaining to their teams that communication from the QA department is expected and accepted, this might have the opposite of the intended impact, becoming a limiting factor/ inhibiting pressure to survey involvement.
- In all cases the QA/QMA did not follow-up on whether the people they contacted actually took action. This is important for a couple of reasons. First, people might

not directly say “no” to participating or advocating the survey, due to high-context communication and confrontations - avoiding tendencies. Interestingly, the QA/QMA did also not have their direct superiors follow-up, which might have had an impact as per hierarchical leading tendencies. Second, following-up is also a consequence, creating somewhat of an accountability to see the intended or planned behaviors through, if they agreed to get involved (Braksick, 2007).

FSC evaluations (Subchapter 4.3, section 4.3.5.) showed that in all the companies the QA/QMA were the main drivers behind food safety assurance, which might be the case why they chose to stay as the main communicators of the survey. The basic assumptions stemming from national organizational culture might enable to better understand why this is the case and why the QA/QMA were not interested in expert suggestions to involve other leaders in communicating and/or advocating the survey:

1. As per hierarchical leading tendencies it is not common to ask input top-down or give it bottom-up. This results in low initiative bottom-up, where direction setting is expected top-down (Meyer, 2014). Thus, the QA/QMA would not be inclined to show initiative bottom-up to get the superiors to advocate the survey.
2. As per hierarchical leading tendencies, competence is expected from leaders in their areas. Thus, asking input or help might come off as being incompetent (Meyer, 2014). Thus, the QA/QMA might not be inclined to include others in organizing the survey as food safety related topics should be their area of expertise. Thus, it might not even be that the senior management would not be willing to get more involved. These basic assumptions were also directly identified in C2, C3, C4 during FSC evaluations (Subchapter 4.3, section 4.3.5.).

As it is not common to ask input top-down or give it bottom-up due to hierarchical leading tendencies (Meyer, 2014), this could also explain why in addition to not creating an environment to ask questions and share concerns, the QA/QMA did not inquire from the frontline reasons behind lack of participation in the survey after its start. Thus, instead of “*Studying*” the reasons behind low participation by obtaining frontline feedback as part of “*Plan, do, study, act*”, which indicates stage 4 of FSC maturity under the Consistency dimension, the whole process of organizing the survey was more similar to “plan, do, check, act”, indicating to stage 2. This is coupled by the fact that the QA/QMA in all companies stated that they expected higher participation rates, as brought out in FSC maturity stage 2 norm’s description of “*Having expectations of 100% perfect solutions from the start*”, (Jespersen et al., 2019).

When it comes to behavior, in “plan, do, study, act”, the emphasis is on ‘studying’ inhibiting pressures/limiting factors and how to create a demand pull. An example to illustrate this could be brought from FSC evaluation semi-structured interviews in C4 (Subchapter 4.3, section 4.3.4.), where short breaks, over hours and staff shortage at the frontline, could be considered as serious limiting factors to survey participation.

4.2.2.3. Supply Push Approach to Change

By not addressing limiting factors/inhibiting pressures, not creating a demand-pull and simply asking/demanding employees to participate in the survey, the companies used a supply-push. While in companies 1- 4 and in 5 only regarding the OSF, the supply-push was exerted directly through the QA/QMA, in company 5´s production part, the QA/QMA organized the supply-push through the senior manager. They not only failed to leverage hierarchical leading and relationship-based trusting tendencies, but their approach ultimately worked to their disadvantage by creating additional limiting factors e.g., with people of questionable influence being the main communicators.

Senior leader´s inclusion was limited to seeking their input and decision authority in companies 3 and 5 to allocate resources. Thus, senior leaders were included, not to communicate and exert influence, but to support establishing the supply-push. From the start, the QMA in company 5 used senior management authority as leverage to exert a stronger push, assuming that solely the QMA push would not be enough to achieve targeted participation rates. In the end, in both the OSF and production parts, the QMA in company 5 exerted a push, with just a more command-and-control-hierarchy-based push in the latter.

The companies followed natural tendencies described by both Senge, (2006) and Wallaert (2019), which are to focus on and increase promoting pressures/reinforcing processes to bring about change (Senge, 2006; Wallaert, 2019). As they made verbal and written reminders and asked for help with the survey upon seeing the low participation rates, they ultimately increased the supply-push. Through this approach, the companies also focused on antecedents, rather than setting consequences (e.g. following-up, having visible metrics or including giving rewards, leaders’ actions, like described under primary embedding mechanisms), which are more effective and could be leveraged to create a demand-pull.

4.2.3. Conceptual Framework

By using the theoretical background on behavior, management and organizational culture science, in conjunction with the data collected through semi-structured interviews on how companies went about organizing the FSC survey (reported behavioral artifacts) and tying this with the low participation rates, a conceptual framework emerged, demonstrating the impact of national culture on these aspects (Figure 4.5). Namely, the basic underlying assumptions stemming from national organizational culture enable to infer possible limiting factors/ inhibiting pressures, which might lead to low involvement, and aspects important for creating a demand-pull, which should be addressed to exert influence for involvement. This in turn enables to interpret the data collected on behavioral artifacts on whether the companies addressed the possible limiting factors/inhibiting pressures and whether they used a demand-pull or a supply-push approach. In the end, it was found that national culture may shape both limiting factors and aspects of demand-pull and also the basic assumptions, which might prevent people from addressing them.

As there might also be other factors, in addition to national culture, which might impact limiting factors, aspects of demand-pull and basic assumptions within the organizational learning history, like occupational and religious macro cultures (Schein & Schein, 2017), these were also brought out in Figure 4.5 and could be subjects for future research.

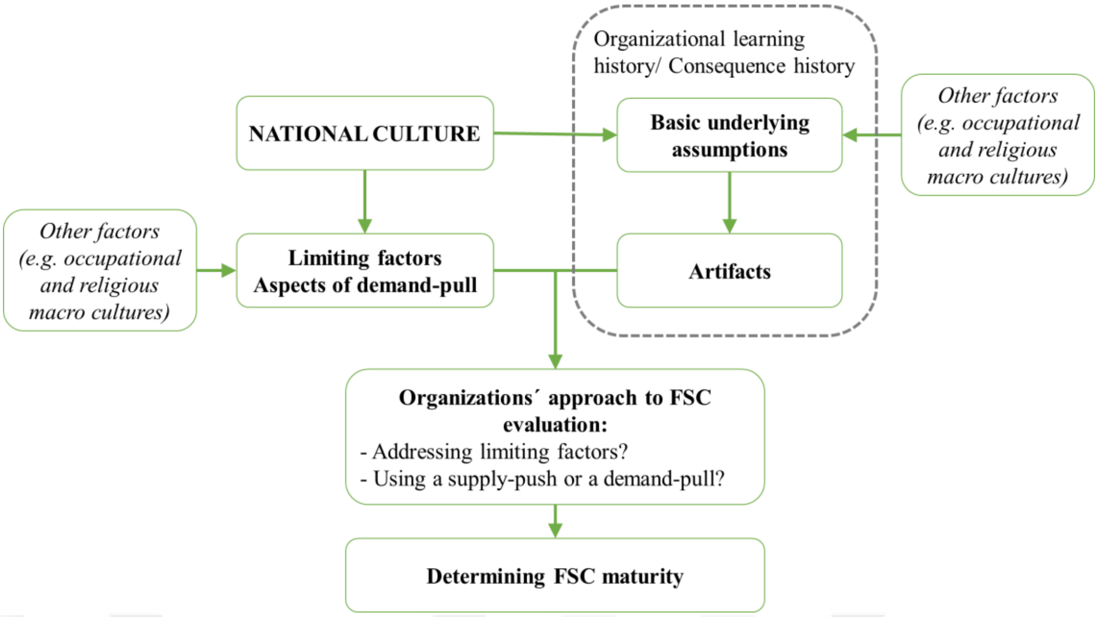


Figure 4.5: The conceptual framework on using basic assumptions stemming from national culture to interpret artifacts in the light of FSC maturity. FSC: food safety culture.

Source: Prepared by the researcher.

4.2.4. Discussion and Conclusion

The basic assumptions of Turkish organizational culture enabled to better decipher artifacts around companies organizing their FSC surveys, like why the QA chose to be the main organizer and communicator and why their efforts had a low impact. These artifacts also gave insight into FSC maturity. As for specific FSC dimensions, these insights were as follows,

- Adaptability: use of minimum or inefficient change management strategies or trying different methods after low participation rates became apparent, in other words ‘reacting’ to an issue, demonstrates stage 2 FSC maturity. There were just some differences in companies’ approaches. For instance, C5 involved a senior manager, shifting some responsibility to the frontline (stage 2-3). On the other hand, C1 specifically stated that they would like to skip any communication before the start of the survey and did not take any action even after low participation rates became apparent (stage 1-2).
- People system: In all companies, the QA was the driver behind the project, minimally involving others (stage 2). Additionally, the QA skipped the middle management and communicating directly with the frontline (stage 2).

The participating companies using a supply-push approach and not addressing inhibiting pressures/limiting factors also gives insight into their FSC, as a supply-push is aligned with the lower, while taking a demand-pull approach with the more mature end of the FSC maturity scale, as elaborated in section 4.2.1. and depicted in Figure 4.2. The lower FSC maturity was also reflected from the FSC evaluation results presented in Subchapter 4.3.

As the supply-push approach did not lead to anticipated participation rates, the companies should work towards a demand-pull, which on the other hand would mean the start of an organizational learning process as per the Competency Model or in other words maturation of FSC (Figure 4.2). Thus, it could be said that it is important to mature FSC to a given level, before using quantitative evaluation methods, which encompass majority of companies' employees, such as the survey.

The conceptual framework (Figure 4.5) could be used as a tool in this learning process to support companies in comprehending the impact of national organizational culture tendencies on their behavior and decisions and how changes in this foundation would enable to mitigate hierarchical and departmental challenges common in the Turkish organisational setting and apply promoting factors to achieve desired behaviors within the companies. The conceptual model could also be used as an analysis tool in the context of other countries to put forth possible foundational challenges and opportunities with regards to FSC, stemming from national organizational culture. For instance, the main challenges and opportunities identified in the Turkish context could be as follows:

Challenge: as organizational culture tendencies, like hierarchical leading, could guide companies toward working in silos and not speaking up, especially to upper positions. Opportunity: hierarchical leading and relationship-based trust building tendency could be leveraged in both communications regarding the company-wide survey and as a strategy to mature FSC, by empowering managers, leaders and influencers in food safety management.

Although maturing FSC before evaluating it, might seem to contradict existing research, that it is important to first measure and then accordingly choose and apply tools to improve FSC (Spagoli, Jacxsens & Vlerick, 2023), this study adds a nuance to this process, suggesting using multiple methods other than survey, including studying national culture, to gain an estimation of existing foundational FSC and the challenges that need to be overcome to build on this foundation. This should also be considered by 3rd parties (e.g. certifiers, inspectors, consultants) when guiding companies regarding FSC evaluation. On the other hand, the way companies go about organizing the company-wide FSC survey could also be used to gain insight into companies' basic assumptions to make conclusions on FSC maturity.

The limitations of this study are the small number of participating companies and taking the Meyer's (2023) cultural map at face value, without assessing companies' organizational culture tendencies. However, the multiple case studies giving similar input regarding companies' approaches in organizing the survey, to some extent mitigates the limitations by strengthening the foundation to make theoretical generalizations, compared to having variation in companies' practices (Robson & McCartan, 2016).

4.3. Food Safety Culture in Large-sized Food Production Companies in Türkiye

This chapter presents the results and discussion of one of the research focuses of this study, aiming evaluate food safety culture maturity in large-sized food production companies in Türkiye. For this purpose, first a literature review was conducted presented in (Chapter 2), followed by its meta-synthesis for initial insights and research gaps on FSC in food production companies Türkiye (presented in Subchapter 4.1) and finally, using a method triangulation approach, direct empirical insight on FSC in food production companies were obtained and analyzed, leading to formation of the current chapter.

As described in the research methodology Chapter 3 (section 3.3.2.), first, data of individual companies was analyzed on FSC dimensions, the Values and mission, Adaptability, Consistency, Risks and hazards, People system (Appendix 7). Then the data under each dimension of each company was gathered in tables as summary findings (Appendix 8), which were used to make inferences on FSC maturity based on the maturity model (Appendix 9). In this chapter, results were presented under FSC dimension subheadings, accordingly. Under each subheading, first, the results on FSC maturity are presented, followed by a detailed discussion of how these maturity stage numbers were obtained. The results tables at the beginning of each subchapter also include FSC maturity-related conclusions from Subchapter 4.2, the survey organizational process.

As the collected data enabled to determine the approximate FSC maturity stages, stage intervals (e.g. 1-2 … 4-5), in addition to whole numbers (e.g. 1 … 5) were used. When calculating the overall score for a dimension, the averages of intervals were used. The meanings behind the FSC maturity stages of different dimensions could be found in Appendix 9, which presents the FSC maturity model by Jespersen et al., (2019).

At the end of each section is a discussion comparing the findings of this chapter with findings of Subchapter 4.1 on the FSC maturity meta-synthesis. After the discussion under each of the dimensions, a conclusion of the FSC maturity results was presented. Then, 3rd party food safety management system (FSMS) certification scores were presented, enabling to compare and contrast these with the FSC maturity results. Finally, a summary of the key findings was brought out in the discussion.

4.3.1. Values and Mission

The results for FSC maturity in the Values and mission dimension are presented in Table 4.5. C1 had the lowest stage of 1.8, while C5 had the highest FSC maturity stage of 2.3. The following section includes a detailed discussion on how these results were obtained.

Table 4.5: FSC maturity stages of participating companies in the Values and mission dimension,

Aspect	C1	C2	C3	C4	C5
Management involvement					
Senior management involvement important upon problems; no specific messaging.	2*	2	2	2	2
Senior management involvement: reporting and meetings	1-2	2-3	2-3	1-2	2-3
Direction setting					
KPIs at the top management level	2	2-3	2	2	2
Discrepancies in norms (discussed under People system dimension)	1-2	1-2	1-2	1-2	1-2
Lack of company-wide cascading performance measures (discussed under Consistency dimension)	1-2	2	2	2	2
Commitment and priorities					
Mitigate food safety risks in response to external auditing	2	2	2	2	2
Investments	2-3	-	2-3	2-3	3
Other priorities than food safety	-	1-2	2	1-2	2
FSC evaluation survey					
Getting the senior managers on board	-	-	3	-	3
Allocating resources before the survey	-	-	-	-	3
Ready to allocate resources after its start to solve the participation problem	-	-	2	-	-
Average scores	**1.9**	**2.0**	**2.2**	**1.9**	**2.3**

'-': no data or practices; *: the numbers in the tables represent FSC maturity scores, which are explained in section 3.3.2.; C1-5: participating company codes.
Source: Prepared by the researcher.

4.3.1.1. Management Involvement

Looking at the norms around senior management involvement, in all companies the GM is involved especially when resources need to be allocated and investments need to be made, indicating stage 2 maturity. Furthermore, no specific messaging on food safety by management was identified.

In C1 and C4, the GM is involved the least, participating in annual reviews in the former and taking part in ad hoc meetings in the latter. In C4, however, the factory/site managers (FM) do participate in monthly food safety related online meetings. As their GMs do not expect to be routinely informed, their FSC maturity is at stage 1-2. The low involvement of the GM might be due to the QA departments having been newly established, while other companies' QA departments have been functional for nearly a decade.

The GMs are a bit more involved in C2 and C3, by participating in monthly food safety meetings to discuss problems. Additionally, the GM in C2 gets a monthly report, including aspects like microbiological sampling and GMP results, while the GM in C3 gets monthly reports on managers' KPI status. Although in a reactive mode of being needed especially when there are problems, the senior management is more involved, indicating a maturity stage between 2-3.

C5 is the most contrasting company compared to others. While the GM does not participate in monthly food safety meetings, instead the operations director (OD) does, he and other board members are in the cc of every reporting email, including microbiological analyses and GMP results. They are also in WhatsApp groups and are instantly informed and even intervene when there are issues, like consumer complaints. The GM and the board are all members of the family, who have grown up working and have become experts in their sector, thus, according to QMA, they are well aware of their products and production. According to the QMA, the OD and GM are available practically on demand either face-to-face or phone call and there is no need for any meeting to make decisions. Thus, organizing annual reviews is challenging to the QMA as the senior leaders are already up to date with issues. Although the GM is not actively present in meetings, he is involved, indicating to a stage 2-3

4.3.1.2. Direction Setting

Although to some extent or another, senior leaders are informed of food safety issues, none of the companies have food safety related performance measures at a senior management level, showing low involvement and direction setting in food safety (stage 2). A slight exception might be C2, as they have cascading KPIs from GM, with one KPI being related to process improvement to organize reviewing of all the procedures and another with a structured approach to identify and solve root causes around main consumer complaints (discussed in detail under the Consistency dimension), indicating at first sight to a higher maturity stage of 2-3. However, the QM and QMA both stated that problem identifying and solving is expected from the QA, including goals around above-mentioned root causes, leaving the maturity more towards stage 2, than 3.

4.3.1.3. Commitment and Priorities

All companies took action to mitigate food safety risks in response to external auditing, mentioning conducting training (C1, C3, C4), FSC survey and policy updates (C1, C3), closing non-conformities (C2), completing meeting reports (C5) as preparation for external audits. As external pressures drive food safety, this indicates to a stage 2 maturity.

Whether through interviewees' or companies' mission/vision/value statements, all companies reflected the espoused values that food safety is important. Companies also demonstrated commitment to food safety through various investments, like

- C1 and C4 have demonstrated their commitment by establishing a QA department a couple of years ago.
- C1 and C3 have demonstrated their commitment by working towards and obtaining an external GFSI benchmarked food safety certificate.
- C5 has demonstrated their commitment by having 2 GFSI benchmarked food safety certificates for over a decade and allocating resources for seeing through the FSC survey.
- C3, C4 have demonstrated their commitment by recently renovating infrastructure. However, in C3 these investments have been on hold for over a year after the founder passed away.

These all show that these companies do not doubt the need to invest in food safety, indicating to stage 2. However, to decide whether companies are at a stage 3, more information is needed on their motives. For instance, C5 has 2 external food safety certificates, because it helps them to stay ahead of the game, indicating that they invest to improve and with that to stage 3, while C1 got the certificate to meet consumer demand, indicating to stage 2.

At C2 and C5, the two biggest companies as per employee number, with the longest standing QA teams and the longest holders of GFSI benchmarked food safety certificates, interviewees reflected that there are no issues with investments to food safety, but also that sometimes food safety might not be prioritized to meet production goals. Additionally, in C2 while managers and some frontline focus groups reflected that there are no issues with allocating resources and/or making investments, department operators brought out long-standing lack of properly working hygiene barriers, issues with washing of containers (both also apparent from observations), in addition to issues with wages, high order amounts, lack of properly trained staff, lack of time and water for cleaning properly.

Similarly, in C4, investments started to be made (e.g. infrastructure, hygiene barriers, QA department) and there are plans to make more, however, interviewees also brought out issues, like lack of ownership from managers on following food safety rules, production lines' high speed, over-worked and tired employees and the resulting lack in cleaning and its training. Already, interviewees stated that at times food safety related aspects are not the first priority, due to their mission.

Thus, while C5 to some extent (reports from some manager) demonstrated inconsistencies in decision making and values around food safety (stage 2), C2 and C4 revealed these to a larger extent (reports from managers and the frontline), indicating to FSC maturity between 1-2.

This does not mean however, that these kinds of consistencies do not exist in C1, just that the existing data did not reveal any of them explicitly. What is more, they might even have low awareness about making compromises around food safety, as there were signs of

- working in silos, as the frontline confused food safety with worker safety and the GM perceived frontline's food safety risk awareness to be good (discussed in detail under the Risks and hazards dimension), and
- having limited self-reflection, as the middle managers (PM and QMA) were blaming the frontline, rather than showing signs of realizing how they themselves contribute to the problem (discussed in detail under the Consistency dimension).

4.3.1.4. Comparison of Meta-synthesis and Empirical Findings

The findings from the meta-synthesis (Subchapter 4.1, section 4.1.1.) and the empirical findings of this chapter support each other, as they both indicate to companies' priorities not being focused on food safety, unless there are external pressures, like 3rd party audits. This chapter also offers novel contributions regarding insights on the involvement of senior management, their direction setting and its impact on performance measures and different departments' expectation and use of consequences (Table 4.6).

Table 4.6: Meta-synthesis findings (Subchapter 4.1) and the empirical contributions of this study regarding the Values and mission dimension,

Findings from literature	FSC related meta-synthesis of this study	Empirical findings of this study
Food safety does not tend to be one of the business priorities (Karaman et al., 2012; Azak, 2011; Gül Özdoğan, 2009). Aspects like decreased consumer complaints, increased product quality and compliance with legislation are the main perceived benefits of FSMS, instead of food safety (Karaman et al., 2012; Demirbas & Karagözlü, 2007; Dilek & Üçüncü, 2022).	Food safety is not perceived as a priority, as companies fail to see its benefit, as external pressure (like compliance with legislation and consumer complaints) drive food safety.	- Willingness to invest, but production goals guiding decision-making. - External pressures, like the 3rd party audits driving food safety.
	-	- Minimum senior management involvement. - Lack of food safety related direction setting and goals and performance measures.

FSMS: food safety management systems.
Source: Prepared by the researcher

4.3.2. Adaptability

The results for FSC maturity in the Adaptability dimension observed in this research are presented in Table 4.7. C1 had the lowest, while C5 had the highest FSC maturity of 1.7 and 2.3, respectfully. The following section includes a detailed discussion on how these results were obtained.

Table 4.7: FSC maturity stages of participating companies in the Adaptability dimension,

Aspect	C1	C2	C3	C4	C5
Change management	2*	2	2	2	2
Frontline involvement and capability building					
- Expected to follow rules and report problems	2	2	2	2	2
- Production additionally expects improvement suggestions	-	2-3	2-3	2-3	2-3
- Distrust in employees	1-2	-	-	-	-
- Frontline grading system	-	-	2-3	-	-
Productive listening and responding to the frontline					
- Soft-skill capability building	1-2	2	2	2	2
- Difficulties with productive listening and responding	1-2	2	2	2	2
- Examples of inconsistencies and capabilities	-	2-3	2-3	2-3	-
Dealing with challenges					
- High number of new employees.	2	2	2	2	2
FSC evaluation survey					
Using a supply-push, showing minimum usage of behavioral science in change management	1-2	2	2	2	2
Could not adapt to challenges with the lack of work force	-	-	-	1-2	-
Quality assurance department including the frontline	-	2-3	-	-	2-3
Frontline not inclined to collaborate	-	1-2	-	-	-
Frontline involvement the lowest	1-2	1-2	-	-	-
Using communicating tactics before the survey	1-2	2-3	2-3	2	2-3
Knowingly using behavioral tactics, like getting the operations director to decide.	-	-	-	-	3
Average scores	**1.7**	**2.1**	**2.2**	**2.1**	**2.3**

'-': no data or practices; *: the numbers in the tables represent FSC maturity scores, which are explained in section 3.3.2.; C1-5: participating company codes; FSC: food safety culture.
Source: Prepared by the researcher

4.3.2.1. Change Management

The adaptability of companies is at a maturity stage 2, because companies did not report using any change management strategies and it is left up to the production to implement changes in whatever way they see appropriate. The QA just notifies every one of the changes.

4.3.2.2. Frontline Involvement and Capability Building

In all the companies, the frontline is expected to follow rules and report problems (stage 2), while production-related interviewees in C2-C5 additionally stated to expect improvement suggestions (stage 2-3). C1, on the contrary reflected distrust in the frontline (stage 1-2). These findings are also consistent with C2-5 having or working on company-wide improvement suggestion initiatives together with rewards, unlike C1. C2 is working on setting up this system, while C3, C4 and C5, did this once/couple times and then it was either not continued or the enthusiasm died down, indicating that this has not become a company culture norm of listening and giving feedback, which will not be thus considered to have an impact on food safety practices and through that FSC maturity.

What makes C3 stand out is that for a couple of years the GM together with the production are giving an effort to implement an employee grading system, including the frontline staff, with each grade having a different set of accountabilities. The system differentiates the frontline staff based on whether they are newcomers, how many production lines they are proficient in and how many other staff have they trained, like this motivating them to learn and share their know-how. The GM has aspirations to set up trainer's trainings for the grades starting to teach others and build the capabilities of the frontline to notice issues, warn and take action and have the managers act on it and not turn a blind eye. The evaluation system includes food safety, in that at a certain point employees cannot progress, if they do not follow hygiene rules. As such, it indicates to working on company-general, rather than food safety specific, norms, indicating to a FSC maturity between 2-3, rather than a stage 3. Interestingly, the QA has no role or involvement in this system, as this is '*something that the production does*', indicating a gap between the functions and with that to subcultures/silos (discussed further under People system).

4.3.2.3. Productive Listening and Responding to the Frontline

While it is important to give an effort to include frontline in change and problem solving, it is equally important to do that efficiently, like having norms in place around productive listening and responding, to create a positive consequence history of psychological safety that the frontline would be inclined to contribute. This requires intentional development of these soft skills (Edmondson, 2019). While in C1 there is none, in C2-C5 according to interviewees, they or white-collar managers/supervisors have had some soft skill training (e.g. leadership, time management, communications, personal development) at some point of working in the companies. For instance, for C1-C3 and C5 2022 performance documents show no such training. Thus, companies have not pinpointed specific skills and behaviors aligning to their values and as such there is a lack of targeted soft skill training. As a result, nuances like productive listening and responding, are left under the influence of their individual learning (stage 2). Thus, while managers in C2-C5 say they would like the frontline to make suggestions, there is not enough data to decide whether they actually listen and respond productively to create a positive learning history for the frontline to do so. Examples of inconsistencies in expecting input and lack of productive listening and responding capabilities are as follows,

- In all companies, whether through observations or semi-structured interviews, the QA demonstrated difficulties/lack of capability around productive listening and responding to frontline workers. This is worrisome, because like this, they will not be able to take appropriate action even after problems are reported, not even involving the frontline reactively, indicating to a FSC maturity stage below 2. For instance, in C1 in the one lavatory with 4 sinks, meant for all ca 150 women of the frontline, there was one air drier for hands. Upon a frontline worker pointing this out as a problem, she was confronted with multiple negative consequences, of being told not to be giving enough effort and scolded for wearing bracelets (negative consequences, stage 1-2 in People system). This in turn creates a negative consequences history for her, others around her and the ones in the company they share this incidence with.
- Although C3 and C4 gave an effort to include the frontline members in meetings (daily huddles and monthly food safety meetings), these also include various managers, site leaders and/or the GM and as discussed before, if not managed well, it is common for people with lower hierarchical status to feel less psychologically safe in the presence of members with higher status (Edmondson, 2019). In addition to not having intentionally worked towards such values and capabilities, semi-structured interviews reflecting conflicts between the QA and the frontline and frontline members reporting that they had made suggestions to solve problems and improve processes on issues directly related with food safety, but with no further

feedback or change, leads the impact of frontline involvement in these meetings questionable. This indicates a FSC maturity rather between 2-3, than 3.

- Similarly, C2 has people development KPIs in place, to have the frontline participate in improvement projects and make improvement suggestions, which is tied to a bonus system. Although data is missing on the effectiveness of the system and to what extent it impacts food safety, this system does demonstrate an effort towards involving the frontline, indicating to FSC maturity at the Adaptive dimension being more than in just at the reactive stage of 2. However, as this initiative is not directly related with food safety, the FSC maturity is less than 3, thus remaining between stages 2-3. On the other hand, a focus group with frontline leaders revealed multiple issues, which had not received enough attention by the management so far, leaving the impact of these initiatives questionable and the company at a FSC maturity stage between 2-3, rather than 3.

4.3.2.4. Dealing with Challenges

All companies brought out challenges with high turnover of the frontline, resulting in trying to keep up with training everyone, having to speed up training and dealing with the lack of proper habits, ultimately leading to more reminding, warning and training again as preventative and corrective measures (elaborated under the Consistency dimension). While this is the case especially with QA (as the driver behind food safety, elaborated under the People system dimension) and food safety -related training in all the companies, the frontline leaders in C4 additionally emphasized these issues regarding cleaning-related training. Thus, all the companies are in a reactive mode of firefighting, rather than adapting to these challenging conditions and finding effective sustainable solutions, indicating stage 2 maturity under Adaptability.

4.3.2.5. Adapting to Requirements on Food Safety Culture

Looking at how managers understand FSC in different companies, it becomes apparent that they confuse it with frontline food safety awareness and/or practices, as they refer to FSC being about training the frontline on food safety. Only the QM in C2 brought out that FSC might be about management ownership, showing a better awareness compared to others. However, this was individual learning and not a company-wide norm, as the TM and PM referred to the company giving an effort for FSC by having induction trainings. The low awareness of FSC also reflects from C1 and C3 conducting the FSC survey and making related policy changes in preparation for a 3rd party audit. While this reflects a reactive stage 2, the fact that they have not started the learning process, demonstrates their low ability to adapt, and thus, they cannot be at stage 3 of FSC maturity, also described as the Know stage, and would be expected to stay between stages 1-3.

4.3.2.6. Comparison of Meta-synthesis and Empirical Findings

The findings from the meta-synthesis (Subchapter 4.1, section 4.1.3.) and the empirical findings of this chapter support each other regarding companies having challenges adapting to the workforce. The empirical data does not explicitly reveal insights on consultancy services' effectiveness (Table 4.8). However, FSC semi-structured interviews were conducted right before and observations right after a third party audit in C1, which was the only one using consultancy services. The consultant was hired for this specific purpose, to assist the company in successfully passing this audit, which the company did, gaining a score of AA (further elaborated under section *4.3.7.*). Despite both the consultant and 3rd party audit, obvious risks to food safety were identified, elaborated under section 4.3.4 of this subchapter and Subchapter 4.5, under section 4.5.2, in addition to the company having the lowest FSC maturity (section 4.3.6.).

This chapter also offers novel contributions regarding other aspects of the Adaptability dimension, like frontline involvement and related soft skill training.

Table 4.8: Meta-synthesis findings (Subchapter 4.1) and the empirical contributions of this study regarding the Adaptability dimension,

Findings from literature	FSC related meta-synthesis of this study	Empirical findings of this study
High cost, inadequacy of the workforce, extra workload and low adaptability of the workforce are the main challenges in implementing FSMS (Karaman et al., 2012; Demirbas & Karagözlü, 2007; Karaman, 2012; Dilek & Üçüncü, 2022; Gül Özdoğan, 2009; Erkan, 2018; Azak, 2011;	Companies may need to improve their change management and problem-solving skills and work on their readiness to change.	- Lack of using change management strategies. - Difficulties with overcoming challenges.

Ali Gürbüz & Yılmaz, 2021).		
Companies use consultancy services when establishing FSMS (Gül Özdoğan, 2009; Bozbey & Güneş, 2021; Azak, 2011; Dilek & Üçüncü, 2022; Erkan, 2018; Aytekin, 2017).	- Some companies showed commitment and gave an effort to overcome challenges by investing in and learning from consultancy services. - There is no research into how effective these consultancy services are in helping to set up company specific FSMS.	- Only one company used consultant services. They gained a high 3rd party audit score, but they FSC had the lowest FSC score and multiple food safety risks, which they had not identified.-
-	-	Frontline involvement and related soft skill training

FSMS: food safety management systems.
Source: Prepared by the researcher

4.3.3. Consistency

The FSC maturity stages in the Consistency dimension are presented in Table 4.9. According to the results, among the participating companies C1 had the lowest FSC maturity stage of 1.7, while C2 had the highest stage of 2.2. The following section includes a detailed discussion on how these results were obtained.

Table 4.9: FSC maturity stages of participating companies in the Consistency dimension,

Aspect	C1	C2	C3	C4	C5
Root causes and continuous improvement					
Understanding of continuous improvement	1-2	2*	2	2	2
Proactive approach	1-2	2-3	-	1-2	-
More structured approach to root cause analysis	-	2-3	-	-	-
To some extent tying root causes with behavioral science aspects, by mentioning the 'forgetting curve' (note: individual learning?)	-	2-3	-	-	-
Performance measures					
Lagging and leading indicators	1-2	2	2	2	2
Taking action mainly in reaction to external input	2	-	2	-	-
Consistency of documents and using software	1-2	3	2-3	2	3
Use of performance data					
Communication of data	2	2	2	2	2
Lack of alignment	-	1-2	-	-	-
Inconsistencies in performance data	1-2	-	-	-	-

Inconsistencies					
Irregular meetings with general manager	-	-	-	1-2	-
Not following up with planned action item	-	-	1-2	-	-
Making sure all the frontline have been trained	-	-	2-3	2	2
Starting and not going forward with initiatives	-	-	2	2	2
Lack in following hygiene/FS protocols in production	1-2	1-2	1-2	1-2	1-2
FSC evaluation survey					
Having expectations of 100% perfect solutions from the start and not studying reasons behind low participation rates	2	2	2	2	2
Average scores	**1.7**	**2.2**	**2.0**	**1.9**	**2.1**

'-': no data or practices; *: the numbers in the tables represent FSC maturity scores, which are explained in section 3.3.2.; C1-5: participating company codes.
Source: Prepared by the researcher

4.3.3.1. Root Causes and Continuous Improvement

Managers' understanding of continuous improvement was related with problem solving and conforming with requirements when they change. This was also reflected from their approach to root cause analysis. Upon issues, there was a 'control more, train more' approach. This is also emphasized by the Campden BRI "*Training aspects of food safety culture*" document that companies rely too much on re-training as the sole corrective action (Emond, 2019). Like with how companies lacked a 'studying' approach when organizing the FSC survey (discussed in detail in Subchapter 4.2), the same misplaced expectations of 'having perfect solutions from start' also reflect here, as they do not question their initial solutions, in this case the training program (Jespersen et al., 2019).

This shows a reactive approach of stage 2 FSC maturity, as they try to solve issues by increasing awareness of some targeted employees, but not actually prevent issues from happening again among the workforce in general. Thus, rather than identifying the real 'root cause', companies take temporary corrective actions rather than actual preventative measures. In other words, companies do not identify the 'factors that caused errors to be made in the first place', which is the essence of prevention and continuous improvement (Frydman, Wilson & Wyer, 2000). Senge, (2016) describes this as being proactive by 'understanding how we contribute to a problem' (Senge, 2006). For instance, while C1 and C4 see fault in the frontline for being unaccommodating by not following food safety rules (stage 1-2), C2 attributed their perceived low frontline food safety awareness to not taking enough ownership themselves (PM) and to not training enough (QM), reflecting on how they contribute to the problem and with that indicating to a higher FSC maturity stage between 2-3.

Furthermore, in C2, the frontline white-collar leaders, in collaboration with the QA, were given projects as part of their KPIs. Using the Pareto principle they had to identify 3 main consumer complaints, find their root causes and accordingly formulate projects. Compared to the above-mentioned approach of other companies, this is a more structured approach to finding root causes and solving underlying problems to prevent them from happening again, indicating to a FSC maturity stage towards 3. However, the company is just starting to implement this and expects the QA to take the lead and drive improvement, indicating a stage towards 2.

For a better root cause analysis, the Competence Model (discussed in Chapter 2, section 2.3.2.), together with confidence measures could be used (GFSI, 2018). Namely, there might be employees with wrong understanding and high confidence and as a result not progressing to stage 2 of the Competence Model to start the learning process and employees with low understanding and "lower" confidence (who are able to admit that they do not know) and as a result being able to progress to stage 2 of the Competence Model (Anderson & Ackerman Anderson, 2010; Chamorro-Premuzic, 2019). While "lower" confidence might be managed with training, for high confidence, training would not be the most effective approach to manage this group, requiring management focus instead (GFSI, 2018).

To progress from stage 2 of the Competence Model, the person should continue learning, be reminded and practice the new behavior, which in turn requires time, effort and consistency leading to building habits of doing the task automatically, which is stage 4 of the Competence Model (unconsciously competent) (Anderson & Ackerman Anderson, 2010). Thus, rather than placing expectations on a training session or annual refresher training, the whole learning experience should be taken into consideration, which is also described by the Alliance to Stop Foodborne Disease in their FSC toolkit, that the companies should design a learning journey (Alliance to Stop Foodborne Illness, 2023). Although the toolkit does not describe the Competence Model per se, it does describe an overlapping concept with Stage 2 of the Model, the '*Forgetting curve*', that if not reinforced, most of the information given during training will not be retained and thus forgotten. This describes a person regressing within the Competence Model, if they do not consciously repeat what has been learnt. Thus, increasing companies' awareness in this regard could be one of the improvement recommendations leading to healthier expectations and a foundation to build their learning programs on.

Only the QM in C2 specifically emphasized that they should train more, as most of the information will be forgotten after training, indicating understanding of the concept of the 'forgetting curve' (Alliance to Stop Foodborne Illness, 2023) and with that getting closer to root causes around poor training effectiveness. As only the QM highlighted this, it is individual learning rather than a company-wide assumption. But since the QA department in this company is the driver behind food safety assurance, this might impact FSC to some degree, in the least, indicating to a better awareness of behavioral science compared to other companies and with that to a FSC maturity stage between 2-3.

4.3.3.2. Performance Measures

Lagging (reactive) indicators were mainly used, like consumer complaints, hygiene audits and external audit results (stage 2). On top of that, in C1 there were no consumer complaints in the past year, making it a poor performance measure of 'having' or 'not having' problems (stage 1-2). This might be due to the fact that they really do not have any, that they have poor systems in place for receiving consumer complaints or that their consumer profile, both Turkish and countries' where they export, are not inclined to complain. Whatever the underlying reasons, it is the responsibility of the company to analyze the suitability of such performance measures, to make sure that they actually reflect their performance. Thus, an improvement suggestion for this particular case might be to have a critical look at the systems in place for receiving consumer complaints.

C2 and C5 additionally used lagging indicators like non-conformities at CCPs, but also environmental monitoring plan as a leading (proactive) indicator (stage 2-3). C1 and C3 also had set leading indicators like the amount/length of food safety training given and supplier audits. Although all companies were conducting supplier audits, only these two companies had set these as their performance measures. Interestingly, from both these companies it became apparent that the training leading indicators were in place for the sake of conformity, as both companies tried to complete training before the external audit. They had also not connected these leading indicators to any related lagging indicators, in other words, using the leading indicator target as an ‘end’, rather than as a ‘means to an end’ (McChesney, Covey & Huling, 2012), indicating to a maturity stage 2.

Additionally, due to the C1 and C3 sharing relevant performance documents, it was possible to establish that some issues, which were not found in internal audit, were identified during the following external audit. These instances are signs that the companies react more to external input, rather than internal discoveries, indicating a reactive maturity stage 2.

Only in C2 did the participants highlight that their KPIs were coming in a cascade from top management down to the frontline white-collar leaders and accordingly dividing into relevant KPIs for each department. Interestingly, the QMA was not quite sure what wider company KPIs hers were contributing to. None the less, she had a process improvement KPI of reviewing documents against actual practices with all the departments, which is directly related with the Consistency FSC maturity dimension. In addition to the quality document management system (QDMS) software, at C2, they also have software to follow-up with the performance measurement system, indicating overall stage 3 maturity.

Similarly, the QM in C3 had a project of documenting processes and project for storing and sharing documents, to present to the board for investments. Furthermore, C3 together with C1 were among the two companies who did not have software for document management (e.g. QDMS system). Thus, while C3 indicates a maturity stage between 2-3, C1 to maturity toward 1-2.

C5, on the other hand, had a software development team and were using their own internal software, in addition to the QDMS program to ensure a standard production process. Both, the QMA and QM reported, how it took several years until everyone got used to the system and how now the terminology related with this software has become second nature and the production personnel demanding requirements to be met through this software, until they more forwards with certain tasks. This demonstrated the company’s efforts towards greater consistency in their production, in addition to consistency in implementation, indicating a maturity above stage 3.

4.3.3.3. Use of Performance Data

In all companies, the QA department controls the frontline through GMP audits and microbiological swabbing. The frontline white-collar leaders are held accountable for the results, except in C1, in which case the GMP scores are the QA's responsibility. Although the new QM in C1 was planning to switch that responsibility to production, it is not yet known whether this will shape into a company norm.

The lack of company-wide cascading performance measures regarding food safety, shows that there were no specific goals and direction setting for food safety assurance, making the results merely a monthly (annual for C1) communication rhythm of non-conformities (stage 2 in Values and Mission dimension). The frontline white-collar leaders have no specific goals to work towards apart from eliminating the existing non-conformities. Their managers and the senior management also do not have related goals and are just being informed in meetings and by email. Thus, the QA sets rules, trains on them, controls and the resulting data are used to reflect conformance, rather than used for continuous improvement. This kind of system also shows that the QA is the driving force behind a supply-push of having other parties 'have to do', rather than 'wanting to do' what is necessary for food safety, indicating to stage 2 in the People system dimension.

This is the opposite to the approach that would be considered effective for an organization with hierarchical leading tendencies, in which communication is expected to take place through a hierarchical cascade, with the direct superiors being the ones to have actual authority over their teams (Meyer, 2014). Interestingly, the QA already uses this as a negative consequence (discussed further under People system) to enforce behavior at the frontline, namely notifying the superior of a team when they do not do what has been told them, rather than working towards the desired behavior through their superiors in the first place, in other words having the QA as a support function instead of a governance body.

Interestingly, there were discrepancies in C2 regarding GMP audit goals, as the PM stated that frontline white-collar leaders have monthly GMP score goals, while the QMA said that there are no such practices, except for couple of departments, like maintenance, who have many things on their plate and that other departments are notified of non-conformities and expected to solve them. The QM also just mentioned the departments getting relevant scores, but additionally mentioned a score on the speed of closing non-conformities. To understand whether it is a case of working in silos or maybe they have their facts wrong, further data should be gathered. In any case, confusion around this shows that they are not aligned on one of the main performance measures around food safety (stage 1-2, Consistency).

Furthermore, it became apparent that in C1, while the performance documents and the QMA stated that training goals were met, internal hygiene audit scores were at the satisfactory limits and on top of evaluating training effectiveness, the external audit reports and observations reflected weaknesses in following hygiene protocols. Interestingly, the QMA herself emphasized the difficulties around getting the frontline to follow rules, in the end, proving the inefficiency of their training. As these aspects indicate to inconsistencies in their performance data, FSC maturity is between stage 1-2.

4.3.3.4. Inconsistencies

Further aspects of inconsistencies, which offer insights to the Consistency dimension, are as follows,

- C4 - food safety meetings with the GM being delayed (stage 1-2).
- C3 sets action to be done, but these are not followed-up. But the GM highlighting this demonstrated an awareness, indicating a maturity above 2, rather than below.
- C4, C5 reflecting not being sure whether all frontline employees have had food safety training (stage 2). At C3, the QM keeps her own set of records to double check. Although this is duplication of work, there is an extra effort towards consistency (stage 2-3). That other companies did not mention these aspects, does not mean that there are no issues with following up with training.
- Furthermore, C3, C4, C5 had started initiatives like getting suggestions against a reward, which were enthusiastically started, but were not continued, except in C5, where it reportedly continues, but with much less enthusiasm. No matter the reason for discontinuation, it shows inconsistency. This is also explicitly emphasized by the QMA in C5, that their company starts, but does not continue other initiatives like performance measures and annual company get-togethers (stage 2).
- Lack in following hygiene/ food safety protocols in production (C1 - C5) (stage 1-2).

4.3.3.5. Comparison of Literature and Empirical Findings

The findings from the meta-synthesis (Subchapter 4.1, section 4.1.4.) and the empirical findings of this chapter support each other regarding companies having a 'project management' approach to continuous improvement (Table 4.10). As novel contributions, this study gives insight into topics, like software use regarding food safety management, documentation's consistency and performance measures.

Table 4.10: Meta-synthesis findings (Subchapter 4.1) and the empirical contributions of this study regarding the Consistency dimension,

Findings from literature	FSC related meta-synthesis of this study	Empirical findings of this study
For continuous improvement, companies are having meetings with staff responsible for food safety, evaluating and setting new objectives, correcting mistakes and making improvements (Dilek & Üçüncü, 2022).	Companies use a "project management" rather than "organizational learning" approach.	- Insights into companies' approach to continuous improvement and approach to root cause analysis. - Use of lagging (reactive) performance measures
Managers realized technology was important to improve food safety practices (Karaman et al., 2012).	Technology and updating documents are somewhat recognized as important in the food safety context.	- Use of software to support consistency. - Insights to companies' documentation consistency.
Companies updated food safety documentation once or twice a year (Kök, 2009).		

Source: Prepared by the researcher

4.3.4. Risks and Hazards

The results for FSC maturity in the Risks and hazards dimension are presented in Table 4.11. In the present study, it was determined that the company C4 had the lowest FSC maturity of 1.6, while C3 and had the highest maturity of 1.9 . The following section includes a detailed discussion on how these results were obtained.

Table 4.11: FSC maturity stages of participating companies in the Risks and hazards dimension,

Aspect	C1	C2	C3	C4	C5
Unmanaged risks - working conditions	-	-	-	1-2	-
Unmanaged risks – employee placement	2*	-	2-3	1-2	2

Unmanaged risks – high number of new employees	1-2	1-2	1-2	1-2	1-2
Unmanaged risks – cleaning	1-2	1-2	-	1-2	1-2
Unmanaged risks – hand washing	1-2	-	1-2	1-2	-
Perception of frontline risk awareness	1-2	-	-	1-2	-
Verifying risk and hazard awareness	2	2	2	2	2
Average scores	1.7	1.7	1.9	1.6	1.8

'-': no data or practices; *: the numbers in the tables represent FSC maturity scores, which are explained in section 3.3.2.; C1-5: participating company codes.
Source: Prepared by the researcher.

4.3.4.1. Unmanaged Risks - Working Conditions

A contrasting example could be brought from C4, where frontline white-collar leaders brought out issues with worn out production lines, high turnover, fast line speed and over hours, leading to lack of training on cleaning and time to do that properly, in addition to incompetent and tired workforce. During interviews, it also became apparent that foreign material contamination is one of the main reasons behind their customer complaints. Although a root cause analysis is necessary to know the ultimate reasons behind these contaminations, the fact is that there are apparent risks stemming from the working conditions, impacting the effectiveness of prerequisite programs, like cleaning the equipment. These are signs of unmanaged risks (stage 1-2). Interestingly, their direct superior (the factory manager), in addition to QC and QM, did not reflect upon this situation, indicating to either misalignment of priorities or poor problem communication between the departments (stage 2, People system).

4.3.4.2. Unmanaged Risks – Employee Placement

Another risk, which became apparent related to managing the frontline, is locating staff in high and low-hygiene areas. C1 and C5 bring out that those who do not follow rules will be placed in the low-hygiene area. This is a sign of a reactive approach, as action is taken after issues occur indicating a stage 2 maturity.

On the other hand, C3 puts more experienced workers, while C1 puts workers with higher exam scores to open product areas (where product is at a higher risk of contamination). At the same time, C3 brings out that having challenges with old-timers in teaching new rules, which is a sign of possible risk related to this practice as well. C3 also places people who they do not know well or who do not follow rules under the supervision of workers they trust, indicating to more than just reacting to a problem and with that to stage 2-3. As for C1, the exam score is a relative measure, as the training is not job specific and the exam is on knowledge and, as per the forgetting curve, workers need repetitive reinforcement to gain proficiency (Alliance to Stop Foodborne Illness, 2023), leading the effectiveness of this practice questionable.

Finally, the most serious issue was seen in C4, where new frontline staff or the ones not properly following rules were placed into the area with tough working conditions. The frontline survey also confirmed this (elaborated in Subchapter 4.5, section 4.5.5. and Appendix 10.), showing that the surveyed employees there had been working for just a couple of weeks/months. The intent was to have a ‘carrot and stick’ motivation system, where the hard-workers would get into better working conditions as a positive consequence and the not-so-hard-working would be placed into difficult ones as a negative consequence (stage 1-2 in People system dimension). However, the so called ‘tough area’ was the open product zone, with its staff being in direct contact with the product. Thus, the consequences system set up by the production directly increased food safety related risks, indicating to low risk awareness and unmanaged risks and with that FSC maturity at a stage 1-2.

In C2 none of the interviewees mentioned these applications, with QMA explicitly pointing out that they do not have these kinds of practices. More data should be collected, to confirm that C2 does not have these kinds of ‘frontline placement’ practices.

4.3.4.3. Unmanaged Risks – High Number of New Employees

All companies had a challenge with high frontline turnover, which means a high number of new employees and as such leads to a high number of frontline workers being at stage 1 (do not know that they do not know) or stage 2 of the Competence Model (know that they do not know; low understanding and skill). This, on the other hand, increases the probability of personnel-related food safety hazards. Although some companies have taken action, like motivation systems (C1, C3) and salary reviews (C2), it still does not change the fact that for some time, until or even if the situation improves, there will be heightened food safety risk, which the companies have not considered. This situation not only shows companies’ low risk awareness (stage 1-2 in Risks and hazards dimension), but the impact low maturity at the Adaptability dimension might have to risk management.

4.3.4.4. Unmanaged Risks – Cleaning

In all participating companies, except C3, issues were mentioned with cleaning. In C2 and 4, this was done by production/frontline leaders, while in C1 and C5, this was done by interviewees at both production and QA positions. This shows insufficiently managed risks around prerequisite programs, like cleaning, indicating to a maturity between stages 1-2.

4.3.4.5. Unmanaged Risks – Hand Washing

Interestingly, in C1 and C3 there was a lack of hand washing facilities except for the ones in the entrance, while in C4 (low hygiene area) and C5 (high hygiene area) there was only one sink for all the department. In C1 there were disinfectant dispensers, which were at the time of the observation empty. What is more, in the high hygiene zone in C4 there were also no hand washing facilities. Although data is lacking on why this is the case, it shows a lack in risk awareness of the QA and production managers, especially at C1, C3 and C4 (stage 1-2). Although C3 is a powder mix production entailing low moisture, which might be the reason behind lack of sinks, but not having any, in addition to having just one lunch break might leave the workers not washing their hands for extensive periods of time. This, in turn, might lead to conflicting situations of employees rinsing their hands in the equipment washing sinks without using soap and disinfectant and not properly drying them, like seen during observations.

4.3.4.6. Perception of Frontline Risk Awareness

Managers' perceptions on frontline' food safety risk awareness gives further insights on managing risks in all companies, except C2, as interviews with some positions were not conducted (Table 4.12). While in C3 and C5 there is a similar perception across different positions, there are discrepancies between positions in C1 and C4. In the latter two, QA perceived frontline's risk awareness to be lacking. In C1, while the senior leader, GM, perceived frontline risk awareness to be good, his subordinate, the PM perceived it to be lacking. Interestingly, in turn the PM's subordinate perceived it to be good. In C4, all production related interviewees, factory manager (FM) and shift manager (SM) perceive frontline's risk perception as good, while quality chief (QC) did not. On the other hand, observations demonstrated (elaborated in Subchapter 4.5) a lack in following hygiene protocols and lack of proper facilities in all companies.

These discrepancies show both unmanaged risks and a lack of its awareness in all these companies, indicating to stage 1-2 maturity in the Risks and hazards dimension, a lack in communicating problems, especially in C1 and C4, indicating in stage 1-2 maturity in People system dimension and expectations regarding the impact of their food safety and hygiene training, indicating to stage 2 in the Consistency dimension.

Some assumptions, which might have led to these perceptions might have been that with training comes risk awareness, which was reflected by C1 and C3 (Table 4.13). C4 had even stronger expectations that after training, workers should know and be held accountable. The QC even went as far to say that if they have had training and do not follow necessary protocols, this is on purpose and due to their self-indulgence. These assumptions show lack of understanding in behavioral science and as a result an inability to adapt to the learning needs of the frontline, indicating to FSC maturity stage 1-2 in the People system dimension.

Only the QM in C2 emphasized that there should be more training, as employees forget most of what is told to them after training, like this referring to the 'forgetting curve' (Alliance to Stop Foodborne Illness, 2023). This might indicate a higher FSC maturity between stage 2-3 (discussed under the Consistency dimension). On the other hand, as this was not reflected by other interviewees, like the PM, this might also be a sign of individual, than company-wide learning, and as such not a sign of FSC maturity. However, as this is a unique piece of data, distinguishing this company from others, it was included in the FSC maturity assessment calculations.

While interviewees in C5 did not exclusively mention such assumptions, the QMA in C5 brought out that she had noticed the internal GMP audit scores increase in specific departments after conducting food safety and hygiene-related training, which might have led to the perception of frontline risk awareness being good. However, without further details on workers' profiles, their learning stages according to the Competency model and training content, it is difficult to draw further conclusions.

Table 4.12: Perception of frontline's risk awareness of different positions at each company,

Position	C1	C2	C3	C4	C5
General manager	Good	-	Good	-	OD: Good
Production manager	Lacking	Lacking	Good	FM: Good	Good
Shift manager	Good	-	Good	Good	-
Quality manager	Lacking	Lacking	Has to be good	Lacking	Good

C1-C5: participating company codes; '-': absence of data; OD: operations director; FM: factory manager.
Source: Prepared by the researcher.

Table 4.13: Assumptions around the impact of food safety training of different positions at each company,

Position	C1	C2	C3	C4	C5
General manager	Know about food safety risks as they have had training.	-	-	-	-
Production manager	-	-	-	Know about food safety risks as they have had training and should be accountable.	-
Quality manager	Will know about food safety risks as they will be trained.	More training is necessary to increase food safety-related awareness.	Should be aware, as they have explained real world examples in training	QC: Know about food safety risks as they have had training. Frontline does not follow necessary protocols due to self-indulgence.	QMA: Noticed that GMP audit scores get better after a FS and hygiene training

C1-5: participating company codes; '-': absence of data; QC: Quality chief; QMA: quality management assurance responsible.
Source: Prepared by the researcher

4.3.4.7. Verifying Risk and Hazard Awareness

As could be seen under the Consistency dimension, although companies have systems to verify aspects such as GMP conformity, these do not verify risk and hazard awareness. While non-conformities do lead to hazards and allow identification of low awareness after an issue occurs, this approach does not capture frontlines' risk and hazard awareness and with that risk probability in general (stage 2). What is more, due to assumptions around training, as discussed above, companies assume frontline to be aware after a training session. However, lack in awareness became apparent through observations, as in all companies where observations were conducted (C1, C3, C4, C5), there were deficiencies with following hygiene protocols.

4.3.4.8. Comparison of Meta-synthesis and Empirical Findings

The findings from the meta-synthesis (Subchapter 4.1, section 4.1.5.) and the empirical findings of this chapter support each other, as they both indicate lack of awareness related with food safety risks (Table 4.14). The chapter also offered novel insights into how companies either have not addressed or even create additional food safety risks, demonstrating their low understanding of their risks.

The literature showed that behavior was not considered when determining the likelihood of risks in their HACCP system. Although empirical data does not explicitly reveal how companies determine the likelihood of risks, they have been able to identify, there are varying perceptions regarding frontline risk awareness, demonstrating that lack of awareness, in the importance of risk-behavior relationship.

Table 4.14: Meta-synthesis findings (Subchapter 4.1) and the empirical contributions of this study regarding the Risks and hazards dimension,

Findings from literature	FSC related meta-synthesis of this study	Empirical findings of this study
While most companies stated that they knew and followed up with food safety legislation, some companies stated that they did not (Azak, 2011; Gül Özdoğan, 2009).	Further research is necessary into how, to what extent and under which circumstances do companies try to understand and act on risk;	- Lack of risk awareness, related with working conditions, employee placement, high number of new employees, cleaning, lack of hand washing facilities.
Some managers and company representatives did not know some basic		

food safety related definitions, concepts, and abbreviations (Bozbey & Güneş, 2021; Erkan, 2018; Ali Gürbüz & Yılmaz, 2021).		
Behavioral factors were not considered when determining the likelihood of hazards within the HACCP systems (Günşen, Eseceli, & Atan, 2019; Karadal & Ova, 2020; Bülbül & Üçüncü, 2020).	There is no research into to what extent behavioral aspects are used by food production companies to determine the likelihood of hazards within the HACCP system.	- Food safety risks stemming from behavior, not taken into consideration. - There were varying perceptions regarding frontline risk awareness.

GFSI: Global food safety initiative; HACCP: Hazard Analysis and Critical Control Points.
Source: Prepared by the researcher

4.3.5. People System

The results for FSC maturity in the People system dimension are presented in Table 4.15. In this study, C1 had the lowest FSC maturity stage of 1.7, while C2 had the highest stage of 2.1. The following section includes a detailed discussion on how these results were obtained.

Table 4.15: FSC maturity stages of participating companies in the People system dimension,

Aspect	C1	C2	C3	C4	C5
QA is the driver behind food safety and problem communication is prevailing.	2*	2	2	2	2
Training	2	2	2	2	2-3
Consequences – individual initiatives: the QA using only negative consequences.	1-2	1-2	1-2	1-2	1-2
Consequences – individual initiatives: the production using additional positive consequences.	-	2-3	2-3	2-3	2-3
Consequences – suggestion and reward system.	-	2-3	2-3	2-3	2-3
Collaboration	-	2	-	-	-
Subcultures/silos	1	1-2	1-2	1-2	1-2
Including other support functions	2	-	2	-	2
Discussed under Risks and hazards dimension					
Assumptions around training (Perception of frontline risk awareness).	1-2	2-3	1-2	1-2	-
Lack in problem communication (Perception of frontline risk awareness).	1-2	-	-	1-2	-
Negative consequences: frontline placement in tough working conditions (Unmanaged risks – employee placement)	-	-	-	1-2	-

Discrepancies between /misalignment of departments (Unmanaged risks - working conditions).	-	-	-	1-2	-
FSC evaluation survey - silos					
QA the main organizer	2	2	2	2	2
QA communication directly with frontline, skipping the middle management	2	2	2	2	2
Middle management not communicating with the frontline on food safety issues	-	-	-	-	1-2
OSF confused about participating in the survey, as it was about food safety	-	-	1-2	-	1-2
Lowest participation rates of OSF	1-2	-	1-2	-	-
Average scores	**1.7**	**2.1**	**1.9**	**1.8**	**2.0**

'-': no data or practices; *: the numbers in the tables represent FSC maturity scores, which are explained in section 3.3.2.; C1-5: participating company codes. FSC: food safety culture QA: quality assurance department; OSF: other support functions.
Source: Prepared by the researcher

4.3.5.1. Problem Communication

As has already become apparent from discussions under different dimensions, the QA is the main driver behind food safety in all companies and food safety related communication takes place in case problems occur, indicating a stage 2 maturity. For instance,

- the QA conducts hygiene audits and microbiological analysis at the frontline and communicates the results either to the direct responsible department heads and/or to the senior management, in other words, they give an effort to identify non-conformities and have people solve them, being the main communicator and governance body for food safety (discussed in detail under Consistency);
- from the QA perspective, upper management is necessary when there are problems and investments need to be made (discussed under Values and mission);
- the QA expects the frontline to report problems (discussed under Adaptability).

4.3.5.2. Training

All companies focus on food safety induction training and annual refresher training for the frontline, which normally contain general food safety related rules, in addition to some company specific aspects (stage 2). Only C5 brought out that the training content varies according to different production department needs (e.g. different allergens, foreign material risks) (stage 2-3). As for white-collar food safety training, interviewees themselves mentioned having or the QA giving food safety standard or HACCP training.

The data collected for both frontline and the managers did not reflect having '*Clear learning objectives for desired behaviours*', or focused training on risk awareness to '*Help employees and senior leaders recognize links between food safety, brand reputations and organization values…*', (Alliance to Stop Foodborne Illness, 2023), with C5 being a slight exception regarding the frontline. Thus, companies' learning programs meet minimum standards with a focus to conduct these in reaction to external pressures, like 3rd party certification and with no training effectiveness evaluation, which indicates to a FSC maturity stage 2. This applies especially for C1 and C3, for which collected data shows that they gave an effort to finish annual training before the external food safety audit. There was insufficient data to make these conclusions for the other companies.

The training effectiveness was also reported to be evaluated through hygiene audits (C1, C4), demonstrating not only companies' expectations of their training programs, but also tying its intended behavior change with the negative consequences (discussed below) used by companies in these compliance check frameworks.

4.3.5.3. Consequences – Individual Initiatives

While QA tends to use negative consequences, like warning and/or letting that person's direct superior know (stage 1-2), production positions at C2, C3, C4 and C5 additionally mentioned thanking the frontline for good performance and/or identifying/solving problems (stage 2-3). This reflects the QA and production having different norms (discussed under subcultures/silos below), with the QA in the role of a governance body policing the frontline using negative consequences to obtain behavior change.

The production leaders, on the other hand, use consequences like placing workers to either low hygiene areas (C1, C3, C5) or areas with tough working conditions (C4), in cases where they do not or might not follow rules (discussed under Risks and hazards). They also mentioned that they would put new, disobeying or distrusted workers to work beside other trusted workers. The fact that these nuances were not brought out by any of the QA related interviewees, again indicates to a gap between functions (discussed under subcultures/silos below).

4.3.5.4 Reward and Recognize – Companies' Initiatives

As for company-general reward and recognition systems, in C1, although they are trying to establish the employee of the month reward system, food safety is built into it in a way that if they do not follow food safety rules, they will lose their opportunity to get the reward, again taking a more negative consequence approach. In comparison, C2 has a salary bonus system for the frontline upon participating in improvement projects and making suggestions (discussed under Adaptability). Thus, one is rewarding for compliance, while other is rewarding an extra effort, indicating the former to be at the FSC stage 2, while the latter between 2-3.

At a point, C2-C5 had or were working on (currently not active in any of them) an initiative to get employees across the companies to make improvement suggestions by providing a monetary reward (stage 2-3) (discussed under Adaptability). As rewarding and recognizing (positive consequences) are an effective approach to reinforcing desired behaviors (Alliance to Stop Foodborne Illness, 2023), these rewards systems are promoting an occasional individual extra effort to notice and suggest, rather than

- the work it takes to improve the processes/procedures and/or implement these suggestions;
- team effort;
- daily/ monthly desired behaviors (Alliance to Stop Foodborne Illness, 2023).

This indicates a maturity stage 2-3.

4.3.5.5. Reward and Recognize – Conclusion

These examples of companies' individual and company level reward and recognition systems also confirm the behavioral biases discussed in Subchapter 4.2 (section 4.2.1.), that when people try to get somebody to do something less, they automatically incline to use inhibiting pressures (like warn, make laws) and when they try to get them to do something more, they incline towards promoting pressures (e.g. rewards for suggestions and posters, emails and pep-talks to participate in the FSC survey) (Wallaert, 2019). Whereas it is important to analyze both inhibiting and promoting pressures. An example could be brought from C4. If inhibiting pressures, like short breaks and over hours are not addressed, there will be little engagement, since workers who are already tired would not be inclined to spend their short break time to write suggestions. Also, if production lines move fast and their work is intense, how could they possibly take the time to write suggestions or participate in the FSC evaluation survey.

A more tangible example are the hygiene barriers, devices with turnstile allowing to pass after cleaning hands, which were especially emphasized by interviewees in C1 and C4 as important to change frontline behavior, to get them to wash hands. In other words, they used promoting pressures to obtain a desired behavior. Interestingly, in the same companies, it was observed that the hygiene barriers were not properly functional (e.g. empty dispensers) and used (e.g. dirty, metal bars removed), demonstrating that just promoting pressures are not enough. This also shows a lack in change management, as limiting pressures were not considered, and with that poor adaptability. Additionally, the companies had not allocated necessary resources to properly maintain these hygiene barriers, even after problems occurred, indicating to a FSC maturity stage between 1-2 in the Values and mission dimension.

4.3.5.6. Collaboration

C2 was the only company to have people development goals for the frontline through improvement projects and suggestion percentages against a bonus. Although relevant for food safety, the QA was not involved and could not comment on its possible impact, again indicating to a gap between the two functions (discussed below under subcultures/silos).

While the PM at C2 mentioned the production and QA to have team goals, the QMA and QM brought out that finding root causes and solutions to main problems and taking lead to implement these is expected from the QA. Thus, although there is an effort to build collaboration the QA is positioned as the main driver, still indicating to stage 2 FSC maturity

4.3.5.7. Subcultures/ Silos

Some differences in norms of the QA and production departments regarding the frontline have emerged from the data analysis indicating to subcultures/silos (stage 1-2),

- QA using negative consequences, like warning, while production might use both negative and positive, like additionally thanking for good performance and identifying/solving problems (C2-C5).

- In all companies the QA expects the frontline to report problems and follow rules, while additionally production leaders expect them to make improvement suggestions (C2-5), (discussed under the Adaptability dimension).
- The QA not having a role in practices used by the production, like conscious placement of frontline workers to mitigate risks (C1, C3, C4, C5) and people development systems (C2, C3) (discussed under the Risks and hazards and the Adaptability dimensions).

The most contrasting example of siloed work among the companies was at C1, where frontline GMP scores were the goal of the QA, while the SM, TM and frontline workers confused food safety with work safety and the GM was being informed just annually or upon problems (stage 1) (discussed under the Consistency and the Values and mission dimensions).

The formation of subcultures/silos indicates that there is lack of intentional and/or consistent direction setting from the top or in other words leadership to get everyone working towards the same goals (Figure 5.1) (Schein & Schein, 2017), indicating to a maturity stage 1-2, in the Values and mission dimension. This is especially noteworthy with hierarchical leading tendencies, where superiors are expected to give direction (Meyer, 2014). GFSI emphasizes its importance regarding FSC using the phrase "walks the talk" (GFSI, 2018), in which case the espoused values are the same as the artifacts (Schein & Schein, 2017).

The formation of subcultures/silos indicates that there is lack of intentional and/or consistent direction setting from the top (Figure 4.6) (Schein & Schein, 2017), especially as in an organization with hierarchical leading tendencies superiors are expected to give direction (Meyer, 2014), also indicating to a maturity stage 1-2, in the Values and mission dimension.

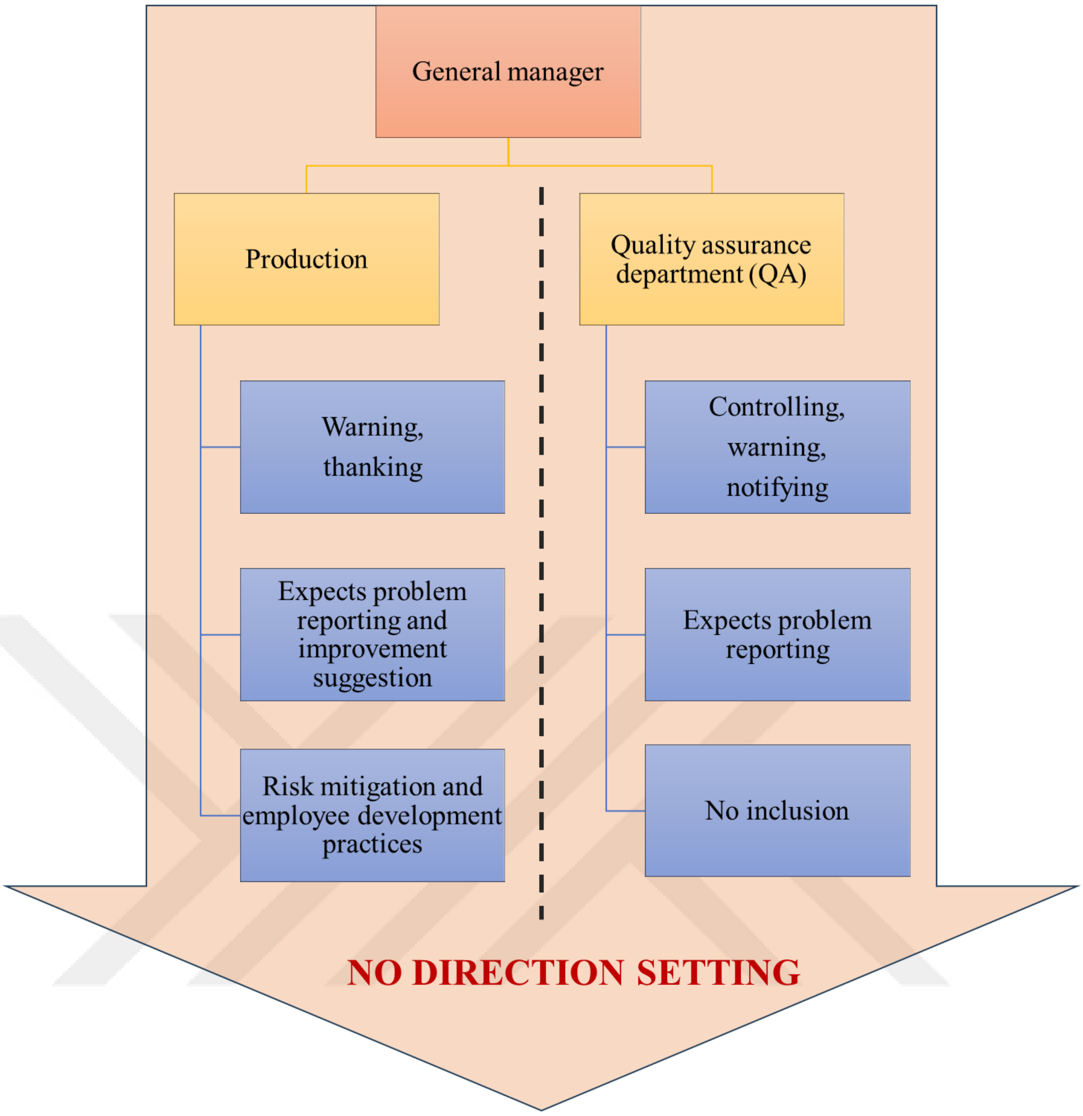


Figure 4.6: No direction setting, leads to varying norms within different departments.

Source: Prepared by the researcher

Secondly, as per hierarchical leading tendencies, leaders are expected to be experts in their field. For instance, GMs in C1 and C5 explicitly stated that they have their QA teams to lead this area. The facts that the QA expects to be treated as such, has also become apparent form statements by QM in C2, C3, C4, examples are as follows:

- *We already know what to do, we have enough experience and expertise. Why we need the GM is to make the final decision on allocating resources*.
- *I am the expert in the field. What else should the GM do but decide on whether to allocate resources*.

- QC said to the SM after the latter commented on company's efforts on food safety, *I think we should leave the commenting to the expert in the field*.

From this, it could also be inferred why QA had not been included in frontline placement and developmental practices, as everyone has their field of expertise.

4.3.5.8. Other Support Functions

According to interviewee statements in C1, C2, C3 and C5, each department is responsible for their area in the external food safety standard. However, performance documents collected from C1, C3 and C5 showed more controlling by the QA as a preventative and corrective measures for non-conformities, which does not demonstrate actual involvement of the OSF, indicating to a stage 2, rather than stage 2-3.

As for C4, the QA department is being set up and they are taking over responsibilities from production and maintenance and it was not quite clear how everything will settle into place (stage 2).

Due to performance documents, it was possible to compare the involvement of other support functions in C1 and C3 and it became apparent that in C3 more responsibilities regarding external food safety standard requirements were distributed to other departments (e.g. purchasing, maintenance) (Figure 5.2). Nevertheless, compared to other companies OSF in C1 and C3 had the lowest OSF participation rates in the survey (stage 2). The QA in C3 and C5 also commented that it was difficult to get OSF participating in the survey, as they at first thought this was not related with their department, since it was about food safety (stage 2).

As a distinct difference from other companies, the production of C3 insisted on taking on more responsibility on food safety, like the PM volunteering to be the leader of the food safety team and the FM stating that the production should control and be responsible for related food safety issues (Figure 4.7), mentioning conflicts around that with the QA, which the latter, interestingly, did not. However, there were also signs of conflict between QM-FM, QA-frontline, QA-maintenance staff and maintenance-frontline, with reports of the GM giving an effort to resolve these in the past couple of years. On the other hand, the QM and QMA in C2 brought out the opposite, that they would like the production to be the main driver behind quality and food safety and the QA to be more of a guiding function. But also mentioned having difficulties with company's priorities and management mindset in trying to apply this approach. Thus, in both cases (C3 and C2) the QA is the main driver behind food safety (Figure 4.7), indicating to a stage 2 FSC maturity, but the underlying basic assumptions behind these differ. This is an important finding, as it demonstrates the need for a different approach to mature their FSCs.

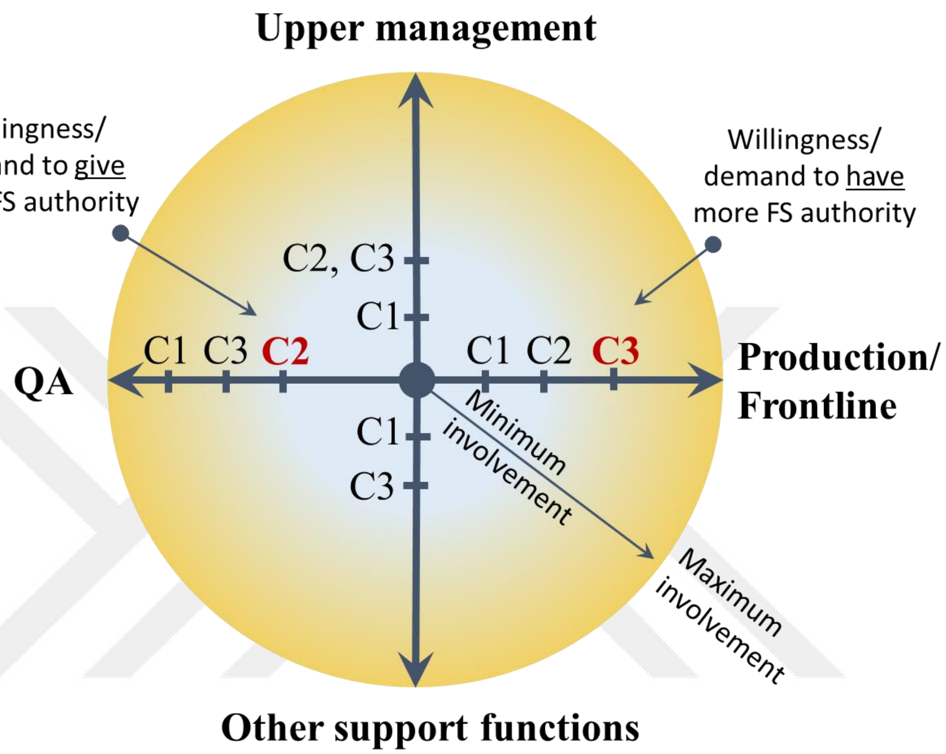


Figure 4.7: Different departments' extent of getting and willingness to get involved. The gradient color of light bluish in middle to yellow at the edges is used to further highlight the extent of involvement. C1-5: Companies 1-5; QA: quality assurance department.

Source: Prepared by the researcher

4.3.5.9. Comparison of Meta-synthesis and Empirical Findings

The findings from the meta-synthesis (Subchapter 4.1, section 4.1.2.) and the empirical findings of this chapter support each other, as they both indicate to the QA taking the main responsibility on managing food safety, focusing on negative consequences and conducting general, rather the job-specific training. The only exception was C5, emphasizing focusing on the needs of different departments, both at the frontline and OSF level. This chapter also offers novel contributions regarding companies' approach to collaboration, OSF involvement, consequences systems, training purposes and effectiveness evaluation (Table 4.16).

Table 4.16: Meta-synthesis findings (Subchapter 4.1) and the empirical contributions of this study regarding the People system dimension,

Findings from literature	**FSC related meta-synthesis results of this study**	**Empirical findings of this study**
Employees´ active role in FSMS is interpreted as having them fill out forms (Dilek & Üçüncü, 2022).	The results show a tendency towards silos, that some companies have the do-it-yourself approach by the quality team, paving the way to silos.	- The QA is the main driver behind FS in all companies and communication on food safety occurs especially upon problems.
In the FSMS implementation process, everything is organized by the quality and food safety team (Dilek & Üçüncü, 2022).		
- Monitoring specified in the HACCP plan is done by the quality and safety team (Hakizimana & Gürbüz, 2019; Altınbaş Özdemir & Kurultay, 2013; Erfa & Taşan, 2007; Küçüktezcan & Dağlıoğlu, 2010; Bayraktar & Gürbüz, 2020; Karadal & Ova, 2020). - In just some cases these responsibilities were divided among the relevant production personnel (Ekici & Turgay, 2016; Bülbül & Üçüncü, 2020; Günşen, Eseceli & Atan, 2019; Sav & Bilgin, 2018).		
The majority stated that the responsibility to implement FSMS is not on one person (Karaman et al., 2012).	Some companies are aware of the need to involve staff and seem to give an effort towards more cross-functional team cooperation.	
Only one study included details on consequences in case hygiene rules were not followed (Özbay Doğu & Akolaş, 2013).	There are documented negative consequences.	- Tendency to use negative consequences regarding frequent (daily/ weekly) communication. - Using rewards systems to promote

		occasional individual extra effort. - Lack of direction setting in consequence management.
The majority of companies were found to provide food safety related training (Bozbey & Güneş, 2021; Kök, 2009; Ali Gürbüz & Yılmaz, 2021; Erkeç & Bilgin, 2020; Karaman, 2012).	There is little recognition that training for different populations of the company is necessary.	- Companies provided induction and refresher trainings related to food safety. - Only one company (C5) focused on the needs of different departments, both at the frontline and OSF level.
-	-	- Lack of measures to promote collaboration. - Minimum OSFs' involvement. - Lack of training effectiveness evaluation.

FSMS: food safety management systems; HACCP: Hazard analysis and critical control points; OSF: other support functions; QA: Quality assurance department.
Source: Prepared by the researcher

4.3.6. Food Safety Culture - Discussion

In this study, it was shown that company C1 had the lowest average FSC maturity of 1,7, while C5 had the highest of 2,1 (Table 4.17). In the Values and mission dimension, upon comparing the highest (C5) and lowest scores (C1), an aspect setting these companies apart was the involvement of management or the lack of it. What increased the score of C5 were especially their investments to assure food safety, like having two GFSI-benchmarked certificates and the way they went about organizing their survey, again getting the management involved and allocating resources.

In the Adaptability dimension, again, C5 had the highest, while C1 had the lowest score. This was impacted especially by the companies' approach to the frontline. For instance, while C1 demonstrated distrust towards their frontline, C5 was counting on their input and involving them in the survey process. The score of C5 was additionally increased due to the company, to some extent, using communication strategies and behavioral science while organizing the survey.

In the Consistency dimension, C2 had the highest, while C1 had the lowest scores. This was mainly due to C1 having serious inconsistencies in their documents and related practices, while C2 had a KPI in place to review and update all written procedures. Additionally, C2 had performance measures cascading throughout the company, with an endeavor to include food safety and quality as well, while C1 had some ad hoc inefficient performance measures, not offering enough and/ or correct data. The score of C2 was further increased by attempts of structures root cause analysis and connecting these with behavioral science aspects.

In the Risks and hazards dimension, all companies had lowest scores compared to other dimensions. C4 had the lowest score of 1.6, as they showed serious lack of understanding of their food safety risks, with a striking example regarding employee placement through which they even increased their risks, by deliberately placing personnel with low awareness in the high hygiene zone in direct contact with the products.

In the People system dimension, C5 had the highest, while C1 had the lowest FSC maturity scores, 2.1 and 1.7, respectively. An aspect setting these companies apart was one's (C5) attempts at working towards collaboration between the QA and production, while the other (C1) demonstrated siloed work, by having even the hygiene audit scores be the responsibility of the QA department.

Since the anticipated quantitative survey data did not reach the threshold participation levels, it is not possible to compare the companies using statistical tests. Nonetheless the companies have been compared qualitatively using the qualitative methods. As recommended in this study (in Chapter 4.2), in future research with Turkish food manufacturers, the FSC should be matured to a given base level to take into account the Turkish organizational culture setting before applying site wide quantitative survey methods in order to achieve participation thresholds and enable statistical comparisons.

Table 4.17: Maturity scores by dimension in the companies studied,

	Values and mission	Adaptability	Consistency	Risks and hazards	People system	Average
C1	1.9	1.7	1.7	1.7	1.7	**1.7**
C2	2.0	2.1	2.2	1.7	2.1	**2.0**
C3	2.2	2.2	2.0	1.9	1.9	**2.0**
C4	1.9	2.1	1.9	1.6	1.8	**1.9**
C5	2.3	2.3	2.1	1.8	2.0	**2.1**

C1-5: Participating company codes;
Source: Prepared by the researcher.

As FSC maturity studies use different evaluation criteria for dimensions and maturity stages, it is difficult to compare the results with other studies. For instance, De Boeck et al., (2016) used a self-assessment survey with frontline workers and managers, while Tomasevic et al., (2020) and De Boeck et al., (2018) used a self-assessment survey filled by one company representative to assess food safety climate. Although Nyarugwe et al., (2018 and 2020) used a mixed methods approach, as did the current study, the FSC dimensions, or elements, as referred to in that study, differed, and so did the maturity stages, using a scoring system between 1-3, instead of 1-5, like in the current study. Zanin et al (2021) also used a 1-3 scoring system, although both Zanin et al., (2021) and Nyarugwe et al., (2020) identified the need for further discrimination among their 3 categories and used interim groupings (1-2 and 2-3) when determining food safety culture maturity, resulting in 5 groupings like the current study. Nevertheless, the elements used by both Nyarugwe et al., (2020) and Zanin et al., (2021) differed in terms of how they were organized and tested from the five dimensions used in this research, the latter being deemed most suitable here since it was developed for larger food manufacturers (Jespersen et al., 2016 and 2019) and the dimensions were adopted by the GFSI in its position paper (GFSI, 2018).As this study used the FSC maturity model developed by Jespersen et al., (2016 and 2019), comparison of results is possible to some extent. Jespersen et al., (2016) evaluated FSC maturity in one food production company in Canada and Jespersen et al., (2019) in five. In both cases, it was found that FSC maturity was between 2-3, as was the case in the current study. However, these studies presented FSC maturity results separately for each method, like this demonstrating the differences between findings of different methods. The current study, on the other hand, compared the findings from each method, putting forth how these findings either support each other or demonstrate discrepancies. The discrepancies were especially focused on, as also suggested by Schein and Schein (2017), as it helped to discriminate between individual and organizational learning (elaborated in detail in sections 2.3.1. and 2.3.2.), in addition to identifying work in silos, which reflects from different norms, beliefs and values across company departments. Thus, through this approach, the current study also offered a new perspective to FSC evaluation, contributing to FSC research.

4.3.7. Food Safety Management and Culture

All companies had obtained a 3rd party food safety certificate. All, except C4, had GFSI-benchmarked certificates (Table 4.18). British Retail Consortium (BRC) has a letter score system of AA, A, B, C, in descending order of success. Although the International Featured Standards (IFS) has updated their scoring system, the scores obtained from the companies were according to their old one of having to obtain at least 75% to pass and a score over 95% demonstrating a high level of compliance. Food Safety System Certification 22000 (FSSC22000) does not have scoring, but a pass/ no pass system (Techni-K, 2023). The ‘+’ sign beside BRC scores demonstrates unannounced audits, in which case the auditors come unexpectedly. This should in turn enable them to evaluate companies’ compliance without great preparation, as would be case of announced audits, enabling to get a more realistic result. While C1 and C3 scores decreased with unannounced audits, C5 score stayed the same, demonstrating the latter’s consistency.

Table 4.18: External food safety certification details of participating companies,

Companies	BRC			IFS		FSSC22000	ISO22000
	2022	2023	2024	2022	2023		
C1	C; A	AA	A+	-	-	-	+
C2	-	-	-	-	-	+	-
C3	A	A; B+	-	-	-	-	-
C4	-	-	-	-	-	-	+
C5	A	A+	-	High	High	-	-

‘-’: lack of application by the companies; A, C, AA: 3rd party audit scores; A+, B+: 3rd party unannounced audit scores; BRC: British Retail Consortium; C1-5: Participating company codes; FSSC: Food Safety System Certification; IFS: International Featured Standards.
Source: Prepared by the researcher

Comparing FSMS evaluation results with the FSC maturity scores enabled to gain novel insights into the extent of their overlap. While C1 had the lowest overall FSC maturity score, they had the same or higher FSMS scores, compared to C5, which had the highest general FSC maturity score (Table 4.19). This shows that a high 3rd party FSMS evaluation score might not reflect high FSC maturity. It also became apparent that these high scores might not reflect food safety management performance, as multiple food safety risks were identified through this study (section 4.3.4. and Subchapter 4.5.), which were not properly identified and mitigated by the companies, which is an additional novel insight into existing food safety research. This, to some extent ties in with the existing research suggesting that a more mature FSC leads to better food safety performance (De Boeck et al., 2016; Nyarugwe , 2018; Wu et al,. 2020), demonstrating the opposite that low FSC leads to unidentified and unmitigated risks. This also aligns with the learning process imbedded in the FSC maturity model, described in this study through the Competence Model perspective (elaborated in detail under section 3.3.2.), as companies at the FSC maturity stage 2, react, focused on problem solving and conforming with requirements when these change, rather than on the learning process, which would lead to data collection to challenge existing systems and with that identifying and mitigating food safety risks, described as the continuous improvement mindset within the FSC maturity model context (GFSI, 2018; Jespersen et al., 2019). Interestingly, companies perceived their current approach as continuous improvement. Thus, the findings of this study put forth that improving companies' awareness of continuous improvement might be a way to nudge them towards maturing their FSC. These findings also demonstrate the need for 3rd party food safety certification bodies to focus on helping companies '*cultivating a culture of continuous improvement*', rather than on standard compliance, as also emphasized in a white paper titled '*The future of food safety auditing think thank*' (World of Auditing, 2024).

Table 4.19: Comparison of external food safety certification and FSC maturity scores.

Companies	**BRC**			**FSC maturity scores**
	2022	2023	2024	
C1	C; A	AA	A+	**1,7**
C3	A	A; B+	-	**2,0**
C5	A	A+	-	**2,1**

'-': lack of application by the companies; A, C, AA: 3rd party audit scores; A+, B+: 3rd party unannounced audit scores; BRC: British Retail Consortium; C1-5: participating company codes; FSC: Food Safety Culture; IFS: International Featured Standards.
Source: Prepared by the researcher

4.3.8. Conclusion

Like the meta-synthesis results, the current study demonstrated through detailed discussion that the participating companies had a stage 2 or in other words reactive FSC, additionally, identifying food safety risks which were not done so by the companies, indicating a questionable food safety performance. This was the case, despite the 3rd party food safety auditing scores being high, highlighting the importance of food safety certification bodies shifting from a compliance-based auditing approach to nudge companies towards continuous improvement and with that challenging their systems to identify and mitigate food safety risks.

Findings demonstrate that although the espoused values reflect the importance of food safety in all companies, there is lack of direction setting, senior management involvement and production goals guiding decision making (Values and mission dimension). The lack of direction setting was seen to impact the companies in multiple ways, like different departments having different expectations towards frontline involvement (problem reporting vs suggesting improvements and as such impacting the Adaptability dimension), using different consequences (warning vs thanking and as such impacting the People system dimension) and leaving the QA department to govern and/or be responsible for food safety in a functional silo and communicating upon food safety problems, rather than working towards collaboration (impacting the People system dimension).

All companies had an understanding that continuous improvement is related with problem solving and conforming with requirements when these change, reflecting a not-being-ready-to-voluntarily-change mindset, rather than themselves looking for ways to collect data to find root causes to problems, to improve or prevent. This is also reflected in the focus on lagging indicators and a lack of both, using leading indicators and properly tying these with lagging indicators to a performance measurement system (Consistency dimension).

All companies had a ‘change when ordered, train more, control more’ approach together with expectations regarding their solutions, rather than trying to find the actual root causes of what caused the error in the first place and how they themselves were contributing to these problems (Consistency dimension). This, in turn, impacts companies’ abilities to adapt with their own workers, like bringing about effective change and learning, as they do not realize the need to use behavioral science concepts to find and address people-related root causes, e.g. using change management strategies, Pressure mapping, Competence and ABC Models (discussed in Subchapter 4.2, section 4.2.1.) to working towards a demand-pull for behavior change. This also reflects in the difficulties companies face when dealing with challenges, like high turnover (Adaptability dimension).

All companies had a lack of deliberately engaging the frontline to innovate and drive change, for which also additional behavioral science concepts, like Patrick Lencioni's obstacles to employee engagement (anonymity, irrelevance and 'immeasurement') (Lencioni, 2007) and establishing psychological safety through listening and responding productively (discussed in Subchapter 4.2, sections 4.2.1. and 4.2.2.), could be used to find and address root causes (Adaptability dimension).

The above-mentioned behavioral science concepts to successfully change behavior and engage also include negative and positive (reward and recognize) consequences, described separately in the maturity model under People system dimension (Jespersen et al., 2019), which ultimately reflect the 'consequences' of ABC model (GFSI, 2018). Thus, the key is not about rewarding per se, but applying effective consequences, like productively listening and demonstrating action, evaluating and giving feedback on performance, in addition to rewarding and recognizing. The participating companies used negative consequences and were at best promoting an occasional individual extra effort to notice problems and suggest improvement, rather than the work it takes to improve, team effort and daily/ monthly desired behaviors. For instance, behaviors promoted by hygiene training were connected with the negative consequences of companies' hygiene conformance evaluation systems, rather than positive consequences to reinforce desired behaviors (People system dimension).

In the end, the lack of focus on people, direction setting and behavioral science, in addition to their relationships with food safety risks, culminated in the various risks and hazards identified under the Risks and hazards dimension, demonstrating their lack in understating and challenging their risks. This highlights that having a management system which is not supported by a strong food safety culture can leave food businesses potentially vulnerable to food incidents.

With the findings presented in this subchapter, the current study to some extent filled the research gaps in the food safety management and hygiene research in food production companies in Türkiye regarding FSC dimensions. In addition to the need for companies to increase their awareness of continuous improvement, other recommendations regarding FSC dimensions specifically might be as follows,

- Include (senior) management into food safety related communication and setting performance measures. This would also be an effective approach due to Turkish organization culture hierarchical leading tendencies (elaborated in detail in Subchapter 4.2), in which case leaders and managers are influential, especially regarding their direct teams (Values and mission dimension).
- Together with the above-mentioned direction setting job-specific training could be used to communicate food safety related expectations and responsibilities to all the different departments and positions throughout the company (People system dimension).
- Furthermore, increasing awareness on Turkish national organizational culture hierarchical leading tendencies, might support the quality assurance team, other departments and (senior) management in distributing responsibilities and authority regarding food safety to relevant departments (People system dimension).
- Increase awareness on and apply behavior change strategies in root cause analysis (Adatability dimension) and incorporate these into the documented and verification systems (Consistency dimension).
- Search for data internally within the company, to challenge existing systems, and externally, to learn from sector experience (e.g. outbreaks, recalls) (Risks and hazards dimension) and incorporate these into the documented and verification systems (Consistency dimension).

A limitation of this study in that researcher bias might have been introduced, as the data collection and analysis were conducted by one person. On the other hand, multiple methods (semi-structured interviews, focus groups, performance document analysis, observations) used to collect data from different levels and positions of the companies (management and on the shopfloor), enabled to cross-check the data to find similarities, validating the findings, or discrepancies, making it possible to distinguish between individual and organizational learning and double check the conclusions made on FSC.

4.4. Halal Food Assurance in Large-sized Food Production Companies and Its Interaction with Food Safety Assurance

Literature review demonstrated limited research in Halal food assurance (HFA) practices, reflected that an organizational culture-based approach would lead to better Halal food management and indicated a lack of empirical research on the impact of HFA on food safety and hygiene practices. Accordingly, this chapter addresses the following aims:

AIM 1: to evaluate HFA practices in Halal-certified food production companies in Türkiye (point 2 in the research framework: Figure 1.1 and 1.2 in the Introduction Chapter).

AIM 2: explore the possibilities behind using the food safety culture concepts (definition, maturity model and evaluation methodology) in the Halal food assurance context (point 2.2 in the research framework: Figure 1.1 and 1.2 in the Introduction Chapter).

AIM 3: explore whether HFA impacts hygiene and food safety assurance (point 2.1 in the research framework: Figure 1.1 and 1.2 in the Introduction Chapter).

Figure 6.1 depicts the way research methodology was used to achieve these aims in this research. The semi-structured interviews together with relevant document review (method 1) with the person responsible for HFA in the companies enabled to achieve AIM 1 of gaining insight into companies' HFA practices (Figure 4.8). Methods 1-2 were used to gain insights into different aspects of FSC maturity model's dimensions (AIM 2). To achieve AIM 3, method 1 was used to understand the role of FS and hygiene within companies HFA practices, methods 3 and 4 gave insight into whether this role is a belief across the company and method 5, observations, gave insight into FS and hygiene related practices.

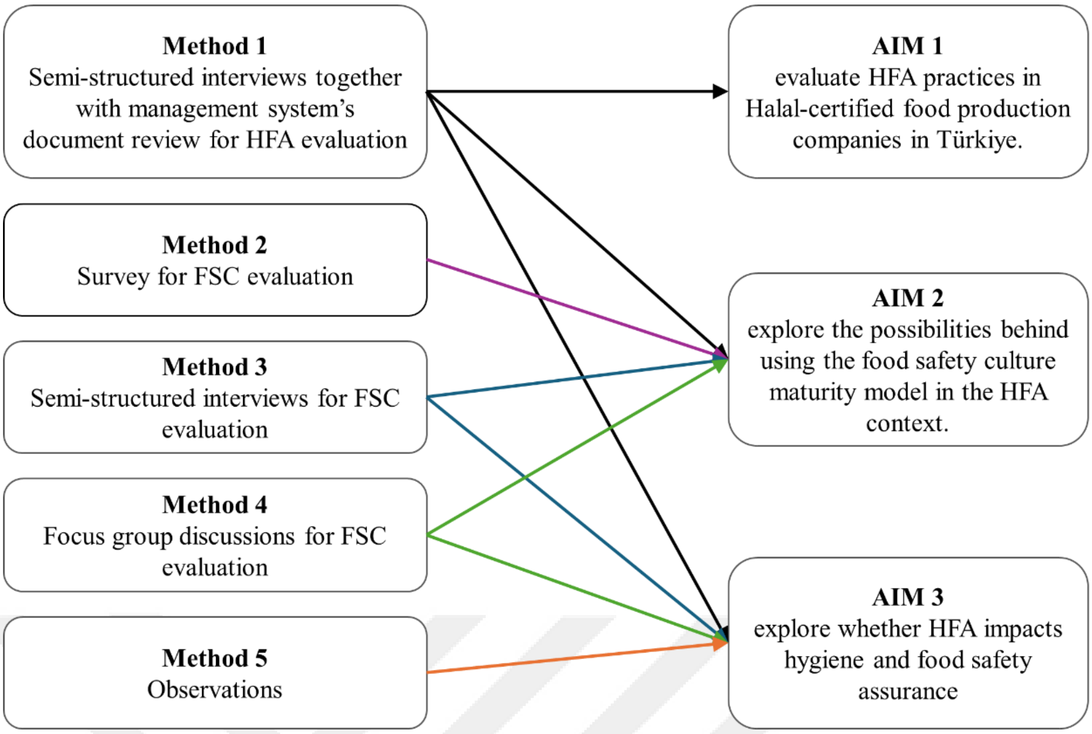


Figure 4.8: Visualization of how research methodology was used to achieve aims in this research. FSC: food safety culture; HFA: Halal food assurance.
Source: Prepared by the researcher.

The initial data collection was conducted between September 2022 and April 2023. Starting from June 2023 in Türkiye all Halal certification bodies (HCB) should be accredited (Presidency of the Republic of Türkiye, 2024). As this might have brought about changes in HFA in the companies, follow-up semi-structured interviews were conducted between May and August 2024. In addition to enabling to ask clarifying questions about the initial data collected, the results of these interviews enabled to gain insight to what extent the initial data reflects current HFA practices. As such, the chapter starts with elaborating on companies' certification details, followed by putting forth the HCB accreditation impact on companies and then continuing with the sections connected with the aims mentioned above.

Furthermore, within these sections, the findings of this study were compared with findings from other studies. As Halal food management practices on a case study bases in food production companies have so far been evaluated in the Indonesian context, the findings from these studies were separately brought out in Tables 4.30 and 4.31. for comparison purposes.

4.4.1. Companies' Halal Certification Details

In the study, it was determined that among the participating companies, C1 was working with a HCB, which did not eventually get accredited in Türkiye and accordingly the company had to switch to another certifier. Other companies were certified against specific Halal standards, C2 and C3 against the Malaysian Halal food standard, called MS1500:2009 *Halal Food General Guidelines* (MS1500 standard) and C4 and C5 against the OIC/SMIIC 1:2019 General requirements for Halal food standard (OIC/SMIIC standard). Thus, this work not only gave insights into Halal assurance practices in food production companies but enabled also to do that in the light of different standards. Additionally, C2 and C3 had the same HCB, which will be referred to as HCB 1 and C4 and C5 had the same HCB, which will be referred to as HCB 2, when relevant.

C2, C3 and C5 had products outside the scope of their Halal certification and as such it will also be possible to get insights on practices in a non-dedicated facility on avoiding cross-contamination. Furthermore, C2 had two factories, but with different HCBs. If not specifically stated, this study reflects the HFA of the factory producing processed products, like the other companies participating in this study.

Finally, the participation of a multinational enterprise, C6 gave insight into the sector's best practices and accordingly enabled to compare these with C1-C5's practices and work towards improvement suggestions.

4.4.2. Halal Certification Body Accreditation Impact on Companies

The results of the accreditation impact could be seen in Table 4.20. The biggest impact of accreditation was seen in C1, which was previously certified by an HCB which is currently not accredited, and which is now certified by an accredited HCB. For instance, while previously C1 had no requirements for their suppliers' HCBs, after being certified by an accredited HCB, C1 reported that they had to start paying attention from which HCB their suppliers take their Halal certificate (HC) and had to conduct a Halal related hazard analysis, which they incorporated into their HACCP plan. In contrast, C5 reported that the accreditation system opened wider opportunities to work with different suppliers and not just the ones specified by their HCB. Also, C1 brought out that more attention was given to FS and hygiene than by their previous HCB, whereas C2-C5 did not bring out any difference in that regard, as it had already been so before as well. Other changes included having to specify the ‘Halal requirements’ to be related to the relevant SMIIC/OIC standard, in relevant documents, like raw material specifications and handbooks (Table 4.20). Thus, from one side, accreditation enabled to increase control over the supply chain, on the other, it unified the practices of different HCBs.

Except for the differences due to HCBs accreditation, HFA practices in the companies for now remain unchanged, which will be presented in the discussion below. However, to make further conclusions on accreditation impact, future follow-up data collection is necessary, as it will take both HCBs and companies time to adapt.

Table 4.20: Companies’ reports on differences after HCB’s accreditation,

Company	Difference
C1	- Had to conduct a Halal related hazard analysis, which they incorporated into their HACCP plan. - Suppliers had to have HC from accredited HCB. - Halal audit focused more on hygiene and food safety. - HCB focuses more on food safety, as the use ISO 22000 as the foundation. - In relevant documents (e.g. specifications) they had to specify the ‘Halal requirements’ to be related to the relevant OIC/SMIIC standard
C2	- Is working on changing their HCB.
C3	- Had to change their HCB, due to delays in obtaining accreditation. - No significant changes, except that they have to make sure the supplier HC should by an accredited HCB, in addition to being a recognized HCB by Department of Islamic Development Malaysia (JAKIM). *Note: As they do not have Halal mentioned in any documents, they did not have to specify the ‘Halal requirements’ to be related to the relevant OIC/SMIIC standard.*
C4	- Company had to focus on raw materials they had not before and not just for Halal. For instance, they had to investigate preservatives used in some raw materials, their limits and whether they are allowed. - Started analyzing ingredients like enzymes, by taking flow charts and Halal declarations from their suppliers.
C5	- Opened wider opportunities to work with different suppliers, as they are not confined to a supplier with a HC from a specific HCB. - External Halal food related trainers must be from an official establishment. - In relevant documents (e.g. handbook) they had to specify the ‘Halal requirements’ to be related to the relevant OIC/SMIIC standard. - Specific requirements for the wording of a Halal declaration from a supplier.
C6	- Communicate with and inform suppliers, which did not have a HC from an HCB accredited in Türkiye. - Challenges were with suppliers outside Türkiye to convince them to get accordingly certified.

	- As their own factories already had a strong HFA foundation with documented system and their own internal Halal standard being based on the OIC/SMIIC standard, with some requirements even more stringent, they did not have any difficulty adapting.

C1-6: participating company codes; HACCP: Hazard analysis and critical control points; HC: Halal certificate; HCB: Halal certification body; HFA: Halal food assurance; OIC/SMIIC standard: OIC/SMIIC 1:2019 General requirements for halal food standard.
Source: Prepared by the researcher

4.4.3. Risk Mitigation from Incoming Materials

4.4.3.1. Suppliers' Halal Certification Bodies

C1 and C3 had all their products in the Halal certification scope and as per their HCB, demanded a HC from all their raw material suppliers. The difference was that for C1 any HCB for the HCs would do (this was before the accreditation), while C3 could accept only suppliers' HCs from Department of Islamic Development Malaysia (JAKIM) recognized HCBs. JAKIM is the governmental body in Malaysia, recognizing HCBs, which in turn could certify food production companies, making them eligible for export to Malaysia (JAKIM, 2024).

C4 also had all their products in the certification scope. C4 and C5, having the same HCB, they required their suppliers of high-risk ingredients to be certified directly by the HCB certifying them (Table 4.21). C4 and C5 additionally brought out that they demand HCs from their suppliers even if HCBs did not explicitly demand an HC for these materials. However, they did not have any requirements for the HCBs of these suppliers. In case the supplier did not have an HC and from the specification it became apparent that the raw material does not include animal-derived ingredients, making it a low-risk ingredient, C5 settled for a declaration from the supplier that their products are Halal.

C2 and C5 did not have all their products within the Halal certification scope. C2 talked about the difficulty of finding suppliers certified by suitable HCB for 100s of ingredients, resulting in all the products of C2 not being in the HC scope. For the ones that were, C2 could accept suppliers with a HC by JAKIM approved HCB. Additionally, both companies were asking for a HC for raw materials used in products, which were not in the Halal certification scope. However, in both cases, companies did not have any requirements for the HCBs of these suppliers.

C6, on the other hand, had requirements for suppliers' HCBs to be accredited by specific accreditation bodies and/or do DNA tests, elaborating, that suppliers having HCs from accredited HCBs is an important risk mitigation strategy, as they have had issues with some companies buying their HCs. Thus, even though C2, C4 and C5, might have taken risk mitigating initiative in addition to the minimum demands of the HBC, they demonstrated low awareness of the HCBs' reliabilities and thus failed to address risks in this regard.

Thus, while C6 showed awareness regarding the importance of HCB accreditation and accordingly took the lead in setting their own requirements for the HCBs of the HCs they accepted from their suppliers, C2-C5 showed low awareness and were guided by their HCBs, demonstrating lack in understanding and challenging risks and that their risk awareness and actions to manage risks depends on external sources (Table 4.21). The worst-case scenario was C1, who showed both low awareness and was not guided by their HCB, at the same time demonstrating the importance of external pressure by the HCBs.

4.4.3.2. Supplier and Their Products' Risk Assessment

While C3 and C5 mentioned analyzing raw materials' Halal-related risks, the C1 and C2 did not. Although C3 and C5 do not have specific procedures for this, both mentioned looking at specifications, in addition to C3 looking at flowcharts and having their suppliers fill in a question list prepared by their HCB, in case a supplier does not have a HC from a suitable HCB (Table 4.21). C3 then forwards the question list filled by the supplier to the HCB for confirming the supplier's suitability. C3 also uses these to identify whether their suppliers are using processing agents.

C4 mentioned using supplier specifications and flowcharts, especially at their initial Halal food related analysis for raw materials like vitamins and flavoring agents to identify ethanol use (Table 4.21). After the HCBs' accreditation, C4 responsible staff took part in the OIC/SMIIC standard's training, leading them to include enzymes in their analysis by using flow charts and collecting Halal related declarations from the suppliers (Table 4.20). C3, on the other hand, was guided by their HCB on risks on enzymes, even before starting to work with an accredited HCB, demonstrating the positive impact of the accreditation.

C6 is a contrasting example, by having a database of ingredients and related risks (e.g. processing aids, fermentation, carriers, extraction) and a documented system on how to categorize supplies into different risk categories (Table 4.21). To make the hazard analysis, from every supplier they demand product specification, questionnaire/declaration, compound flow chart and look at the company profile. Like this, they could make sure whether the suppliers use any processing aids and whether they produced or used any high-risk ingredients (e.g. vitamins). Additionally, with the questionnaire/declaration, C6 identified whether any high-risk products were produced on the same or adjacent line, making the supplied product also high-risk, and whether the suppliers had fermentation processes or used ethanol, animal-source materials or glycerin (both as raw material and within packaging materials). This process also helped them to decide what documents and/or analysis they should demand from their suppliers. For instance, from product suppliers identified as high-risk, they demand an HC from their list of suitable HCBs or DNA tests (Table 4.21).

Thus, there are significant differences between companies on the extent they analyze risks from suppliers' production, with C6 demonstrating the most stringent and systematic documented approach to understand and mitigate these risks.

Table 4.21: Companies' risk assessment practices regarding raw materials,

Aspect	C1 (before/after HCB accreditation)	C2	C3	C4	C5	C6
HCB conditions for HC	Existence of HC / HC by accredited HCB.	All ingredients for products in the HC scope need to have a HC from an HCB recognized by JAKIM.	High-risk materials should have HC from a HCB recognized by JAKIM. In other cases might use question list to get confirmation from the HCB.	High-risk materials should have HC from the certifying HCB.	High-risk materials should have HC from the certifying HCB.	High-risk materials should have HC from accredited HCBs or DNA test from high-risk raw materials.
Company conditions for HC	-	Any HC will do for products' ingredients outside the HC scope.	-	Any HC will do for materials, which are not high risk.	Existence of HC or declaration will do for other than high-risk ingredients.	-
Risk assessment	No risk assessment	No risk assessment	High-risk ingredients are determined by HCB (e.g. gelatin, glycerol, milk powder, corn flour).	High-risk ingredients are determined by HCB (animal-based ingredients like whey, ethanol	High-risk ingredients are determined by HCB (animal-based ingredients, like sausage casings)	Documented risk assessment procedure. Have a database guiding risk analysis, enabling to categorize materials into high and low-risk products.

				content in vinegar)		
Documents from suppliers used for risk assessment	-	-	Specifications and question list	Specifications, flowchart	Specifications	Component flowchart, company profile, specification, questionnaire/ declaration
Aspects considered in risk assessment in addition to ingredients	-	-	Animal-based ingredients, processing aids, enzymes, ethanol content	-	-	Animal-based ingredients, processing aids, enzymes, ethanol content, fermentation, extraction,
Risk assessment documented	- / Incorporate Halal control points in hazard analysis.	-	Risk analysis not documented	Has incorporated high-risk ingredients in hazard analysis.	Brings out high-risk contents in the handbook. No other processes in writing.	Written Halal assurance related risk analysis and procedures are expected from factories.

‘-‘: lack of practices; C1-6: participating company codes; HC: Halal certification; HCB: Halal certification body; JAKIM: Department of Islamic Development Malaysia.
Source: Prepared by the researcher.

4.4.3.3. Awareness of High-risk Ingredients in Terms of Halal Assurance

In this research, the companies coded C4 and C5, having the same HCB, emphasized that their HCB focuses directly on animal-based ingredients (e.g. whey powder, meat) as high risk, which were thus compulsory for having a HC from their own HCB. The former brought these ingredients out in their HACCP hazard analysis, while the latter emphasized these in their Halal handbook (Table 4.21). Unlike C4 and C5, C2 and C3 did not explicitly emphasize animal-based ingredients. C3 just mentioned their HCB focusing on some ingredients deeming these as high-risk, like gelatin, glycerol, milk powder, corn flour, which should thus have an HC from a HCB recognized by JAKIM. Just like C1 and C2 were not conducting any raw material risk analysis, discussed above, they also did not mention any which they focused on as high-risk.

C5 emphasized Halal risks related with animal-sourced products like sausage casing, but not with products like food additives, which might be derived from or mixed with animal source ingredients, like emulsifiers, although they are using these in their production. Interestingly, C3 differed, as they brought out Halal related risks with ingredients such as processing aids and enzymes, showing greater awareness.

As mentioned above, C6 had a database of ingredients and related risks (e.g. processing aids, fermentation, carriers, extraction), which their factories had to use as a guide, in addition to the information obtained from the suppliers, to analyze all supplied products, in the end categorizing them according to risk (high and low risk).

Thus, there is a difference regarding the awareness of materials, which could pose a risk to Halal food assurance, which is also related with the extent companies focus on suppliers' production. While, this might be shaped by the HCBs, these findings are also in line with statements by C1, C4 and C5 that Türkiye is a Muslim country and thus there are no big risks related with Halal. Even though HCBs might have conducted this analysis, these companies are currently not engaged as active members of the supply chain to mitigate Halal food related risks.

4.4.3.4. Risks Regarding Other Materials

C6 was the only company to identify risks related to maintenance oils/ lubricants, as animal DNA might be present and they either require an HC or a DNA test, like with high-risk raw materials. C6 was also the only company who had rules in place for outsourced visiting maintenance staff, who might bring with them materials posing a risk, like maintenance oils / lubricants (Table 4.22).

Additionally, only C3 and C6 considered aspects regarding utensils (e.g. brushes). These companies, in addition to C1 and C5, considered Halal-related risks with packaging, demanding a flowchart or a declaration from their suppliers (Table 4.22). While C3 considered packaging regarding fats/oils, which might be used on their surface, C6, additionally considered animal-source biomass used for plastic production and related risks regarding animal DNA, to the extent that they conduct DNA analysis from packaging raw materials (Table 4.23). A case study with a food production company in Indonesia, also identified that packaging material had not been considered in their HFA (Wulandari, Sirajuddin & Qui, 2022).

C2-C5 mentioned risks related with cleaning chemicals and ethanol, however, C6 stated this not being an issue, as long as the ethanol does not come from alcoholic beverage production. They also mentioned checking for the use of glycerin, which might be of animal source.

As for genetically modified organisms (GMO), C6 mentioned it is allowed for as long as the source does not cause a risk. Other companies mentioned they had to be careful about GMO, as there is a minimum limit set by regulations, but only C3 and C4 mentioned that their HCBs investigated this topic (Table 4.22).

In a study conducted in Malaysia, a multinational enterprise considered Halal certification sufficient for risk mitigation, they also settle for a declaration from the supplier, if they could not find a Halal certified supplier (Fujiwara & Ismail, 2017). But what this study did not mention was whether the company considered the level of risk of the raw material. For instance, C5 also might settle for a declaration if certified suppliers are not available, but not for raw materials, which they consider high risk. On the other hand, as this study has demonstrated there are considerable differences in what HCBs and with that companies perceive as a Halal food assurance related risk, which does not only put the risk mitigation impact of declarations, but also HC under question.

Despite the Halal standards directly mentioning some of these risks, the low awareness of C1-C5 is noteworthy. For instance, standards mention these aspects as follows:

- OIC/SMIIC 1:2019 standard had a clause on maintenance oils: 7. Machinery, utensils, production lines: c) Oils used in the maintenance of machines and devices that come into contact with the food shall be food grade oil and shall not contain any ingredients that are non-Halal.
- OIC/SMIIC 1:2019 standard had a clause on food-contact utensils, which could be related with brushes: Any part of the machinery, utensils, production lines which comes in contact with food material used for processing Halal food shall not be made of or contain any materials that are decreed as non -Halal according to Islamic Rules and shall be used only for Halal food.
- Both MS1500:2009 and OIC/SMIIC 1:2019 standards have similar clauses on packaging materials: The packaging materials shall not be made from any materials that are non-Halal. The packaging materials shall not be prepared, processed or manufactured using equipment that is contaminated with non-Halal materials.
- Both MS1500:2009 and OIC/SMIIC 1:2019 standards have similar clauses on GMO: Food and beverages containing products and/or by-products of GMO or ingredients made by the use or manipulating of genetic material of animals and plants that are non-Halal according to Islamic Rules, are not Halal.

Interestingly, these standards did not directly contain clauses related with cleaning materials, despite this companies were more aware of its related risks (Table 4.22), compared to areas directly listed as clauses in the standards. The standards indirectly referred to its related risk, through a general clause, like 'should no *contain anything in any quantity that is decreed as non-Halal according to Islamic Rules*',

In conclusion, companies' Halal food-related risk awareness and accordingly actions taken vary greatly with regards to both ingredients and other materials, discussed in this section, compared to C6. This is worrisome as this demonstrates that the risks in the Halal supply chain are not managed properly, leaving the effectiveness of Halal certification under question.

Table 4.22: Companies' considering materials other than raw materials in risk assessment,

Aspect	**C1 (before/after HCB accreditation)**	**C2**	**C3**	**C4**	**C5**	**C6**
Maintenance oils/lubricants.	-	-	-	-	-	Requires HC (as animal DNA might be present).
Brushes	-	-	HCB: Wants to see brush specification.	-	-	Forbidden materials must be identified and removed from production
Packaging	Declaration	-	Flowchart from packaging supplier, as oils/fats might be used on their surfaces.	-	Declaration for packaging.	Requires HC and invoice of their plastic supplier (as tallow and animal DNA might be present).
Cleaning chemicals	-	Cleaning chemicals should not be ethanol based.	Cleaning chemicals should not be ethanol based. HCB wants to see receipt.	Cleaning chemicals should not be ethanol based.	Cleaning chemicals should not be ethanol based. HCB looks at its ingredients.	Cleaning chemicals: - containing ethanol not an issue. – risk analysis includes. – should not contain acids dangerous for health.
GMO	Some declarations present	Should not be present due to minimal legal limit.	HCB asks about this. Should not be present due to minimal legal limit.	HCB asks about this. Should not be present due to minimal legal limit.	Should not be present due to minimal legal limit.	Allowed, if DNA source is ok.

'-': lack of practices; C1-6: Company 1-6; GMO: Genetically modified organisms; HC: Halal certification; HCB: Halal certification body;
Source: Prepared by the researcher.

4.4.3.5. Analyses

In this research, C1, C2 and C5 did not mention conducting any analyses with Halal assurance in mind, with C5 highlighting that their customers conduct DNA analyses from their products, verifying their system. Both C3 and C4 demand a porcine DNA test for high-risk raw materials and an ethanol test for ingredients like vinegar and flavors (Table 4.23). This was practiced by C4 even before they got a HC, demonstrating taking a preventative, rather than a reactive approach regarding HFA (discussed further in section 4.4.6.). C6, on the other hand, accepts DNA tests from their suppliers as an alternative control measure for an HC. Of all the companies, only C4 and C6 mentioned the importance of having the analysis conducted in an accredited laboratory and with that demonstrating awareness of such a risk.

Both C4 and C6 have documented the kinds of analyses necessary. While C4 includes these in their sampling plan, C6 has a database of raw materials, which guides factories regarding the analysis they should make or have the supplier make. They also had their factories do DNA tests on well water, which was a requirement when water from nearby facilities or farms might contaminate it with animal DNA. They also had factories conduct analyses such as porcine DNA analysis from packaging raw material or ethanol analysis from flavors (Table 4.23). As such, C6 was the only company demonstrating awareness of these risks.

Thus, as demonstrated in the sections above, just as awareness on Halal related risk varies between C1-C5 and also these companies and C6, so do the types of analyses conducted for Halal assurance verification.

Table 4.23: HFA-related analyses conducted and/or demanded by companies,

Aspect	C1	C2	C3	C4	C5	C6
DNA tests from high-risk ingredients	-	-	+	+	-	-
DNA tests from high-risk ingredients in case there is no HC	-	-	-	-	-	+
DNA analysis from well water (in case nearby farms) and packaging raw materials	-	-	-	-	-	+
Ethanol from specific products	-	-	+	+	-	+

'-': no practices; C1-6: participating company codes.
Source: Prepared by the researcher

4.4.4. Risk Mitigation from Suppliers

4.4.4.1. Control of Halal Certificates

Credibility of the HC is considered as an important Halal food assurance performance indicator (Tieman, van der Vorst & Ghazali, 2012). Among the participating companies, having a HC from suppliers was one of the main Halal food assurance controls for the companies, however the practices of how and what they controlled differed. While the expiry date of the HC was controlled by all, the aspect of HCs being genuine was only considered by C6 (Table 4.24). This was partially also done by C5, who was checking from their HCB's database, whether supplier's HCs for high-risk raw materials had been cancelled or renewed, like this, also verifying whether these HCs were genuine.

Both C3 and C6, also mentioned that there must be exact product name or code on the Halal certificate, as there might be products with similar names (e.g. citric acid, flavors), but different product codes. Regarding C3, this was brought to their attention by their HCB in the audit report as a non-conformity. Additionally, they both checked whether the address of the supplier and the address on the certificates match. C2 and C6 mentioned controlling whether the HC is from a manufacturer or distributor, to make sure they have the manufacturers' certificates.

While C1 and C4 did not, C2, C3 and C5 had a supplier list to follow-up on their HCs' details. C4 does not have such a list, as their supplier contracts last for 6 or less months and every time they ask for necessary documents. C6 expects their factories to have such a list regarding their suppliers and together with a supplier monitoring plan demonstrate their due diligence.

There are not only differences on what companies control regarding HCs, but also regarding how companies go about these controls. While C1-C5 focus on getting everything ready for the HCB audits, C6 considers this as a sign of poor/passing working culture and has emphasized that supplier controls should not be conducted for the sake of audits, but factories should have a sampling plan based on risk to routinely review all suppliers and their documents.

Thus, not only does C6 have a thorough risk assessment approach of the suppliers, but also considers conducting it as a monitoring procedure, while C1-C5 have a more ad hoc approach to managing their suppliers.

Table 4.24: Companies' supplier control and monitoring practices,

Aspect	C1	C2	C3	C4	C5	C6
Control of certificates	**- e**xpiry date - *HCB accreditation*	**- e**xpiry date - HCB recognition *and accreditation* - manufacturer and/or distributor	- HCB recognition *and accreditation* - HCB address - expiry date, - company name and address - product name/code	- HCB *accreditation* of high-risk ingredients - expiry date - company and product name	- HCB *accreditation* of high-risk ingredients - expiry date - product name - HC status from database	- HCB accreditation - HC being genuine - expiry date - company name and address - product name/code - manufacturer or distributor
Documentation for monitoring suppliers	Planning to make a list to get an overview of manufacturers and their HC expiry dates.	Has a supplier list to follow-up on suppliers.	Has a supplier list to follow-up on suppliers.	-	Has a supplier list to follow-up on suppliers.	Every factory must have a list, including relevant details.
Control frequency and other details	Annually before the audit.	Annually before the audit. Contracts renewed annually and new certificates demanded each time.	Annually before the audit.	Contracts renewed frequently and new certificates demanded each time. HCs double checked before the audit.	Annually for animal and processed raw materials. In every 3 years raw materials with low risk and no HC.	Based on risk, factories should have a sampling plan to review all suppliers and their documents annually. Controls should not be specifically for audits. Lack of due diligence in supplier monitoring is a sign of poor/passive work culture

C1-6: participating company codes. HC: Halal certificate; HCB: Halal certification body; Text in italic – after accreditation of HCBs.
Source: Prepared by the researcher.

4.4.4.2. Supplier Engagement

Tieman, (2017) emphasized the importance of having Halal requirements stated in a legally binding document, like a contract, and that Halal food requirements tend to be covered rather with suppliers of ingredients and additives, than other supply chain partners, like distributors and logistic service providers (Tieman, 2017). However, in this study there were gaps in both cases.

While C4 and C6 both had a system for legally binding the supplier, C6 was the only company who emphasized the importance of having a legally binding document with regards to Halal assurance (Table 4.25). C6 had two documents for this purpose, the supplier contract and questionnaire/ declaration including a disclaimer guiding back to the contract, making the supplier liable for any reputation loss. They especially brought out that it should be signed by the GM or the technical director or in other words people who are authorized by the company to act on its behalf.

The questionnaire/ declaration of C6 also includes a clause communicating the expectations for the suppliers to practice the same due diligence towards their own suppliers (Table 4.25). Like this, the company does not only work towards lowering their risks regarding the supply chain but increase supplier awareness, as leaders of the supplier company at least must read through the questionnaire/ declaration, potentially increasing their awareness and a sense of accountability. This also enables C6 to set expectations, communicate and make the possibility of consequences more tangible. Additionally, C6 was the only one to emphasize setting consequences in the context of Halal assurance that suppliers will be delisted if they declare a wrong address or do not notify of changes (e.g. in production process, packaging). As discussed in Chapter 2 (section 2.3.2.), regarding the ABC model, consequences are more effective in impacting behavior, compared to antecedents, like related requirements. Thus, not only the HCBs, but companies could also have a role in increasing awareness, accountability and facilitating continuous improvement, mitigating supply chain risks.

C6 was also the only one who had thought things through regarding any changes at the suppliers' and had incorporated this in the legally binding documents. C4 was the only one who specifically stated that there is no need to pay attention to this aspect, as they often renew their contracts demanding and checking all the documents from their suppliers (Table 4.25). However, these work processes mitigate the risk only to some extent. The worrisome aspect around suppliers making changes is that they might not even be aware of how some changes might impact Halal food assurance, as also demonstrated by the variations in the extent of awareness and risk mitigation of the participating companies.

Tieman, (2017) also emphasized the importance of having Halal requirements a part of supplier audits (Tieman, 2017). While all conducted supplier audits regarding FS, none did so for the sake of Halal food assurance. C6 had a third party do that as an option, in case factories' suppliers did not have a HC. Two Malaysian companies reflected the same, with the difference of one company annually auditing logistics operations of distributors if they did not have a HC (Fujiwara & Ismail, 2017). This is interesting, as integrating some basic Halal food management requirements in FS related supplier audits might not only enable to some extent mitigate supplier related risks, but could be leveraged for continuous improvement regarding Halal food management practices within the supply chain.

4.4.4.3. Alternative Suppliers

A multinational enterprise in Malaysia had identified a single supplier for particular ingredients as a risk source, because if issues occurred with this supplier, they would have difficulties with procurement and producing the Halal products (Fujiwara & Ismail, 2017). These kinds of difficulties also put companies under pressure to quickly find suppliers and with that increase the risk of starting to work with suppliers not so thoroughly checked out as they could be.

Although participating companies have alternative suppliers, none of them considered this to be a risk with regards to Halal assurance (Table 4.25). C1 and C5 said that they have stock, which mitigates this risk to some extent. Just C2 mentioned that as they have a high number of raw materials and already have difficulty finding proper suppliers to get all their products within the Halal certification scope, that it might as well be that they have alternative suppliers without the proper Halal certification, demonstrating the high probability of this kind of risk.

Table 4.25: Other supplier management practices related to Halal food assurance,

Construct	C1	C2	C3	C4	C5	C6
Suppliers notifying about changes	Not considered regarding Halal assurance.	Not considered regarding Halal assurance.	Not considered regarding Halal assurance.	No need, because they renew contracts in or less than in every 6 months.	Not considered regarding Halal assurance.	Supplier must notify about any changes according to legally binding documents and is delisted if does not do that or declares wrong address.
	Manufacturer is told about the need to notify about changes verbally	-	-	-	Manufacturer is told about the need to notify about changes through email.	
Legally binding documents	No contract with suppliers.	Has contract with supplier, but no legally binding documents with regards to Halal.	Supplier signs raw material specification, which does not include Halal requirements.	Contract includes conforming with raw material specifications, which includes Halal requirements.	Has contract with supplier, but no legally binding documents with regards to Halal.	Halal clause in supplier contracts and disclaimer guiding back to the contract in the questionnaire/ declaration, which has to be signed by general manager/technical director.
Alternative supplier	They have stock, so no problem.	There might be alternative manufacturers without HC.	All alternative suppliers must be approved.	All alternative suppliers must be approved.	They have stock, so no problem.	All alternative suppliers must be approved.

'-': lack of practice; C1-6: participating company codes.
Source: Prepared by the researcher

4.4.5. Risk Mitigation from Internal Halal Food Management Systems

While the discussion so far has been about what materials are considered as a risk, what processes are in place to identify these and how to mitigate these risks externally or in other words outside the company through supplier management, the following two sections will analyze risk mitigation internally, or in other words the impact of management and organization culture on Halal assurance.

While C2 and C3 had to align according to the Malaysian MS1500:2009 *Halal Food General Guidelines* (Standards Malaysia, 2019), C4 and C5 had to do so according to the OIC/SMIIC 1:2019 *General Requirements for Halal Food* (SMIIC, 2019). These standards set the scene on what is to be expected of these companies regarding a Halal food management system (Table 4.26). While MS15000 standard clearly states the need for a control system, a responsible person or a team, their training and allocation of resources accordingly, the OIC/SMIIC 1 standard does not offer such detail, but mentions that that Halal assurance activities could be incorporated into the existing system.

Table 4.26: Comparison of Halal food standards regarding management system requirements,

MS1500:2009 **Source:** Standards Malaysia, 2019	**OIC/SMIIC 1:2019** **Source:** SMIIC, 2019
3.1 Management responsibility:	**Introduction:**
3.1.1 The management shall appoint Muslim halal **executive officers** or establish a **committee** which consist of Muslim personnel who are responsible to ensure the effectiveness in implementation of **internal halal control system.**	The standard was formulated based on the concept of halal that integrates the requirements of halal food products as part of the overall management and control systems to ensure that the halal food products are produced in accordance with Islamic Rules.
3.1.2 The management shall ensure that they are **trained** on the halal principles and its application.	
3.1.3 The management shall ensure that sufficient **resources** (i.e. manpower, facility, financial and infrastructure) are provided in order to implement the **halal control system.**	
	12 Presentation for the market: c) The management shall ensure all activities are properly **recorded.** All documents and records shall be maintained and traceable.

4.4.5.1. Documents

This section puts forth the extent companies' C1-C5 Halal food management systems were documented. C6 was not included in this section, as the data collected from this company reflected the central committee's expectations from their factories to have all their Halal food management system aspects documented and not the actual practices of the factories.

Having a JAKIM recognized HCB aligned according to the MS1500 standard, C2 and C3 are expected to set up a Halal food management system. While C2 showed signs of a documented system, like the existence of a Halal handbook and policy, C3 was working on setting that up (Table 4.27). Although C1 and C5 both had handbooks, these still contained HCB names, with whom they were not working together anymore, leaving these documents outdated. C4 just used the OIC/SMIIC standard as a guide. C4 mentioned Halal in raw material specifications and the hazard analysis part of the HACCP plan. After starting to work with an accredited HCB, C1 also included Halal related concepts in raw material specifications and the hazard analysis part of the HACCP plan. Thus, C1 and C4 are aligned with the OIC/SMIIC standard requirements of incorporating Halal requirements into their existing systems.

Among the five case studies conducted in Indonesia (Table 4.30), only one company had written procedures on multiple aspects like, Halal policy and Halal team, internal audit and management review procedures (Anggi & Rahayu, 2022), while another company demonstrated only a documented policy and management team (Wulandari, Sirajuddin & Qui, 2022). The reason behind these companies already having documented procedures might be that they were already certified, unlike the other three companies, which were supposed to be preparing for the upcoming mandatory governmental certification (further elaborated in Chapter 2, section 2.5.4.). For instance, in one of the non-certified companies, with no Halal team, internal audit nor management review, the owner was the driver behind Halal assurance, communicating and delegating responsibilities as he saw fit (Perdani, Chasanah & Sucipto, 2018).

Table 4.27: Companies' Halal food assurance related documents,

	C1	C2	C3	C4	C5
HCB details	HCB non-A/ HCB A*	HCB1	HCB1	HCB2	HCB2
Halal Handbook	Outdated/ ND	+	-	Showed the OIC/ SMIIC standard	Outdated
Halal policy	-	+	-	-	-
Raw material specs	-/+	-	-	+	-
Hazard analysis	-/incorporated Halal CCPs to HACCP	-	-	Had Halal CCPs in the HACCP plan	High risk ingredients brought out in the handbook

**: present/absent status of documents before/after starting to work with an accredited certification body;* '-': lack of Halal-related documents; '+': presence of Halal-related documents. C1-5: Company 1-5; CCP: critical control points; HACCP: Hazard analysis and critical control points; HCB: Halal certification body; HCB non-A: not accredited Halal certification body; HCB A: accredited Halal certification body; OIC/SMIIC: Organization of Islamic Countries/ Standards and Metrology Institute in Islamic Countries; ND: no data.

Source: Prepared by the researcher

4.4.5.2. Team, Meetings, Auditing

In this study it was put forth that while C1, C4, C5 said they do not have a Halal related team and in case of any issues, things can be handled with the FS team. C2 mentioned a team in the Halal handbook, however, from the interview it became apparent that it is not active as an actual team, but that the responsibilities of different roles have been described and they do not necessarily have to know about the details of each other’s roles. C3, on the other hand, mentioned that their HCB had demanded that they prepare a Halal handbook/procedure and set up a Halal team. As C2 and C3 have the same HCB recognized by JAKIM and certified accordingly, again demonstrates how Halal food standards influence Halal food management practices.

C6 has requirements for their factories to establish a team including Halal food management among other responsibilities. People from different departments must be included in the team (like a manager from production, logistics, procurement etc.), with the leaders of the factory appointing a chair for the team and top management having to approve both the chair and the team. There must be terms of references outlining the responsibilities of a team, including analyzing Halal food management related risks.

As for internal audits and meetings, while C1 and C4 did not do any type of reviewing specifically on HFA, C2 and C3 mentioned having these once a year, to prepare for the HCB audit. However, these processes were not being documented. C5 reports to the senior management once a year, in case any issues occur. C6 mentioned their factories having to conduct internal audits at least two and meetings 3 times a year, with also the central committee auditing all their factories annually. Regarding the latter, minor and major non-compliance details and the passing scores have been described in writing. Factories have a minimum score they are expected to obtain from this audit, the results of which are reported to the top management. Regarding the meetings, general topics have been determined and factories are expected to go over and discuss these, prepare meeting minutes and upload to the internal system.

The two Halal-certified Indonesian case study companies were found to have established documented Halal teams and internal audit procedures (Table 4.30). However, in one of the companies, the Halal team was mentioned not being effective due to the workload of the team members (Table 4.31) (Wulandari, Sirajuddin & Qui, 2022). This is a good example, as it is not only about setting up a team, but the team being effective in understanding and challenging Halal food assurance-related risks and accordingly engaging other relevant parts of the company. Only one of these companies had a documented management review procedure. No other insights were offered on the approach and efficiency of the Halal teams, internal audits and management reviews.

4.4.5.3. Training

While C1 had no HFA related training, C6 in contrast had compulsory trainers training for factories' senior management and their teams, after which they were expected to train their factory personnel, including the critical departments discussed above and the frontline staff. It was determined that C6 was also the only one to mention the importance of comprehension tests in both cases (Table 4.28).

The responsible staff in C2 – C4 had external training on Halal food. While C2 and C3 had the training only for directly responsible staff, which is also expected according to the MS1500 standard, C4 had these people in turn train other relevant staff in the company, without specifying which positions were considered relevant. C5 differed as they had external training on Halal fundamental to all relevant support functions and the frontline. According to the QMA, as this training remained too general, the company conducted additional internal job-specific training to purchasing, planning, R&D and frontline (Table 4.28). Thus, C5 and C6 were the only companies to mention conducting job-specific training up to the frontline level.

Existence of Halal related training was evaluated in four Indonesian case studies (Table 4.30) and none of the companies were found compliant regarding internal training of employees regarding the Halal management system, even not the two companies, which had been Halal certified. At only one company the Halal management team had external training (Table 4.31).

Table 4.28: Companies' Halal food assurance related training details,

Aspects	C1	C2	C3	C4	C5	C6
No training	+	-	-	-	-	-
QMA has had Halal related external training	-	+	-	-	-	-
Only staff responsible for Halal have had training.	-	-	+	-	-	-
One person received external trained, who in turn trained others, including frontline	-	-	-	+	-	-
External training on Halal fundamental to all relevant department and frontline	-	-	-	-	+	-
QMA gives internal job-specific training to purchasing, planning, R&D and frontline	-	-	-	-	+	-
Factories' senior management and compliance team members get 2 days of training and have to renew it every 3 years. To pass the training they have to complete an online test including correct answers at the end for post-comprehension.	-	-	-	-	-	+
Compliance team members in turn train factory staff, including frontline. There should be job-specific training, focusing on critical areas, with content being renewed annually (e.g. pictures) and a comprehension test.	-	-	-	-	-	+

'-': not applicable; QMA: quality management assurance responsible; R&D: Research and development.
Source: Prepared by the researcher

4.4.5.4. Halal Critical Processes

This part of the discussion will analyze the importance of different positions in Halal food assurance management and how companies go about distributing these responsibilities. While in C2 and C5 quality management assurance (QMA) staff were responsible for Halal certification, in C1 and C4 quality manager (QM) and/or chief (QC) were responsible, as these companies, in addition to C3, did not have a separate QMA department. In contrast, in C3, Research and development (R&D) staff were responsible, as this was not considered as a part of a management system. C6 leaves it up to their factories on how they divide related responsibilities.

C6 directly had in place Halal related CCPs for their companies regarding reception, R&D, purchasing, while other companies did not emphasize the importance of their roles that explicitly:

- Reception - C6 considers controlling addresses as a CCP (Table 4.35), namely, having factories control whether the address on the Halal certificate is same with the address in the approved supplier list and with the senders address on reception documents, as suppliers with multiple factories might send goods from factories producing the same things from the nearest one, which might not necessarily be Halal certified or certified by an accredited HCB. At reception, C1-C5 had no controls with Halal in mind, with C1, C2, C4 and C5 emphasizing no need for any controls at the reception since the supplier had already provided them with a HC.

- R&D - C6 considered R&D as a CCP and had requirements for their factories to have procedures in place to mitigate any risks with new raw materials and supplier changes (Table 4.35). While in C1 R&D demanded a HC from purchasing themselves, with QA in the email cc, to confirm the suitability of a raw material, C5 has software in place needing QA confirmation before approving a raw material, who double checks its suitability. Although C2 and C4 did not emphasize software per se, they did mention that raw material status should be confirmed with the QA.
- Purchasing - C6 also considered 2 aspects of purchasing as CCPs (Table 4.35). Namely, there should be procedures in place to control that factories order from the approved supplier list and controlling the suppliers' list on whether all the necessary documents are present, and the risk analysis has been properly conducted. As discussed earlier, in C1-C5 the latter is done annually and is not considered a CCP per se. As for the former, all have an approved supplier list, but only C5 emphasized having software and its importance for making sure purchasing could only order from among them, making their job easier of not having to control.

Regarding storage, after starting to work with an accredited HCB, C1 were asked to conduct a risk analysis. As risks they identified raw materials and storage. Upon asking, why they consider storage as a risk even though all their products are in the Halal certification scope, the reply was '*just in case any non-approved materials enter and have to be kept in storage*'. While cross-contamination in storage might pose a risk, there are multiple controls at different critical processes which could be addressed beforehand, like HC controls, purchasing, reception, which would mitigate this risk, which the company did not consider.

Furthermore, none except C6 mentioned control activities important for logistics (Table 4.35):

- controlling addresses and packaging to understand whether the goods are packed by manufacturers or agents. If packed by an agent, they should also be included in the Halal risk analysis, to identify whether their activities might pose a risk.
- making sure products are not repacked and have manufacturers put codes on packaging or the factory must describe packaging in detail and/or have a sample of packaging. This is for both Halal food assurance and protect against fraud.
- controlling cleaning records of tankers. C1-C5, for that matter, all were receiving raw materials with tankers.
- controlling for condensation formation in trucks, as a possibility for cross-contamination.

While the Indonesian HFA studies did not, a study including two Malaysian companies, an SME and a multinational enterprise, also considered logistics to be a risk. While the former work towards collaboration with their suppliers and decrease the use of overseas suppliers, the latter conducts annual on-site audits to their distributors who do not have a HC (Fujiwara & Ismail, 2017). Also concurrent with C6 activities, Tieman et al., (2017) brought out that cleanliness of tankers and mixing/stuffing of Halal and non-Halal products on a pallet, containers, transport vehicles, should be a Halal control activity to avoid contamination (Tieman, 2017).

By not having control activities and procedures in place for reception, R&D, purchasing and logistics, C1-C5 had not mitigated risks to the extent C6 did. For instance, governmental driven HFA practices in Indonesia include written procedures for critical activities like selection of raw materials, purchasing, product development, reception and production, storage and transportation (Table 4.30). For instance, regarding reception, companies should examine packaging label, to ensure the conformity of the information contained on the label with that contained in the material supporting documents, regarding product development, all new ingredients should be accordingly certified and regarding purchasing, this should be done according to the list of ingredients approved by the HCB. These are to some extent in line with C6 CCPs of critical activities. However, while C6 emphasized the risk regarding the address of suppliers, discussed above, it is not quite clear, what the Indonesian companies are expected to control with regards to packaging labels. Only one study brought details on the company checking the expiration date, brand name, price order quantity and the halal logo (Table 4.31) (Wulandari, Sirajuddin & Qui, 2022).

Regarding production, the Indonesian companies were expected to have procedures in place related to hygiene, cross-contamination and for washing the facility and equipment. However, there were no further details on what the companies should pay attention to regarding the latter and also regarding procedures around storage and transportation (Table 4.30 and 4.31). Only one study mentioned details such as the washing area for production facilities should be kept away from the toilet and production room (Wulandari, Sirajuddin & Qui, 2022).

4.4.5.5. Other Risks

With especially Halal food assurance in mind, C6 had rules in place for visitors, employees bringing their own food and drink and catering in their factories. Among the Indonesian case studies (Table 4.30), only one controlled the existence of the procedure for visitors, finding it absent (Anggi & Rahayu, 2022).

4.4.5.6. Non-dedicated Facilities

From the participating companies, C2, C3 and C5 had products outside the scope of their Halal certification and that is why, in these companies the planning department had a role in their HFA. It was used as a risk mitigation strategy to avoid cross-contamination through time segregation by placing non-certified products after the Halal certified ones (Table 4.29). All companies also had separate storage areas for the raw materials not within the Halal certification scope. Only C2 and C5 had rules in place for rework. C2 additionally emphasized the importance of weighing staff, who were important in controlling what raw materials go into production.

While C2 did not have non-Halal ingredients, just ingredients outside the Halal certification scope, due to not finding appropriately certified suppliers, C5 used ingredients considered doubtful with regards to Halal food assurance and thus not accepted by their HCB, making switching the production lines a higher risk production practice compared to other companies. It was found that accordingly C5 had more risk mitigation actions in place compared to others as well, like validating the efficiency of cleaning procedures after the non-halal-certified production and including planning in job-specific training regarding HFA (Table 4.28, 4.29).

C2 and C5 had Halal food assurance related handbooks, however, while C2 had mentioned storage, rework and time segregation, C5 had mentioned only the first two and not one of main strategies to prevent cross-contamination. On the other hand, C5 did state that the department managers themselves should train on this and that the QMA department conducted job-specific training on this as well.

Furthermore, from FSC focus groups in C2 (Table 4.35), it became apparent that there were issues with conducting proper cleaning of production lines (e.g. lack of water, time and proper cleaning verification), indicating to time segregation being an insufficient risk mitigation measure.

Tabel 4.29: Companies' cross-contamination prevention measures in production,

Aspect	C2	C3	C5
Storage	Certified and non-certified raw materials are stored on different shelves	Non-certified raw materials have a separate storage area	Certified and non-certified raw materials are stored on different shelves
Weighing	Workers using a list of raw materials used in products in the Halal certification scope. 'Workers at these positions have worked for a long time, know the products and the lists and what raw materials go to what products.'	-	-
Rework	Product reworks are used in the same product to avoid confusion.	-	They have specific work procedures, including software to manage that rework not in the Halal certification scope would not be used Halal certified products.
Planning (Time segregation)	First, products in the Halal certification scope are produced.	Non-certified raw material packaged rarely. If done so, this product is produced last.	First, products in the Halal certification scope are produced. QMA double checks the production plans
Cleaning	Daily visual verification of cleaning.	-	Had validated the efficiency of cleaning procedures after the non-halal-certified production. Verify cleaning through testing every 3 months. Verify lack of cross-contamination through annual final product testing, in addition to customer conducted tests. Daily visual verification of cleaning.

'-' – lack of practices; C2,3,4: participating companies 2, 3, 5; QMA: quality management assurance responsible.
Source: Prepared by the researcher.

Table 4.30: Overview of research results on Halal food management practices in Indonesia,

Halal assurance system related criteria	Sources				
	(Perdani, Chasanah & Sucipto, 2018)	(Al Adiat et al., 2018)	(Wulandari, Sirajuddin & Qui, 2022)	(Dewantara et al., 2018)	(Anggi & Rahayu, 2022)
Has a Halal certificate?	-	-	+	-	+
Written Halal policy	-	ND	+	ND	+
Communication	ND	ND	ND	-	ND
Halal team	-	ND	+	ND	+
Internal training	-	ND	-	ND	-
Training and socialization	ND	ND	ND	-	ND
Internal audit	-	-	+	-	+
Management review	-	-	-	-	+
Traceability	-	ND	+	ND	+
Handling unsuitable products	-	ND	+	ND	+
Material (*List of ingredients approved by the HCB)*	ND	-	+	-	+
Product (brand or product name do not use words leading to something prohibited)	+	ND	+	ND	+
Use of Halal critical point decision tree for ingredients	+	ND	ND	ND	ND
Use of Halal critical point decision tree for ingredients and processes	ND	-	ND	-	ND
Written procedures of critical activities (set of standardized work procedures for controlling critical activities)					
Selection of raw materials *(changes in the type of materials or production)*	-	**No written procedures**	+	-	+
Purchasing *(could refer to the list of ingredients approved by the HCB)*	+		+	-	+

Product formulation procedure *(The formulation that has been determined must be used as the basis for the production process)*	+		-	-	-
Reception *(an examination of the material packaging label, to ensure the conformity of the information contained on the label with that contained in the material supporting documents)*	+		+	+	+
Production *(cross contamination; hygiene)*	-		+	+	+
Procedures for washing production facilities and auxiliary equipment	ND		+		+
Storage and handling	+		+	+	-
Transportation (tight packaging and in good condition)	+		+	ND	-
Procedures for visitors	ND		ND	ND	-

'+': company was found compliant; '-': company was found not compliant; HCB: Halal certification body; 'ND': no data presented in the studies.
Source: Prepared by the researcher

Table 4.31: Details on Halal food management practices/procedures and/or compliance findings in studies conducted in Indonesia,

Halal food management practices/procedures	Sources		
	(Perdani, Chasanah & Sucipto, 2018)	(Wulandari, Sirajuddin & Qui, 2022)	(Anggi & Rahayu, 2022)
Halal policy	The company did not have a documented Halal policy. The only policy was the one spoken by the owner that all materials used must have a halal label of the Indonesian governmental agency LPPOM MUI.	The company did not have a documented Halal policy. However, there was evidence of dissemination from Muslim employees.	Documented Halal policy. The dissemination had only been done orally from the company leadership to all employees.
Halal Team	No systematical halal management team. Issues are handled by the owners of the company, who might also delegate related tasks to others.	Documented halal management team. However, members of the halal management team were preoccupied by the workload of the company.	Documented halal management team, signed by the owner.
Training	No internal training. The owner conveyed rules orally, which was that the materials used must have LPPOM MUI halal logo or certification.	Internal training related only to production practices, but no evidence of training and education attendance. No evidence of the team's training.	No internal trainer or training. Halal management team had external training from LPPOM MUI. No evidence that the team had obtained the HAS 23000 training license certificate.
Internal audit	ND	ND	Documented internal audit procedures. Internal audits had been carried out, but not repeated systematically.
Management review	ND	ND	Documented management review procedure. Management reviews had been carried out regularly,

			involving all related departments and the top management.
Reception	ND	Things that are checked include the expiration date, brand name, price, order quantity and the halal logo.	ND
Procedures for washing production facilities and auxiliary equipment	ND	The washing area for production facilities should be kept away from the toilet and production room.	ND
Packaging	ND	Halal status of the packaging material not considered.	ND

HAS: Halal assurances system; ND: No data. LLPOM MUI: Halal inspection agency in Indonesia.
Source: Prepared by the researcher

4.4.6. Risk Mitigation Through Organizational Culture

Even though a management system might not be in place, existence of it, including a team, meetings and audits, would also not necessarily dictate culture maturity, like seen in the FSC evaluation Subchapter 4.3, with companies having international benchmarked food safety management system (FSMS), but a food safety maturity score around 2, which in turn impacts the effectiveness of this system. Thus, in addition to the above discussion around HFA practices, this part of the discussion will investigate companies' work culture and its basic assumptions around Halal food assurance.

Importance of company culture and evaluating it in managing Halal food was also reflected by C6. For instance, they expect their factories to '*have a working culture working towards the ultimate system regarding both food safety and Halal… the factories should be in an active mode of wanting to do their due diligence… if they see checking something, like addresses on Halal certificates, burdensome, this means they are in passive mode*'. Here, a parallel could be drawn with organizational maturity, with the phrase 'passive mode' describing a culture maturity below stage 3 and the phrase 'active mode' describing a maturity above 3. Thus, C6 does not only focus on the management system, but company culture to mitigate risks.

It was also discussed and demonstrated in the literature review (Chapter 2), that food safety and Halal food related work cultures are important for the success of both their assurance and that the success factors identified for Halal food assurance could also be aligned with the FSC dimensions (Table 2.2 in Chapter 2, section 2.5.2.). Furthermore, as food safety and hygiene are a part of Halal food assurance, in addition to avoiding fecal contamination as an unwanted substance, FSC aspects, such as involving and engaging the frontline, also become important aspects in the light of Halal food assurance, especially, if all products are not within the Halal certification scope and the frontline are responsible for following procedures to avoid cross-contamination (Figure 4.9). Thus, a FSC maturity model could be taken as a foundation, extending some of its dimensions to evaluate Halal food assurance culture, which could ultimately be called Food safety – Halal food assurance culture (FS-HFA culture). As such, the globally accepted GFSI's FSC definition could also be extended accordingly to define FS-HFA culture, "*the shared values, beliefs and norms that* *affect mind-set and behaviour toward food safety and Halal food assurance in, across and throughout an organization*" (adapted from GFSI, 2018).

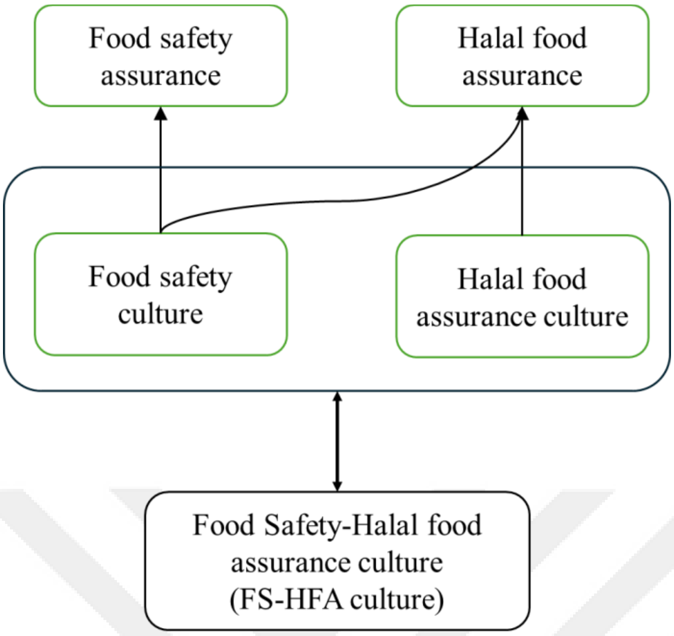


Figure 4.9: Conceptual framework for Food Safety–Halal food assurance culture (FS-HFA culture).

Source: Prepared by the researcher

This approach will be used in this section to present findings on Halal food assurance culture. The FSC maturity model's dimensions (Jespersen et al., 2019; GFSI, 2018) could be extended to evaluate Halal food assurance culture as follows:

- Values and mission dimension: motivation behind Halal food assurance, senior management being aware of the risks and accordingly setting the direction and getting involved. For instance, establishing a Halal policy and accordingly setting expectations for different departments, setting and following-up performance measures and getting involved in communicating Halal food assurance related values.
- People system: responsibility not being on one person/department (work in siloes), but being distributed among relevant departments (e.g. purchasing, R&D, reception, logistics, production etc); communication and collaboration regarding mitigating these risks; rewarding and recognizing desired behaviors related with Halal food assurance.

- Risks and hazards / Consistency: Considering that Halal food assurance revolves around understanding and challenging risks and keeping up with sector's best practices, new risks and changes (e.g. through horizon scanning), the norms described in the FSC maturity model might be combined as shown in Table 4.32 to describe Halal food assurance culture, resulting in a culture dimension with norms describing a company taking action due to external pressure at one (lower maturity) end and norms describing a company taking action due to internal motivation at the other (higher maturity) end. Stages 1-3 reflect the original Risks and hazards dimension stages, stage 4 was transferred from the Consistency dimension, since horizon scanning and a continuous improvement mindset could also describe the preventative stage 4 regarding risks and hazards and previous stage 4 of the Risks and hazards dimension was transferred to stage 5, as 'integral part of the organization' part of the norm in the Competence Model context describes its consciously competent stage of something being done on autopilot or in other words being internalized, which overlaps with FSC maturity stage 5 (discussed in detail in Chapter 3, section 3.2.1.).
- Adaptability: companies adapting to changes, improvements and challenges related with risks around Halal food assurance internally (e.g. risk analysis, supplier monitoring, auditing) and foreseeing risks/changes imposed/identified externally (e.g. through horizon scanning), in the end changing company systems accordingly. Another aspect would be how HFA aspects have been adopted into the existing systems and whether the expected systems are implemented in practice
- Consistency: whether there is documentation, whether companies show consistency in practice and how companies go about consistency regarding continuous improvement

Table 4.32: Modifications to the Risks and hazards dimension maturity stages for HFA-culture maturity evaluation,

Stage 1, doubt	**Stage 2, react**	**Stage 3, know**	**Stage 4, prevent**	**Stage 5, internalize**
The organization relies mostly on external sources and inspections to understand and act on its risks and doesn't identify risks internally	Actions to manage risks are mostly taken in response to external audits or inspections and internal identification is sometimes incorrect	Risks are understood and continually challenged by a cross-functional team through planned risk management	Identifying risks through horizon scanning and continuous improvement followed by mitigation plans built into the food safety system	Understanding and reducing risks are an integral part of the organization's continuous improvement efforts
Risks and hazards dimension stages			*Previously under Consistency dimension stage 5*	*Previously under Risks and hazards dimension stage 4*

Source: Prepared by the researcher

4.4.6.1. Value and Mission

The participating companies C1-C5 stated that they obtained an HC due to customer demand, while C6 had a policy that their factories should be Halal compliant, even if they did not have a Halal certificate, which stems from the policies set by the founder and risks regarding reputation loss (Table 4.33). Additionally, with C1, C2, C4, C5 explicitly stating that Türkiye is a Muslim country and there is no immediate risk for their companies per se, not only demonstrates their low-risk awareness, but their intentions of obtaining a certificate for the sake of it, rather than to assure better Halal food production, indicating to a stage 2 HFA-culture maturity. On the other hand, while C1 chose an HCB based on convenience, C2 and C3 chose their HCBs according to export market needs and C4 and C5 chose their HCB according to its good reputation in the local Turkish market, the latter two demonstrating an effort towards Halal food assurance, indicating to a higher maturity between 2-3.

This is also the foundation, which sets the tone in their practices around Halal food assurance, which reflects from the awareness and norms around risk identification and mitigation discussed in the sections below.

Table 4.33: Companies' reasoning behind obtaining Halal-certification,

	C1	C2	C3	C4	C5	C6
Reasons behind obtaining a HC	Customer demand					Founder policy and reputation
Reasons behind choosing their HCB	To obtain a HC.	Needed to sell to a specific market		It was an official and trustable establishment in Türkiye		Factories could choose from a list of accredited HCB

C1-5: participating company codes; HC: Halal certificate ; HCB: Halal certification body;
Source: Prepared by the researcher

Furthermore, senior leaders of C1-C5 refer to either having no role or HFA being the responsibility of a specific department (Table 4.35), indicating to low management involvement and awareness in Halal food assurance, indicating to a HFA culture stage between 1-2. C6 was a contrasting example, as site leaders and other managers had to get a comprehensive 2-days HFA training organized by the companies central Halal committee (Table 4.28), the site leaders were expected to appoint a leader for the HFA team, who in turn should announce the team members to them for their approval. Additionally, the company's central committee conducted HFA audits once a year, with the sites having performance goals accordingly and the audit results being reported directly to the senior management. Also, the sites were expected to communicate their Halal policy, HFA teams and relevant actions on a noticeboard and during training. In the context of the Competency Model, this shows that they were aware of the need to increase management awareness, engage management and found solutions around that, indicating to HFA-culture maturity of at least between 3-4. Further data is necessary on the consistency of these practices to decide on whether they have reached a consciously competent stage or in other words stage 5 HFA-culture maturity.

Looking at the FSC survey results regarding the questions on Halal food assurance, it becomes apparent that most of the participants were aware that their company had a Halal certificate and perceived products of their companies to be Halal as well (Table 4.34). Caution needs to be taken when interpreting these results, especially regarding C1-C4, as the overall companies' participation rates were well under the targeted threshold of 60%. That the participants perceived their company to produce Halal food (Q2), might also be impacted from the mindset demonstrated above, that Türkiye is a

Muslim country and food products are bound to be Halal, or in other words a low awareness of risk. Thus, based on the survey results it is difficult to make conclusions on how values around Halal food assurance have been communicated or to what extent awareness building has taken place.

Table 4.34: FSC survey results for questions related to Halal food assurance, presented as % per answer category,

Answer categories	C1		C2		C3		C4		C5	
	Q1	**Q2**	**Q1**	**Q2**	**Q1**	**Q2**	**Q1**	**Q2**	**Q1**	**Q2**
Yes	75	96	95	87	93	92	86	94	82	81
No	7	4	0	4	0	0	0	0	2	2
Do not know	18	0	4	6	7	4	12	6	15	14
Prefer not to answer	0	0	0	3	0	4	2	0	2	3
Total number of participants	**28**		**337**		**72**		**49**		**499**	
Total participation % of the whole company	**6**		**15**		**24**		**26**		**53**	

C1-5: participating company codes; Q1: Does your company have a Halal certificate?; Q2: In your opinion, does your company produce Halal food products?
Source: Prepared by the researcher

4.4.6.2. Risks and Hazards

In terms of the Risks and hazards dimension, C6 expects internal due diligence from their factories, demonstrated by their identified risks and control measures, auditing, reviews, teams, policies, communication and a written management system bringing it all together. On the other hand, C1-C5 HFA practices reflect HCB demands, in addition to there being room to improve, compared to C6 risk mitigation strategies. These are signs of lack of understanding and challenging risk and Halal food assurance being driven externally in C1-C5, compared to being internally motivated like demonstrated by C6, indicating to the HFA-culture maturity stage 2 in the former and stage 3-4 in the latter.

There are a few exceptions, like C4 emphasizing the importance of accredited laboratories regarding analysis and conducting DNA analyses for Halal food verification purposes even before they got Halal certified and C2 and C5 gathering HCs even for raw materials of products not in the scope of Halal certification, demonstrating a bit better risk awareness and a preventative approach compared to other companies.

4.4.6.3. Consistency

The not up to date handbooks of C1 and C5 (stage 2) and the lack of handbooks in C3 and C4 (stage 1-2), demonstrate low FSC maturity in the Consistency dimension. The higher-risk non-dedicated productions (C2, C3 and C5) including products not in the Halal certification scope, also demonstrated issues in the Consistency dimension. While C3 did not have any documentation on preventing cross-contamination of Halal-certified production, C5 had not documented the time segregation procedures (elaborated under the Planning section), further indicating to low consistency (stage 1-2).

4.4.6.4. Adaptability

While C2 had a handbook, evidence was found that the cleaning procedures crucial for segregating Halal-certified and non-certified production were lacking (elaborated under the Planning section), indicating to low adaptability (stage 1-2), as the company was using no change management strategies or behavioral science for their adoption, in addition to a lack of problem solving strategies, indicating to low maturity also in the Consistency dimension.

C5 had found solutions for adapting to practices around mitigating risks regarding cross-contamination between Halal certified and non-certified production, like job-specific training to the planning department and frontline and tailor-made software to decrease risks regarding cross-contamination from rework. On the other hand, there is no data on the effectiveness of these solutions, which would give further insight to the maturity in the Adaptability dimension and the consistency of using these solutions, which would give insight into the maturity in the Consistency dimension.

4.4.6.5. People System: siloes vs Cross-functional Collaboration

At the participating companies, the main responsibility of HFA is on specific positions (QA in C1 and C4, QMA in C2 and C5 and R&D in C3) who are conducting risk mitigation activities, like following up with supplier documents, controlling and confirming the suitability of raw materials and HCs (Table 4.35). Also, the top management and production related staff at different positions (from both semi-structured interviews and focus group discussions) refer to either having no role or HFA being the responsibility of a specific department (Table 4.35). Interestingly, this includes maintenance/technical managers, although the risks regarding maintenance oils are directly related to their area. For instance, interviewees at C4 explicitly stated that due to worn out equipment, oil leakages are a contamination issue they have on the agenda, demonstrating not only a FS, but a Halal assurance issue, as maintenance oils might be derived from an animal source.

In all companies, except C3, R&D is expected to inform the QA about any new raw materials and get their confirmation. As for purchasing, they were expected to order from an approved supplier and communicate with the suppliers on any necessary documents. Only C5 mentioned giving Halal related job-specific training to R&D, purchasing and planning and as risk mitigation having software in place that R&D should have QA approve any raw materials and that purchasing could order only from the approved supplier list. Responsible at C3 mentioned working towards purchasing starting to control Halal certificates' expiry dates, which was also confirmed in the focus group by purchasing staff (Table 4.35). Just like no risks were determined regarding reception, they also do not have any role in companies' HFA. Tieman, (2017) also brought out this gap in the Halal supply chain that '*Halal SOPs are not being defined in functions like purchasing, sales, logistic and marketing*' (Tieman, 2017).

As such, specific departments holding a central role in their companies' HFA and minimal awareness and training outside that, indicate to functional silos and with that to HFA culture maturity stage 2 in the People system dimension.

Table 4.35: Responsibilities, awareness and practices related to Halal food assurance in participating companies,

Department	C1 (before/after HCB accreditation)	C2	C3	C4	C5	C6
Semi-structured interview with the HFA responsible:						
Quality assurance department (QA)	QA follows up with supplier documents and asks purchasing.	QA follows up with supplier documents and asks purchasing.	-	Purchasing and/or QA follow up with documents.	QA follows up with supplier documents and asks purchasing.	ND
	QA controls HCs	Controls HCs.	-	QA controls HCs	QA controls HCs	
Research and development department (R&D)	Demands HC for new raw materials from purchasing. QA in cc.	Does not consider Halal. QA does that.	Responsible for organizing the Halal certification process.	Must confirm Halal status of raw materials with the QA.	Must confirm Halal status of raw materials with the QA. Software in place.	R&D is a CCP: have procedures
	-	-	R&D controls HCs	-	-	ND
Purchasing	-	Controls whether the supplier has a HC	R&D set up the system, purchasing is expected to take over following up supplier documents.	Purchasing and/or QA follow up with documents.	Software in place to order from an approved supplier.	Purchasing has 2 CCPs: ordering from the approved supplier's list and regularly conducting their risk analysis
	Should order from an approved supplier	Should order from an approved supplier	Should order from an approved supplier	Should order from an approved supplier		
	Purchasing asks HC from suppliers.	Purchasing asks HC from suppliers.	Purchasing asks HC from suppliers.	Purchasing asks HC from suppliers	Purchasing asks HC from suppliers	
Reception	-	-	-	-	-	Reception is a CCP: address control

Planning	-	As all products are not in the HC scope, production sequence is used for segregation. Planning department should put noncertified after certified ones with cleaning in between.	-	-	As not allowed ingredients are used, production sequence is used for segregation. The planning department should put the production of these last. QA double-checks ad-hoc from production plans.	All factories have to be dedicated to Halal certification
Logistics	-	-	-	-	-	Packing by manufacturer or agent. Repacking. Delivery with tankers. Condensation
Semi-structured interviews for FSC evaluation:						
General manager (GM)	Our direct responsibles know better	ND	Does not have a role, but has to do with raw materials' having Halal certificates	ND	ND	ND
Factory manager (FM)/ operations director (OD)	ND	ND	FM: Does not have a role. Has to do with raw materials' and hand disinfectants having Halal certificates	FM: They do not have raw materials or processes which would pose a risk.	OD: QA is responsible.	ND
Production manager	Use only allowed ingredients	Concerns raw materials' Halal certificates and ISO22000 requirements	Make sure disinfectants having Halal certificates are used. No other role.	ND	QA is responsible	ND

			Direct responsibles take care of raw materials having Halal certificates.			
Shift leader	Does not concern my department (packaging)	ND	ND	No role; Issues with food safety and hygiene.	ND	ND
Maintenance/ technical manager	This does not concern his area	Slaughter procedure details are important	Does not have a role	QA is responsible.	No role	ND
Focus groups for FSC evaluation:						
R&D	Halal is about the HC of raw materials. QA takes care of the documents.	ND	ND	ND	ND	ND
Purchasing	Halal is about the HC of raw materials. QA takes care of the documents.	ND	Follows up with HC expiry dates and control suitability from JAKIM list. In case of any issues R&D controls and confirms.	ND	ND	ND
Frontline	Use only allowed ingredients. / We do not do anything in particular	ND	After getting HC, they did not use cleaning chemicals containing ethanol	ND	ND	ND
Observations:						
Hand-washing facilities	Lack of proper hand-washing facilities	Did not identify a problem	Lack of proper hand-washing facilities	Lack of proper hand-washing facilities.	Did not identify a problem	ND

Hygiene barriers	Hygiene barriers broken or not properly working	Hygiene barriers broken or not properly working	No barriers	Hygiene barriers broken or not properly working	Properly working	ND
Hygiene protocols	Serious lack of frontline following hand-washing protocols	Did not identify a problem	Some instances of frontline not following hand-washing protocols	Some instances of frontline not following hand-washing protocols	Some instances of frontline and QA not following protocols for high hygiene area	ND

'-': lack of practices; CCP: critical control point; HC: Halal certificate; JAKIP: Department of Islamic Development Malaysia; ND: no data;
Source: Prepared by the researcher.

4.4.7. Food Safety, Hygiene and Halal Food Assurance

When interviewees responsible for Halal management at C1-C5 were asked about whether they pay attention to anything related to Halal in the production, all brought out that the HCB focuses there on FS (Table 4.36). They emphasized the importance of cleaning, hygiene and FS, with C1 and C5 additionally mentioning the HCB evaluating according to ISO22000 standard.

It was noted that C2 had two HCBs, both evaluating hygiene and cleaning, just that one of them was emphasizing this under the Tayyib (pure/clean) concept. C2 also mentioned the importance of cleaning and hygiene in their Halal handbook.

In addition to cleaning and hygiene, the HCBs also investigated topics such as microbiological safety, pesticide residues, various toxins, GMO and the correctness of claims, which were emphasized especially by C3, C4 and C5 (Table 4.36).

Again, C6 had incorporated the Tayyib concept into their internal Halal food management system, emphasizing that it means life preservation and is thus '*compulsory and represents food safety*.' Additionally, they follow regulators' lists of allowed/dangerous food additives and chemicals (e.g. regarding cleaning materials), connecting it with their HFA.

Table 4.36: Participating companies' statements regarding food safety and hygiene in their Halal food assurance context,

Content	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
HCB focuses on food safety in the production.	+	+	+	+	+	-
HCB checks according to ISO22000.	-/+	-	-	-	+	-
Production has to be clean; Hygiene is important.	+	+	-	-	-	-
HCB emphasizes Tayyib.	-	+	-	-	-	-
Frontline should follow cleaning and hygiene rules.	-	+	-	-	-	-
Storage conditions; cleaning procedures.	-	+	+	-	-	-
HCB checked chemical residue reports, allergen management, proper labelling/claims.	-	-	+	-	-	-
Halal requirements are intertwined with food safety.	-	-	+	-	+	-
Had microbiology, pesticide residues, various toxins, GMO, claim check/ingredient analysis conducted	-	-	+	+	+	-
Check cleaning and maintenance plans.	-	-	-	-	+	-
Tayyib is compulsory in HFA and represents food safety.	-	-	-	-	-	+
Considers regulators' lists of allowed/dangerous food additives and chemicals	-	-	-	-	-	+

'+/-': presence/absence of practices; GMO: genetically modified organisms; HCB: Halal certification body; HFA: Halal food assurance.

Source: Prepared by the researcher

Although both C1 and C2 stated hygiene and cleaning to be a part of the Halal concept, in both cases, issues were found with lack of proper/ or properly working hand-washing facilities (Table 4.35). For instance, observations showed that C1 did not have hand-washing sinks in the production area, hand disinfectant dispensers were empty, in the lavatory hand-drying options were lacking and hygiene barrier dispensers were empty, some broken and where not properly used by the staff. At C2, the hygiene barriers were also not properly functioning. In both cases, it was reflected by the interviewees and focus groups that this had been an issue for a while (Table 4.35). In addition to C1 and C2, C4 also reflected a lack of following/being able to follow proper cleaning procedures and other worrisome contamination issues (elaborated in detail in Subchapter 4.5).

Looking at the interview results with different positions, like general manager, factory manager, operations director, production manager, shift leader and maintenance/technical manager, except for the production manager in C2, they did not reflect HFA being related with food safety (Table 4.35). This indicates that the connection between HFA and food safety is not a part companies' basic assumptions. Thus, even though the HCBs are the driving force behind this connection, the companies are not intentionally working towards better FS and hygiene practices based on the assumption that these are important in Halal food assurance. On the other hand, research shows that religious commitment could be leveraged for better FS and hygiene practices. This study is especially noteworthy, as the participants were Muslims, like in the case of this study, emphasizing the connection between Islam and good hygiene practices (Al Bayari et al., 2023; Yetim & Türker, 2020).

Thus, while HCBs have made an impact on the staff responsible that food safety and hygiene are important with regards to HFA, the awareness of this notion had not been spread within the companies, failing to use this as a leverage for better food safety and hygiene practices. This is emphasized as an additional red dotted line between Halal food and food safety assurance in the FS-HFA culture conceptual framework in Figure 4.10, demonstrating the potential for impact.

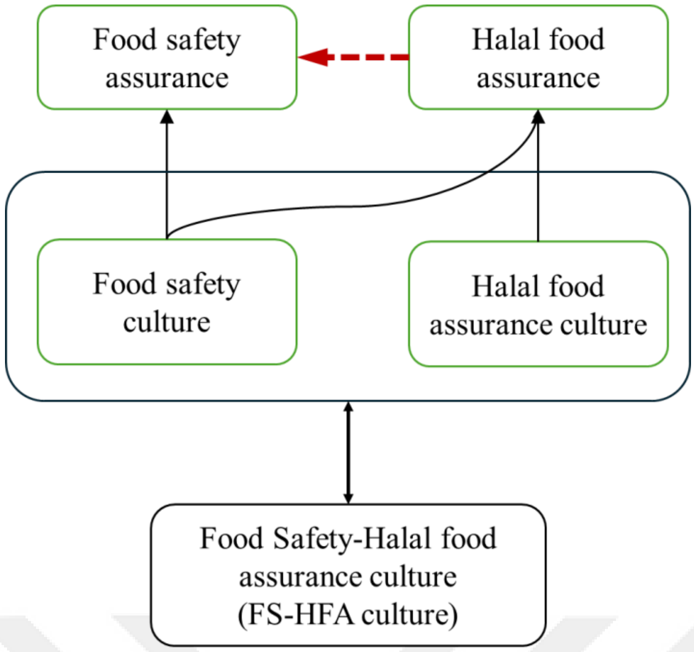


Figure 4.10: Conceptual framework for Food Safety – Halal food assurance culture, modified according to research findings. Yellow dotted arrow – unused potential to improve FSM practices through Halal food assurance.

Source: Prepared by the researcher

4.4.8. Discussion and Conclusion

This discussion and conclusion section will give an overview of the results of each of the three aims elaborated in the beginning of this subchapter; improvement recommendations and the strengths and weaknesses of the research methodology.

4.4.8.1. Halal Food Management Practices

This part of the discussion elaborates on AIM 1 specified in the beginning of the chapter: to evaluate HFA practices in Halal-certified food production companies in Türkiye (point 2 in the research framework: Figure 1.1 and 1.2 in the Introduction Chapter).

While the Halal food management related risk identification and mitigation studies (Lau, Jamaludin & Soon, 2016; Maonah & Saroso, 2018; Vanany, Maarıf & Soon, 2019; Kristanto & Kurniawati, 2023; Sucipto et al., 2022) bring out supplier Halal certification as a risk mitigation activity, this study took a step further and offered novel insight into companies' supplier management and engagement regarding Halal food assurance, with some of the key findings as follows:

- While HCBs guided C2-C5 on their suppliers' HCB selection and high-risk ingredients, this was not the case for C1 before the accreditation of HCBs, demonstrating the positive impact of HCB's accreditation in mitigating risks to some extent.
- Unlike C6, C1-C5 did not have systems in place for risk assessment of ingredients and other materials (e.g. maintenance oils, packaging materials, utensils, cleaning chemicals), demonstrating differences also between C1-C5 in the risk awareness and in the extent, they focus on suppliers' production practices. Even though HCBs might have conducted the risk assessment, this demonstrated that these companies are currently not engaged as active members of the supply chain to mitigate Halal food related risks.
- Unlike C6, C1-C5 did not have systems in place regarding controlling supplier's HCs and renewing Halal assurance related documents from suppliers.
- In some instances, companies demanded Halal related declarations from suppliers, however, as this study has demonstrated, there are considerable differences in what companies perceive as Halal food assurance related risks, which puts the risk mitigation impact of declarations under question.
- Only C6 focused on having a legally binging document with regards to Halal assurance requirements, signed by an official representative of the supplier company and a clause for suppliers to notify of any changes, like this having an impact on suppliers' awareness, engagement and accountability.
- None of the companies focused on Halal related aspects in their supplier audits, which is interesting, as integrating some basic Halal food management requirements in FS related supplier audits might not only enable to some extent mitigate supplier related risks but could be leveraged for continuous improvement regarding Halal food management practices within the supply chain.

This chapter also gave insight into companies' internal management systems. To some extent C2-C5 seemed to shape according to the Halal food standard against which they were certified, with C2 and C3 focusing on a Halal food management system as demanded per the Malaysian standard MS1500. Despite this, in all the companies there was a lack of management system activities, like a team, meetings, internal audits and management review, for which C6 also shared their best practices.

An interesting finding was C6 emphasizing different departments, like purchasing, R&D and reception as their Halal-related CCPs. The Indonesian government and the related studies (Al Adiat et al., 2018; Anggi & Rahayu, 2022; Dewantara et al., 2018; Wulandari, Sirajuddin & Qui, 2022; Perdani, Chasanah & Sucipto, 2018) also had a similar approach to Halal food management, in that companies had to identify and have written procedures for critical activities. While C1-C5 did not have controls related to Halal in reception, they did consider Halal in the R&D and purchasing processes. Unlike C6, which had their factories set up routine control procedures regarding risks and documents of suppliers under the purchasing CCP, other companies reviewed their Halal food assurance activities together with suppliers before the external audit by the HCB.

4.4.8.2. Interaction Between Food Safety Culture and Halal Food Assurance and Its Culture

This part of the discussion elaborates on AIM 2 specified in the beginning of the chapter: to explore the possibilities behind using the food safety culture concepts (definition, maturity model and evaluation methodology) in the Halal food assurance context (point 2.2 in the research framework: Figure 1.1 and 1.2 in the Introduction Chapter).

This chapter also investigated Halal food assurance from an organizational culture perspective and as a result proposed to use the FSC maturity model as a novel approach to evaluate both FS and Halal food assurance related cultures in conjunction with each other, as Food Safety-Halal food assurance culture (FS-HFA culture). Accordingly, a FS-HFA culture definition was set forth. The study also used the same approach to evaluate and provide novel insight into companies' HFA-cultures. A contrast was seen between C1-C5 and C6, offering examples of lower and higher maturity HFA culture in the Values and mission, People system, Adaptability, Consistency and Risks and hazards dimensions.

a) Improvement recommendations:

This study puts forth a myriad of Halal food assurance risks not only related to incoming materials, but supplier processes, awareness, trustability, companies' internal management processes and organizational culture, in addition to novel empirical findings on whether and how companies mitigated these. Accordingly, for improvement in the Halal food sector, it is important to create change. In the process of creating change, Kotter, (2012) brought out establishing a sense of urgency as the first step (Kotter, 2012). As the source of urgency for lower FS-HFA culture maturity companies (< stage 3) are external factors, as also demonstrated in this study (e.g. customer, followed by HCB demand), one of the improvement recommendations emerging from this study is related with HCBs. HCBs could focus on analyzing their certification and auditing priorities and opportunities with regards to compliance vs '*cultivating a culture of continuous improvement*' (World of Auditing, 2024) to impact companies' sense of urgency accordingly. For instance, rather than diving into the risks and hazards themselves, HCBs could work on building companies risk awareness, support them in establishing their own risk identification/management/challenging systems and evaluate its rigor and companies' Halal food assurance through both management and FS-HFA culture assessment perspective.

This might in turn guide the companies to focus on analyzing risks and their consequences to their companies and together with building the awareness of the senior management, establish a sense of urgency regarding why change is necessary with their Halal food management approach. An increase in Halal food assurance rigor in food production companies would in turn reflect on the demand and the dept of focus of their suppliers, potentially creating a sense of urgency in them as well and as a ripple effect throughout the sector.

4.4.8.3. Halal Food Assurance Impact on Hygiene and Food Safety

This part of the discussion elaborates on AIM 3 specified in the beginning of the chapter: explore whether HFA impacts hygiene and food safety assurance (point 2.1 in the research framework: Figure 1.1 and 1.2 in the Introduction Chapter).

Finally, the study gave novel insights regarding the unused potential of impacting food safety practices through Halal food assurance. Although food safety and hygiene are depicted as integral parts of Halal food assurance by standards (SMIIC, 2019; Standards Malaysia, 2019) and HCBs, the reality is that this is not a shared belief in the companies, but isolated in the siloed work of the responsible staff. This, in turn, could be overcome by work on FS-HFA culture.

4.4.8.4. Strengths and Weaknesses of the Study

One of the strengths of the chosen methodology was that the document analysis enabled to verify data collected through semi-structured interview questions on Halal food management and probe for further in-depth insights. Another strength was piloting the semi-structured interview guide with a company (C6) demonstrating best practices in the field, enabling to probe the other companies for more detailed insight. An additional strength of the methodology was that incorporating Halal food assurance related questions into FSC evaluation methodology enabled to collect data throughout the companies and as a results make conclusions on Halal food assurance and culture related aspects as well. Limitations were that the data collection and analysis were conducted by one person, giving way to potential researcher bias and that respondents' answers might have social desirability bias (Jespersen, MacLaurin & Vlerick, 2017). The latter bias, on the other hand, might have been mitigated to some extent through a multiple-methods approach.

4.5. Investigating the Interaction Between Process Hygiene, Food Safety Culture and Halal Food Assurance Through Observations and Indicator Organism Detection

The literature review showed that more empirical work is needed to fully demonstrate the connection between FSC maturity and microbiological hygiene, that process environment microbiological sampling has not been used in the context of food safety culture research in food production companies, in addition to process environment hygiene, and fecal contamination potential not being evaluated within the context of Halal food assurance. Accordingly, this chapter addresses the following aims:

- to investigate the relationship between FSC maturity and microbiological hygiene.
- to evaluate process environment hygiene and possibilities for fecal contamination in Halal-certified companies.

To meet the aims, this study used a combination of observations and microbiological analysis. Observations enabled to determine different sampling zones, behaviors leading to cross-contamination between these zones and finally, working conditions and habits/practices, which might further increase food safety risks. Regarding microbiological analysis, using both count and enrichment conditions for indicator organism detection enabled to determine the risk as per microorganism presence.

In this chapter, first, as a separate section, the zoning concepts commonly used while choosing sampling locations were introduced, followed by descriptions of their slight modifications, suggested and used in this study. Results are presented in sections separately for each company. Each section starts with an overview of the microbiological analysis results, including their zones, followed by the scenario analysis, bringing together observation and microbiological analysis results (drivers) and relationships between them, to construct storylines highlighting the possible consequences of the findings regarding food safety risk. To clearly separate the collected data from the storyline assumptions, these were highlighted accordingly, with either the word ‘observation’ or ‘storyline’ as the start of relevant paragraphs.

For more complex scenarios, a visual was prepared and presented at the end of the scenario to give a clear overview of the risks.

Microbiological analysis results’ tables for each company could be found in the appendix (Appendix 10), which include results obtained using count and enrichment conditions and detailed descriptions of sampling sites. Before or after frontline workers were swabbed, a small survey was conducted with them (specified in Chapter 3, under section 3.3.5.) to help put the findings into context, the results of which were presented in tables together with the microbiological analysis results of hands and/or clothes (Appendix 10). During observations and swabbing, a small survey was also conducted with the accompanying responsible staff (specified in Chapter 3, under section 3.3.5.) regarding companies' process environment microbiological evaluation, the results of which were presented under a separate section in this subchapter.

Microbiological analysis results of surfaces enabled to confirm the existence and extent of the risk, which reflect in the following,

- A higher number of different positive indicator microorganisms demonstrate and verify an increased contamination at the sampling location and with that an increased risk.
- Positive results under count conditions show an increased risk due to the number of cultivatable cells initially present, which indicates to either a more extensive contamination or microorganism growth at the sampling location. To emphasize this, the analysis conditions were specified in the scenarios by the microbiological results as '(count)', if the sample was positive under count conditions and as '(enrichment)', if the sample was negative under count, but positive under enrichment conditions.

Accordingly, phrases, such as 'high(er) risk' and 'heavy contamination' were used to emphasize these situations.

While the data collection approach offers valuable insight into both hygiene practices and microbiological hygiene in Halal certified food production companies, combining both observations and microbiological analysis enabled to better pinpoint fecal contamination possibilities as well, as none of the applied indicator organisms are absolute indicators of fecal contamination, depending on the context and location of sampling (discussed in detail in Chapter 3, section 3.2.3.).

4.5.1. Zoning and Sampling Locations

Currently, guidance on how companies could choose their sampling locations for their environmental monitoring plans are based on multiple aspects (Bourdichon et al., 2021), which are to some extent used in the current study as well. For instance, unpackaged ready product area is considered as high risk and as such a high hygiene (HH) zone, while production areas before the CCP step and after packaging are considered as low risk and as such low hygiene (LH) zones. Within these areas there is another categorization of sampling locations, based on the distance from the product, with Zone 1 (Z1) being the food contact surface and Zone 2 to Zone 4 (Z2-Z4) in ascending order of distance from the product. Bourdichon et al. (2021) suggested that Z1-Z3 locations at the HH zones are higher priority sampling sites, compared to Z4 at the HH zone and Z1-Z3 at the LH zones. However, a recent guidance document, interpreting companies' approach to environmental monitoring from a FSC perspective, also brought out the importance of microorganism entrance and movement or in other words, transfer between these zones (3M & Cornell University, 2019). This transfer is determined by the behavior of workers, which is on the other hand impacted by FSC maturity. Thus, determining the zones in conjunction with behaviors, led to the need to develop the zoning concept further, regarding the risks based on workers, utensils and equipment being in contact with different surfaces, as this enabled to better highlight their risk. Thus, to describe the zones better in the context of risk and behavior, the following modifications were made:

Z1 – food contact surfaces;

Z2.1 – (non-food contact) surfaces at the HH or LH zones, which are usually touched by production line workers (hands or clothes) or utensils/equipment (e.g. handles, pallet jack, packaging materials);

Z2.2 – (non-food contact) surfaces at the HH or LH zones, which are not usually touched by production line workers or utensils/equipment (e.g. supervisor door handle);

Z3.1 - surface at the HH or LH zones not touched by production line workers, but touched by objects these workers (hands or clothes) or utensils might come into contact with either (e.g. pallets where packaging materials are placed on, sink where utensils are placed on);

Z3.2 – surface at the HH or LH zones usually not touched by production line workers and the objects they come in contact with (e.g. floor);

Z4 – surfaces at the entrance/exit of the HH or LH zones.

The zones were determined according to companies' procedures. For instance,

- if a pallet was meant to touch a food contact surface (Z1), then the zone was determined as Z2.1, like in C4, which had product crates stacked directly on pallets. However, if these crates were stacked on the floor as a habit, which is not actually an accepted practice, the floor was determined as Z3 and not Z2.1.
- if a pallet was not meant as a place to directly store packaging materials (as in C5), but they were done so nonetheless, the pallet was determined as Z3.1 and not Z2.1.
- if a sink, even if located at the entrance of the production, is the kind that clothes come into contact with while using it, this was determined as Z2.1, instead of Z4. However, if after using this sink, workers were expected to wear extra protective clothing at the HH zone (as in C5), preventing contact between the original clothing and other surfaces, this sink would be determined as Z4.

Depending on the circumstances, some surfaces may be considered under multiple zones, in which cases, the zone of the surfaces are presented with a slash, as follows: Z1/Z2.1.

4.5.2. Company 1

Microbiological test results are displayed in Tables 1 (hands, gloves and clothes) and Table 2 (surfaces) of Appendix 10. At the HH zone of the production *Enterobacteriaceae* (EB) were detected on hands/gloves of workers (Z1/Z2.1) no 5, 6 and 7 and on clothes (Z2.1) of workers no 3, 4 and 5. EB, coliforms (CF), thermotolerant coliforms (ttCF) were detected on hands of worker no 6 and additionally *E. coli* was detected on hands of worker no 7 (Appendix 10, Table 1).

At one of the entrances/exits (no 1) to the production (Zone 4 of the HH zone), sink (no 1), trash bin by the curtains and the same curtains were found positive for EB, CF and ttCF (Appendix 10, Table 2). While hygiene barrier bars (meant to disinfect hands) at this entrance were negative for any findings, they were positive at the second entrance/exit (no 2) (also Zone 4 of the HH zone) for EB, CF and ttCF. The sink (no 2) before entrance/exit (no 2) in the women's toilet was positive EB, CF, ttCF and *E. coli.*

Inside the production (HH zone), floor (no1, Z3) at the ready product packaging area and floor (no2, Z3) and sink (no3) in the raw material mixing area were positive for EB, CF, ttCF and *E. coli*.

4.5.2.1. Scenario 1 - Worker Hygiene Procedures/Conditions at Production Entry

Observations: There was only one toilet for the men and one for the women of the frontline. The following observations were conducted in the women's toilet room. It had a sink with 4 washbasins and one air drier. During the observations, the room had a flow of workers entering and exiting the toilet. After washing their hands, the exiting women either held their hands below the drier for a moment, dried their hands in their work clothes or aprons or did not dry at all.

Storyline: Hand (Z1/Z2.1) and clothes (Z2.1) contaminate each other. Thus, other sources of contamination of clothes become more relevant. Hands make clothes wet. Residual moisture on both hands and clothes increases food safety risk due to microorganism resuscitation, growth and increased transfer.

Observations: It was also observed that sinks come in contact with workers' clothes when they wash hands. Sinks were swabbed from the edges and front surfaces, with what workers' clothes might come into contact with and the results were as follows,

- Sink 1 at entrance was positive for EB, CF and ttCF (enrichment, count had overgrowth).
- Sink 2 in the toilet was positive for EB, CF (enrichment; count had overgrowth) and ttCF and *E. coli* (count).

Observations: The production had two entrances (food court and toilet). To enter, workers had to pass hygiene barriers (meant for hand disinfecting), go up the stairs and due to that touch railings and pass through the curtains. In both locations, hygiene barriers were not used properly, as their metal bars were pulled back to pass. Hygiene barriers were either not working properly or there was a lack disinfectant in them. Only one hygiene barrier was identified to work properly. Despite that, its metals bars were pulled back to pass. Workers were observed to exit the toilet, pass the hygiene barriers and continue towards the production with wet hands. At both entrances, hygiene barrier bars were swabbed and at the food court side, curtains were swabbed. In both cases railings were not swabbed. The toilet side curtains and railings might be targeted for swabbing upon further investigation.

- Hygiene barriers' 3 metal bars at the toilet side entrance were found to be positive for EB, CF and ttCF (enrichment) and at another entrance were found to be negative for contamination.
- Food court side curtains were positive for EB, CF and ttCF (enrichment).

Storyline: Surfaces, like hygiene barrier bars (Z4), staircase railings (Z4), curtains (Z4), which workers as a habit or out of necessity constantly come into contact with, are more relevant sites for cross-contamination at the entrance of the production. Although the results are positive for enrichment conditions, the food safety risk increases due to wet hands (Z1/Z2.1) (microorganism resuscitation, growth and increased transfer) and lack of disinfectant use. Thus, also other sources of contamination of these surfaces become relevant.

Observations: For instance, a trash bin was near the curtains of the food court side entrance/exit. To exit the production, workers were taking off their gloves and with their bare hand lifting the trash bin cover to open it and throw away the gloves and then pushing the curtains aside to exit.

- Trash bin cover near food court side curtains were positive for EB, CF and ttCF (enrichment).

Storyline: Trash bin cover (Z4) and hands (Z1/Z2.1) might contaminate each other, in turn, hands and curtains (Z4), in turn hands of workers entering production might get contaminated.

Observations: It was further observed that an outsourced maintenance worker (man) exited the toilet with wet hands and by pulling back the metal bars of the hygiene barrier he passed them. His hands were swabbed.

- Maintenance workers' hands were found to be positive for EB, CF, ttCF and *E. coli* (enrichment).

Storyline: Poor hand washing practices increase food safety risk further, as workers' hands (Z1/Z2.1) and hygiene bars (Z4)/railings (Z4)/curtains (Z4) might contaminate each other. Although the results are positive at enrichment conditions, his wet hands increase food safety risks due to microorganism resuscitation, growth and increased transfer. Being a maintenance worker increases the food safety risk, as he was assembling a production line or in other words, in contact with food contact surfaces.

Observations: After exiting the toilet, a worker (woman) with wet hands passed the hygiene barriers as described above. Upon the QM asking why she does not disinfect, she replied that as her hands are wet, she will do that at the production area (HH area). However, the existing disinfectant dispensers at the production were observed to be empty. Additionally, at the production there was no sink dedicated for hand washing. The one existing sink (no 3) at the raw material mixing side was meant for washing utensils. According to the QM, workers also use it to wash their hands. However, at the sink there were no soap dispensers, no hand drying options and the disinfectant dispenser was empty. Upon further investigation data might be collected on how workers go about washing/rinsing and drying their hands at that sink.

- Sink 3 (at the raw material part of production) was found to be positive for EB, CF, ttCF (enrichment, counts had overgrowth) and *E. coli* (enrichment).

Storyline: Food safety risk increases as there are no proper hand washing and drying facilities in the production and there is a lack of disinfectant in the production.

Storyline: ‘Washing’ or in other words rinsing hands in sink no 3 might also contaminate the sink and its surroundings, especially since hand washing protocols might not be properly followed. The sink 3 (Z2.1) might contaminate utensils (Z1) placed on the flat surface area of the sink, which in turn might contaminate workers’ hands (Z1/Z2.1), who might also be handling raw materials, or the ingredients these utensils are used with. Food safety risk increases as all indicator microorganisms were present and the surface was wet.

Observations: Hands were swabbed from an operator, who was fixing a production line after finishing maintenance. The operators in this company are also responsible for the maintenance of their lines. Upon distancing and looking around, the operator was sliding his hand on the surface of the products on the line. This is despite the fact that reportedly he had had hygiene training 2 months ago. There is no data on how this worker might or might not have cleaned his hands. There is only one utensil washing sink nearby, without soap, hand drying options and disinfectant.

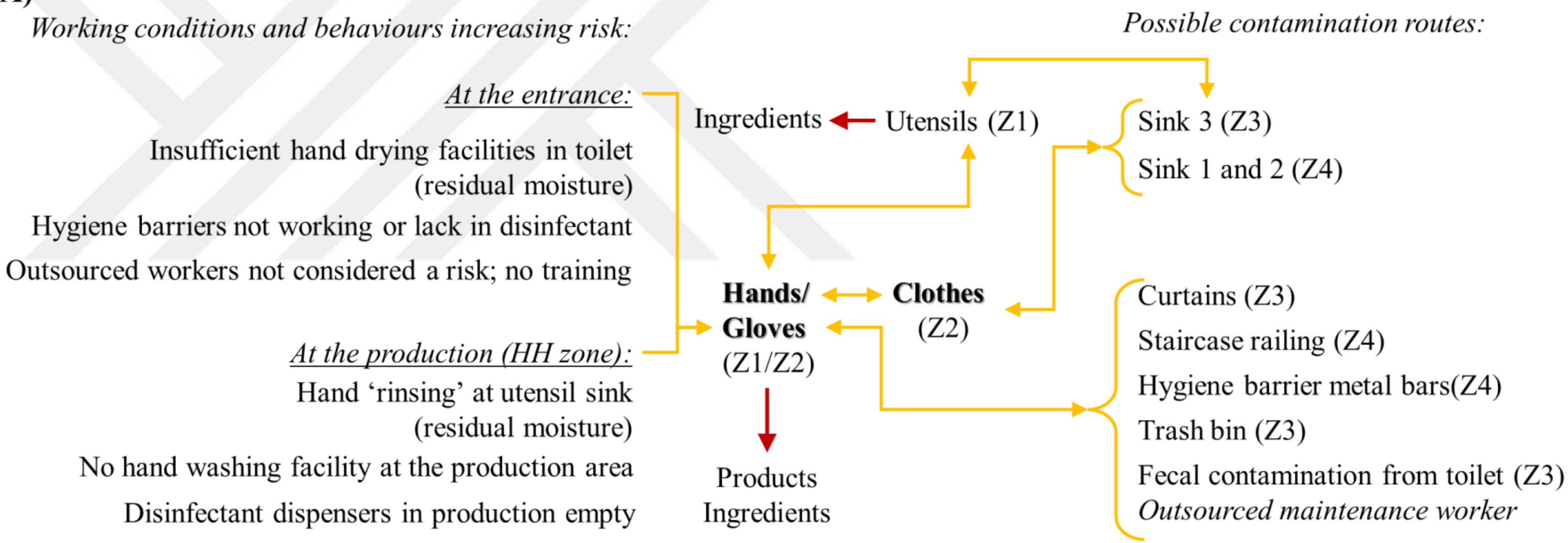
- Operator’s hands were found to be positive for EB, CF and ttCF (enrichment).

Storyline: Hands (Z1/Z2.1) could contaminate the product. Food safety risk is increased as improper hand cleaning facilities and practice were observed.

Except for the outsourced maintenance worker (no 7) and operator (No 6), the hands and clothes of workers no 1 to 5 were not significantly contaminated, with 3 workers' clothes and 1 worker's hands being positive for only EB (enrichment). From the 5 workers swabbed, 2 were women, with only one's clothing being positive for EB (enrichment). While these results do not reflect the consequences suggested by the storylines, the sample size was small to make solid conclusions.

A visual overview of the scenario was also prepared to summarize the microbiological risks (Figure 4.11). While the figure in the visual demonstrates contamination routes, working conditions and behaviors increasing food safety risk, the table below gives an overview of high risk surfaces regarding the types of surfaces being positive under count conditions, the number of positive indicator organisms and also the wet surfaces, which increase risk through microorganism transfer, resuscitation and growth and in turn highlight risks regarding positive enrichment results, in addition to results obtained under count conditions. If a sample was positive under both count and enrichment conditions, only the count part of the table was filled in the visual, to highlight the risk and not overload the table with data, for a clearer interpretation. In some cases, microbiological analysis results for count conditions showed overgrowth with another microorganism turning the agar yellow (discussed in detail in Chapter 3, section 3.3.5.). However, if enrichment and/or if a positive result was obtained for some of the indicator organisms under count conditions, these were depicted in the table of the visual as present under count for the sake of emphasizing the risk.

A)



Working conditions and behaviours increasing risk:
Possible contamination routes:
At the entrance:
Insufficient hand drying facilities in toilet (residual moisture)
Hygiene barriers not working or lack in disinfectant
Outsourced workers not considered a risk; no training
At the production (HH zone):
Hand 'rinsing' at utensil sink (residual moisture)
No hand washing facility at the production area
Disinfectant dispensers in production empty
Ingredients
Utensils (Z1)
Sink 3 (Z3)
Sink 1 and 2 (Z4)
Hands/ Gloves (Z1/Z2)
Clothes (Z2)
Products
Ingredients
Curtains (Z3)
Staircase railing (Z4)
Hygiene barrier metal bars(Z4)
Trash bin (Z3)
Fecal contamination from toilet (Z3)
Outsourced maintenance worker

B)

	EB	CF	ttCF	*E. Coli*
Count	Sink 1, 2, 3 (wet)	Sink 1, 2, 3 (wet)	Sink 1, 2, 3 (wet)	Sink 2, 3 (wet)
Detection	Hygiene barriers' metal bars (residual moisture) Curtains Trash bin Maintenance worker's hands (wet) Operator's hands	Hygiene barriers' metal bars (residual moisture) Curtains Trash bin Maintenance worker's hands (wet) Operator's hands	Hygiene barriers' metal bars (residual moisture) Curtains Trash bin Maintenance worker's hands (wet) Operator's hands	Maintenance worker's hands (wet) Sink 3 (wet)

Figure 4.11: Risk map of post-process contamination potential based on scenario analysis 1 in company 1 (C1). A: Contamination routes and microorganism zone transfers. Red arrow – direct contamination possibilities of products. Orange arrow - contamination between surfaces. B: Indicator organism analysis results highlighting aspects of microbiological risk. Light to dark red gradient - highlights risk from lower to higher. *E. coli*: indicator organism *Escherichia coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: high/low hygiene zones, explained in section 4.5.1; Z: Zoning concept, explained in section 4.5.1.

Source: Prepared by the researcher.

4.5.2.2. Scenario 2 – Pallet Jacks as a Vector for Contamination

Observations: Raw materials were brought from storage with a pallet jack in an elevator entering the finished open product area, which were then brought to the raw material area. Pallet jacks move between the raw material and ready product areas contaminating the floors and storage areas in between.

- Elevator floor was positive for EB, CF, ttCF and *E. coli*.
- Raw material floor (wet) was positive for EB, CF, ttCF and *E. coli*.

Storyline: To understand the food safety risk of such contamination of the floor, further observations should be made regarding behavior patterns, which might lead to cross-contamination from the floor. Examples of behavior patterns could be brought from C4, where workers touched both pallets (Z3.2) and food contact surfaces (Z1) or from C5, where a worker dropped a product on the ground (Z3.2), picked it up and put among other products (Z1).

4.5.2.3. Food Safety Culture Insights

Observations: At the women's toilet, upon observing difficulties with hand drying and inquiring the QM why they use a hand drier, the QM explained that she had replaced the paper towels with a hand drier, to prevent sabotage and contamination of product with the paper. Asking the QM how workers are supposed to dry their hands, led to the QM asking a frontline worker why she did not use the air drier, who replied that her hands were sensitive to that and suggested having workers use paper towels instead. The QM in return commented that the worker not using the hand drier was about the worker and not the drier. At the same time multiple women passed them without drying or drying their hands in their aprons.

FSC insight: The QM was reacting to an incident, indicating a stage 2 FSC maturity. Looking from the Competency Model perspective (discussed in Chapter 3, section 3.3.2.) this stage of maturity increases the food safety risk, as individuals do not go into the consciously incompetent stage to start the learning process and through that move towards finding and solving the root cause.

From the hierarchical leading dimension perspective, it might not just be that the QM is not ready to learn, but that as it is not common to get input from positions at a lower hierarchical rank and at the same time from a person outside their area of expertise (also discussed in detail in Subchapter 4.2, under section 4.2.2.), it might also not be expected for the learning to start from such a source.

Observations: On the same worker, the QM noticed jewelry and asked for reasons behind wearing them. She said to her that she had just told at the hygiene training that they should not wear jewelry at the production. Then she told her to come by her office the next day to show that she was not wearing any.

Observations: A woman was wearing a head cover other than the prescribed work clothing. The QM asked for reasons behind them, told her to wear the correct clothing and again said that she had just told about proper work clothing at the hygiene training.

FSC insight: Firstly, the QM had expectations about the outcomes of her hygiene training. This indicates stage 2 FSC maturity in the Adaptability dimension, as she does not show awareness of behavioral science concepts, such as the learning path of the Competency Model. Secondly, the QM uses negative consequences, indicating stage 1 FSC maturity in the People system dimension.

Frontline survey upon swabbing: Workers who did remember training had it just recently. A storage worker and 2 foreign line workers were not sure what was asked from them. At a point, the QM said to a worker being swabbed 'all had the hygiene training a few months ago, just before the audit.'

FSC insight: The situation shows poor impact of the training, QM expectations of the training, like previously discussed and a reactive FSC stage 2, as the training was done in preparation for the audit.

Observations: QM one by one took pictures of disinfectant dispensers.

FSC insight: The QM took the lead in reporting/solving the situation with empty disinfectant dispensers, although other shop floor responsible staff were present. Thus, there seems to be unstructured problem solving and lack of responsibility distribution to the responsible staff in the production, indicating FSC maturity stage 2.

Observations: Regarding the outsourced maintenance worker discussed above, the QM did not think that swabbing him is relevant, saying that he is not a part of their company's staff. Thus, these kinds of risks are not analyzed or considered by the company. The food safety risk is increased even further, as the outsourced maintenance worker had not had hygiene training (Appendix 10, Table 1).

FSC insight: As the company had not analyzed risks regarding outsourced staff, there is a lack of understanding and awareness of risk, indicating a FSC maturity below stage 3.

Observations: Regarding the operator who touched the open products on the line. At the same time, other line workers were around and did not interfere.

FSC insight: This shows that the frontline is either not aware of the risks or do not freely give input or report issues. As discussed above, from the hierarchical leading dimension perspective (also discussed in detail in Subchapter 4.2, under section 4.2.2.), it is not common to give input to a higher-ranking position. In any case, this shows that the company has not worked on norms to get the frontline involved and with that to FSC maturity below stage 2.

In conclusion, observations of behaviors enabled to gain insights on FSC, which further increase food safety risk, like not properly analyzing risks (e.g. outsourced staff), focusing on incidence, instead of working towards root causes and lack of interfering or problem reporting and productively responding to input.

4.5.2.4. Halal Food Assurance

The lack of proper hand washing facilities and following hand washing and drying protocols, in addition to the routes leading to post-processing contamination of products, compromise Halal food assurance by increasing the risk of the product becoming a health hazard. Additionally, *E. coli* findings at or after the toilet, with a high probability indicate that this contamination is of fecal origin, which is not only a concern for FS, but that the products might come into contact with Najis (filthy). The hands of an outsourced maintenance worker and the sink in the women's toilet were positive for both. What makes the contamination of the sink worrisome is that clothes come into contact with the surfaces of the sink while washing hands, after which the hands were dried into the clothes, spreading and increasing the probability of the contamination.

4.5.3. Company 2

Only observations were conducted in this company, which enables to gain insight on hygiene practices and FSC maturity.

Observation 1: Hygiene barriers (meant to wash and disinfect hands and clean shoes) at the entrance were not working, as they did not dispense disinfectant, and workers were just passing them.

Observation 2: Some raw materials were broken into smaller pieces, using the help of the pallet. On two separate occasions, by workers at different departments, upon breaking the raw material it was observed to touch the ground. These raw materials will eventually pass the CCP, which will decrease the microorganism count; nevertheless, this is a cross-contamination risk.

Observation 3: A line was washed with pressurized water, while on the adjacent line production was ongoing. These products will eventually pass the CCP, which will decrease the microorganism count; nevertheless, this is a cross-contamination risk.

Observation 4: A vessel was washed with pressurized water and adjacent to a working production line. Without drying, the vessel was used.

Observation 5: Rework, product and waste crates were mixed up, as the same-colored crate might have been used for different purposes.

Observation 6: A large container for wasted products was unlabeled and near the crates of products.

FSC insight: These observations confirm the statements of one of the three frontline focus groups (elaborated in Subchapter 4.3. and Appendix 7.). The observations were conducted before the focus group sessions and were thus not guided by them. As people in two of the focus groups did not feel free to speak about issues or were not aware enough of risks and hazards to do so, indicates a lower FSC maturity of stage 1.

Observation 7: A utensil fell to the ground and workers picked it up and continued working with it. The surrounding staff did not interfere.

FSC insight: That people do not interfere, even though something poses a food safety risk, demonstrates a FSC maturity stage 1.

4.5.4. Company 3

Microbiological test results are displayed in Tables 3 (hands, gloves and clothes) and Table 4 (surfaces) of Appendix 10. Hands/gloves of workers no 2, 6, 7 and 8 were positive for EB. Worker no 6 and 8 were additionally positive for CF (this result was not available for no 7) and no 7 and 8 for ttCF (Appendix 10, Table 3). Clothes of workers no 2, 4, 7 and 8 were positive for EB, no 2, 4 and 8 were additionally positive for CF and no 2 and 8 for ttCF.

Surfaces workers touched before the HH, such as sink 2 (Z4), staircase railing 1 (Z4) and heavy door 1 (Z4) were positive for EB and CF and the first two were additionally positive for ttCF (Appendix 10, Table 4). Interestingly, the password/ fingerprint device, which everyone who wanted to enter the HH zone had to touch, was found negative for all indicator organisms.

Multiple surfaces in the HH area were found positive for EB, CF and ttCF, like utensil 1 (Z2.1), pallet 1 (Z3.1), floor (Z3.2), pallet jack handle (Z2.1) and demijohn (Z2.1). Additionally, pallet 2 (Z3.1) was positive for EB and staircase railing 2 (Z2.1) for ttCF. These surfaces together with door 2 also showed yellow overgrowth regarding other indicator organisms, thus they should still be considered as a risk and included in any future investigations. Interestingly, the sensor to open the door to exit the HH zone was negative for any findings. Although it is a touch-free sensor, people were observed to touch it.

In the utensil and equipment washing room in the HH zone, curtains (Z2.1), its part touching the ground (Z2.1), drain (Z3.2) and sink 4 (Z2.1) were found positive for EB, CF, ttCF. Additionally, the drain (Z.3.2) was found positive for *E. coli*. Normally, the curtains should not touch the ground to avoid contamination from the floor, especially since they come into contact with mixing vessels.

In the LH zone of packaged products crate handles were found positive for EB and CF. Finally, the sinks 1 and 3 in were found positive for EB, CF and ttCF.

4.5.4.1. Scenario 1 – Contamination Routes at the Entrance and in the High Hygiene zone

Observations: The only sinks equipped for washing hands were at the entrance of the production. To reach the HH area, workers must walk through the LH area, after which they should push open a heavy door (door 1). Workers were observed to do this by pushing the long horizontal leaver covering the door crosswise by pushing the body against it, to open it.

- Sink 2 at the entrance was positive for EB, CF and ttCF (count).
- Door 1 was positive for EB and CF (count).

Storyline 1: The sink 2 (Z2.1) at the entrance might contaminate clothes (Z2.1). Cross-contamination might occur between door 1 (Z4) and hands (Z1/Z2)/clothes (Z2.1). Thus, aspects which might contaminate hands and clothes prior to that become more relevant. As workers at the HH area are men, the sink (no 1) at the women's dressing room in not directly relevant to the contamination path storyline of the HH area.

Observations: For instance, the QA said the workers rest outside. They take their tea from the food court and go outside. Upon asking where they go in the winter, she did not know.

- The clothes of 2 workers (no 2 and 8) were positive for EB, CF and ttCF (enrichment). While no 2 was a responsible supervisor at a HH area, no 8 was a supervisor at the LH zone. Clothes of No 4, a worker at the HH zone, was positive for EB and CF (enrichment) and had overgrowth regarding ttCF. No positives were found for 4 HH zone workers' clothes (no 1, 3, 5, 6).

Storyline 2: Some contamination of clothes was identified, however, based on the existing data, no direct assumptions could be made on what might have contaminated them. More observations are necessary on behaviors around clothes coming in contact with surfaces and hands, to identify risks to products.

Observations: After opening the heavy door (Zone 4), it is necessary to go up 2 flights of stairs. This area was not considered as a part of production, as the cleaning of these stairs (railing 1) was the administration's responsibility. Workers entering/exiting the HH zone might touch the railings (no 1) of the staircase (Z4). The entrance to the production at the 2nd floor was locked, where workers should use fingerprint identification (push a finger to the reader) or enter a password by pressing the adjacent buttons. This device has been the company's focus for contamination, as the responsible staff said that multiple microbiological samples were taken from this location, with negative results, which was also the case for the keypad.

- Railing 1 was positive for EB, CF and ttCF (count).
- Keypad was negative for contamination.

Storyline 3: Railing (Z4) and hands (Z1/Z2.1) might contaminate each other, as workers touch it before entering or after exiting the HH zone.

Observations: According to the reports of responsible staff, at the HH zone there were no hand washing sinks, because it is a low moisture area. However, there was a utensil washing area in a separate room, the entrance of which was covered with a curtain. A line worker was observed to 'rinse' his hands in this room at a sink meant for washing utensils. This sink in the washing room was meant to wash utensils, including sieves, which the company had identified as a CCP.

- The sink 4 for utensils was positive for EB, CF and ttCF (count).

Storyline 4: Wet hands result in increased microorganism transfer, resuscitation and growth. Thus, the surfaces, with what wet hands might come in contact with, become more relevant. Upon further investigation, observations could be conducted to see whether this 'rinsing' is a common practice among the HH zone staff and what surfaces are commonly touched afterwards.

Storyline 5: The contaminated sink 4 (Z2.1) increases the probability of contaminating the utensils (Z1) and with that the products.

Observations: Curtains are one the surfaces workers come in contact with, as they touch these upon entering and exiting the washing room. A part of the curtain was too long and touching the ground. Moreover, vessels used in production area are pushed through the curtains to wash and then pushed out again after washing, touching the curtains in the process.

- Curtains in the utensil washing room were positive for EB, CF and ttCF (count)
- Bottom part of the curtain (the one touching the ground) was both positive for EB (enrichment), CF (count) and ttCF (enrichment).

Storyline 6: Curtains (Z2.1) and the outer surface of the vessels (Z2.1)/hands (Z1/Z2.1)/clothes (Z2.1) might contaminate each other. The outer surface of the vessel (Z2.1) and hands (Z1/Z2.1) might also contaminate each other, as workers come into contact with that.

Observations: There were vessels in production, into which workers were emptying raw materials. To secure the cover of the vessel a device (utensil 1) was used, which touched the vessel edge and the cover. This edge in turn comes into contact with raw material packaging materials as they are poured into the vessel. Raw materials were prepared and stored on the pallet to be carried and emptied by the frontline staff.

- Utensil 1 (Z2.1) (a device, covering the edges of the vessel and its cover) was found positive for EB and CF (count) and the presence of ttCF (enrichment).
- Pallet was positive EB, CF and TtCF (count).

Storyline 1: Utensil 1 (Z2.1) and the vessel edge (Z2.1) might contaminate each other. Raw material packages might get contaminated from the pallet (Z3.1), which might in turn might contaminate hands (Z1/Z2) and clothing (Z2) and which might in turn contaminate the vessel. Packages might also contaminate the edge of the vessel (Z2.1), which might come in contact with raw materials. There is no CCP process afterwards.

Observations: Other areas and surfaces in the HH area were also swabbed, which the frontline was observed to touch and accordingly swabbed:

- Pallet jack handles (Z2.1) were positive for EB, CF and TtCF (enrichment).
- Water dispenser (Z2.1) surface was positive for EB, CF and TtCF (enrichment).

Storyline 2: As these are areas that the frontline often touches during their work, this increases the probability of contamination of surrounding surface and product. The observation discussed above that a worker rinsed his hands, results in residual moisture on the hands. Therefore, although the above microbiological analysis results are positive for enrichment conditions, the residual moisture leads to increased risk as microorganisms might resuscitate and grow. Finally, as hands might get contaminated from various surfaces at the HH area, this justifies the need for a hand washing facility near or at the HH zone.

Observations: For instance, a technician (no 6) was swabbed, whose hands were covered with the product, and he reported to have helped the frontline staff with some issues, also being in contact with the product and had not washed his hands for around 1.5 hours (Appendix 10, Table 3).

- The hands of worker no 6 were positive for EB and CF (count).

Storyline 3: The hands of the worker might contaminate the product. However, before swabbing the worker might also have been in contact with surfaces, which might have led to such contamination, like the door he exited right before the swabbing or utensils he reported to have touched. Further observations are necessary to see whether he might find it suitable to come in contact with products again before cleaning his hands, which is not possible at the HH zone where he was stationed.

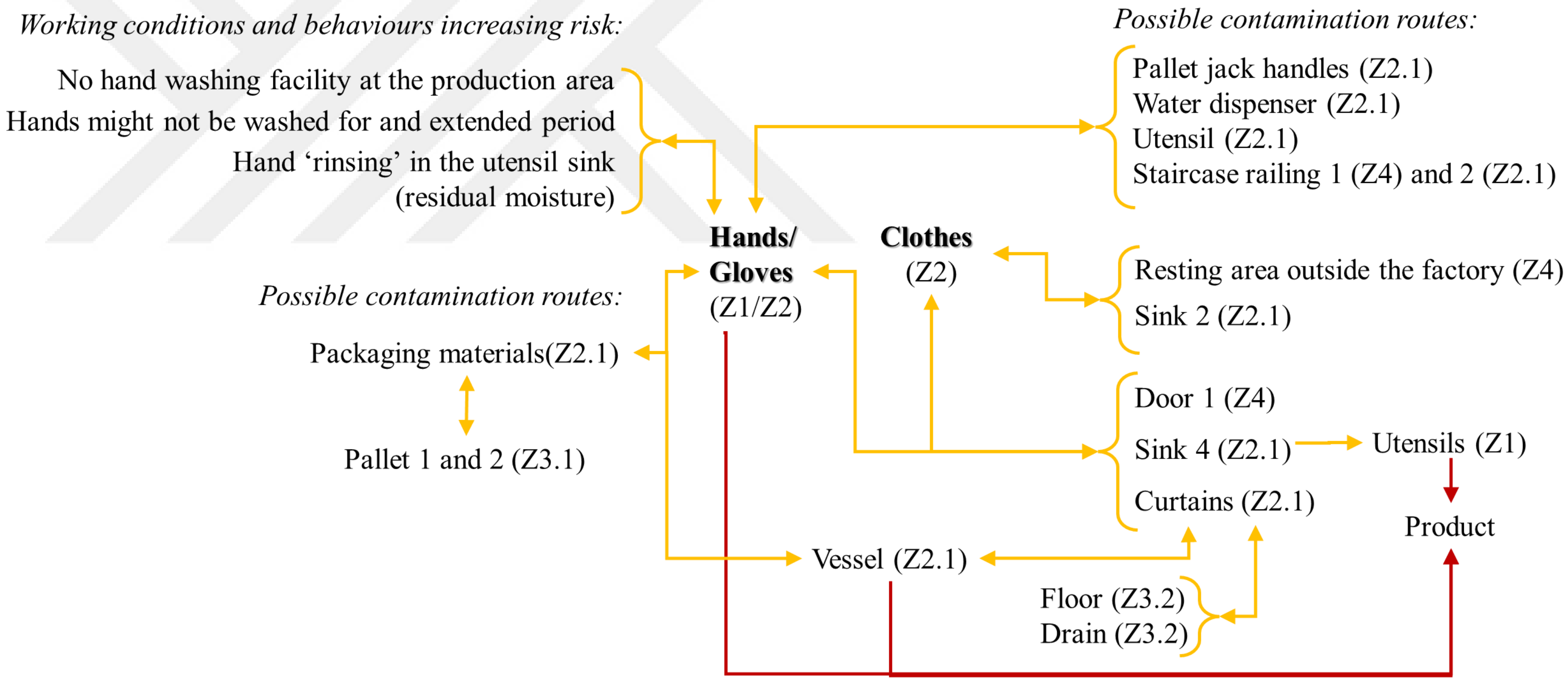
Observations: Two floors were swabbed, elevator from the storage directly opened to the HH area and the drainage area of the washing room.

- Elevator floor was positive for EB, CF and ttCF (count).
- Drainage (wet) on the floor was positive for EB, CF, ttCF and *E. coli* (count).
- Curtain part touching the ground was positive for CF (count) and EB and ttCF (enrichment).

Storyline 1: Workers might spread the contamination around the production floor with their shoes (Z3.2) or pallet jacks' tires (Z3.2). The curtain touching the ground (Z2.1) might get contaminated and in turn contaminate the outer surface of the passing vessel (Z2.1). More observations could be made on behavior patterns, which might lead to cross-contamination from the floor (Z4).

A visual summary of the scenario is depicted by Figure 4.12.

A)


Working conditions and behaviours increasing risk:
No hand washing facility at the production area
Hands might not be washed for and extended period
Hand 'rinsing' in the utensil sink (residual moisture)
Hands/ Gloves (Z1/Z2)
Clothes (Z2)
Possible contamination routes:
Pallet jack handles (Z2.1)
Water dispenser (Z2.1)
Utensil (Z2.1)
Staircase railing 1 (Z4) and 2 (Z2.1)
Resting area outside the factory (Z4)
Sink 2 (Z2.1)
Door 1 (Z4)
Sink 4 (Z2.1)
Curtains (Z2.1)
Utensils (Z1)
Product
Possible contamination routes:
Packaging materials(Z2.1)
Pallet 1 and 2 (Z3.1)
Vessel (Z2.1)
Floor (Z3.2)
Drain (Z3.2)

B)

	EB	CF	ttCF	*E. Coli*
Count	Sink 2 and 4 Staircase railing 1 Door 1 Utensil Pallet 1 Curtain Worker no 6 Drain (wet) Floor	Sink 2 and 4 Staircase railing 1 Door 1 Utensil Pallet 1 Curtain Worker no 6 Drain (wet) Floor	Sink 2 and 4 Staircase railing 1 Pallet 1 Curtain Drain (wet) Floor	Drain (wet)
Detection	Staircase railing 2 Pallet jack handle Demijohn Pallet 2	Staircase railing 2 Pallet jack handle Demijohn Pallet 2	Staircase railing 2 Utensil Pallet jack handle Demijohn	

Figure 4.12: Risk map of post-process contamination potential based on scenario analysis 1 in company 3 (C3). A: Contamination routes and microorganism zone transfers. Red arrow – direct contamination possibilities of products. Orange arrow - contamination between surfaces. B: Indicator organism analysis results highlighting aspects of microbiological risk. Light to dark red gradient - highlights risk from lower to higher. *E. coli*: indicator organism *Escherichia coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: high/low hygiene zones, explained in section 4.5.1; Z: Zoning concept, explained in section 4.5.1.

Source: Prepared by the researcher.

4.5.4.2. Scenario 2 – Contamination Routes in Low Hygiene Zone

Observations: At the LH area, a crate, turned upside down, was seen on the floor. The operators said that they washed it with water and were letting it dry. Reportedly, it is disinfected weekly.

- Crate handles out and inside were positive for EB and CF (count).
- Hands of workers (no 7 and 8) at the LH area were positive for EB, CF and ttCF (enrichment), except the overgrowth for no 7 regarding CF.

Storyline 1: The crates (Z2.1) might contaminate hands and product packages. Residual moisture induces microorganism resuscitation and growth. The risk of product contamination is low, as the product is packaged. However, further data might be collected on utensil, pallet and crate washing and drying practices at the HH zone, to see whether similar practices are used.

4.5.4.3. Food Safety Culture Insights

Observation: Upon swabbing workers, no 2 worker was the responsible technician and no 4 the line worker. No 2 was happy to have himself swabbed. When no 2 called no 4 for swabbing he said that he had to bring some things somewhere and disappeared. When the young man finally returned and I asked him when he washed his hands, he said that he just did. No 4 was also outsourced staff, which might have impacted his reaction.

FSC insight: Whatever the underlying reasons, it became apparent that swabbing as a tool for continuous improvement is not a general norm.

Observation: Upon seeing a worker 'rinse' his hands at the utensil sink, two responsible staff did not interfere, but whispered to each other about the low awareness of the person. At that area (the HH zone) there were no hand washing facilities, for the whole workday, they would only have one longer break for lunch, omitting the shorter tea breaks in between. This means, if the workers do not especially walk to the sink at the entrance to wash their hands, they are expected to do so in the beginning of their shifts two times a day, in the morning and after lunch. Although disinfectants were available in the HH zone, line workers are in constant contact with powders, raw material packaging materials and various surfaces, which were revealed to be contaminated, creating a need for them to wash their hands more often that two times a day. There is no data on why a hand washing option had not been made available at the washing area of the HH zone.

FSC insight: The responsible staff not interfering to catch a near-miss situation, and the assumptions made by the responsible staff regarding the line worker, indicate to them having expectations and a lack of focus on root cause, in turn indicating to a stage 2 FSC maturity.

4.5.5. Company 4

Microbiological test results are displayed in Tables 5 (hands and gloves), Table 6 (clothes) and Table 7 (Surfaces) of Appendix 10. Hands/gloves of workers no 2-8 were positive for EB and CF (Appendix 10, Table 5). Workers no 1, 2, 6, 7 and 8 were additionally positive for ttCF and 6 for *E. coli*. Interestingly, hands/gloves of workers no 1 and 9 were only positive for ttCF. Clothes of workers no 3, 5, 6, 7 and 9 were positive for EB, CF and ttCF (Appendix 10, Table 6). Additionally, clothes worker no 2 was positive for EB and no 10 only for ttCF.

Surfaces workers touched at the entrance/exit to the production, door 1 (Z4), hygiene barrier's (meant to wash and disinfect hands and clean shoes) metal bars (Z4), staircase railing 1(Z4) and sink 1 (Z2.1), were positive for EB, CF and ttCF (Appendix 10, Table 7). At the high hygiene zone, the production line band (Z4), pallet (2.1), floor 1 (Z3.2), crate (Z1) and curtains (2.1) were positive for EB, CF adn ttCF. The production line band (Z4), pallet (2.1) and floor (Z3.2) were additionally positive for *E. coli*. In the LH area, staircase railing 2 (Z2.1), utensils 1 and 2 (Z2.1), pallet jack (Z2.1), doors 2 and 3 (Z2.1), floor 2 and sink 2 were positive for EB, CF and ttCF. Utensil 2 was additionally positive for *E. coli*.

4.5.5.1. Scenario 1 – Contamination Routes at the Entrance and in the High Hygiene Zone

Observations: There were three entrances to the LH zone, which had hygiene barriers. Two of the three hygiene barriers were out of soap and towels for drying. In the third one, the disinfectant part was not working.

Storyline: The lack of consumables and broken hygiene barriers sets a foundation for improper handwashing practices.

Observations: When a worker was passing the hygiene barriers to enter production, he straight away started disinfecting his hands without washing. When he noticed the observers, he turned back to the sink to “wash” or wet his hands, as there was no soap or paper there.

Storyline: In addition to lack of facilities, hand washing practices were also lacking. The residual moisture on the hands increases the probability of microorganism transfer, resuscitation and growth.

Observations: Although not an observed behavior, like in C1, according to the supervisor, upon passing the hygiene barriers, workers had a habit of touching the metal bars. At one of the entrances, after the hygiene barriers, there was a door (no 1) that workers should push open to enter the production. Upon exiting the dressing rooms, there were stairs, which led to both LH and HH areas, as the fourth entrance. Their railings were swabbed.

- Hygiene barrier’s metal bars were positive for EB, CF and ttCF (enrichment).
- Door 1 was positive for EB, CF and ttCF (count).
- Railings were positive for EB, CF and ttCF (count)

Storyline: Metal barriers/door/railing (Z4) and hands (Z1/Z2.1) contaminate each other, especially if the hands are wet. Although metal bars were positive for enrichment conditions, the residual moisture might lead to microorganism resuscitation and growth, increasing food safety risk.

Observations: HH zone is within the production, at a separate area, however, before entering, there were no hygiene barriers or hygiene protocols to follow. Furthermore, there were no hand washing options in the HH zone. At the HH zone, products come in front of the workers on the production line, who place them in crates. The QA stated that the production line surface is not washed but replaced when it wears out. Workers wear special thick gloves to take the hot product and place it in the crates. These gloves were changed weekly. Each worker had their own gloves and an area to store them.

- Production line surface was positive for EB, CF, ttCF and *E. coli* (enrichment).
- HH zone line workers’ (no 2-5) gloves were positive for EB (count) and CF (enrichment). No 2 was additionally positive for ttCF (enrichment).

Storyline: Production line's surface (Z1) and gloves (Z1) might contaminate products. The enrichment method enabled to identify the potential food safety risk and indicates that there are instance/behaviors, which lead to the contamination with even ttCF and/or *E. coli* on surfaces such as Z1. While there is no data on how the production line might have gotten contaminated, possible contamination routes were identified for crates.

Observations: Some of the product crates stacks were placed on the ground. The QA reported that normally crates should be on pallets. Same pallets were used in both the finished product packaging and distribution area. After products were packaged in crates, these were stacked on top of each other and as open products brought to the distribution area by the outsourced staff, who put them into vans for distribution. The same crates were returned to the factory for further use. As discussed in Subchapter 4.3. (section 4.3.4.), the crate washing line does not have enough capacity to wash all. Thus, after the crates were brought back to the factory, they might not be necessarily washed before the next products were put inside.

- Floor 1 by the crates was positive for EB, CF, ttCF and *E. coli* (count).
- Pallet was positive for EB, CF and ttCF (count) and *E. coli* (enrichment).
- Crate handles were positive for EB, CF and ttCF (count)

Storyline: Floor (Z3.2) and pallet (Z2.1) contaminate crates (Z1). Thus, even if crates were placed on pallets instead of the floor, crates might still get contaminated. As crates were stacked on top of each other they may contaminate each other as well and possibly the products. However, as crates might not be washed after being returned to the factory, contamination might as well be from outside the factory (Z4).

Observations: The outsourced distribution staff bring pallets and crates to the line workers and like this, being in contact with both the pallets and crates. They were observed to stack the crates by both the packaging line and distribution area. Two of the outsourced distribution staff (no 6 and 7) were swabbed. Worker no 6 was holding from the top crate to steady a stack of crates while transporting them, which was the same area the line workers were holding the crates to stack them. Like in the HH zone product packaging area, there were also no sinks in the distribution area.

- Gloves of no 6 were positive for EB, CF, ttCF, *E. coli* (count);
- Hands of worker no 7 was positive for EB and CF (count).

Storyline: Gloves and hands (Z1/Z2.1) of workers no 6 and 7 might contaminate crates (Z1) and through that product line workers' hands, as they are both holding crates from the handles. Hands and gloves being contaminated to the extent of being positive for ttCF and *E. coli* under count conditions demonstrates high risk. No hand washing facilities at the open product and distribution area, increase probability of contamination spread from both line workers and outsourced distribution workers. For instance, worker no 6 reportedly changes his thick work gloves daily, thus, either the gloves were contaminated from crates, either there are poor hand washing and glove handling practices or the gloves are not changed as often as reported.

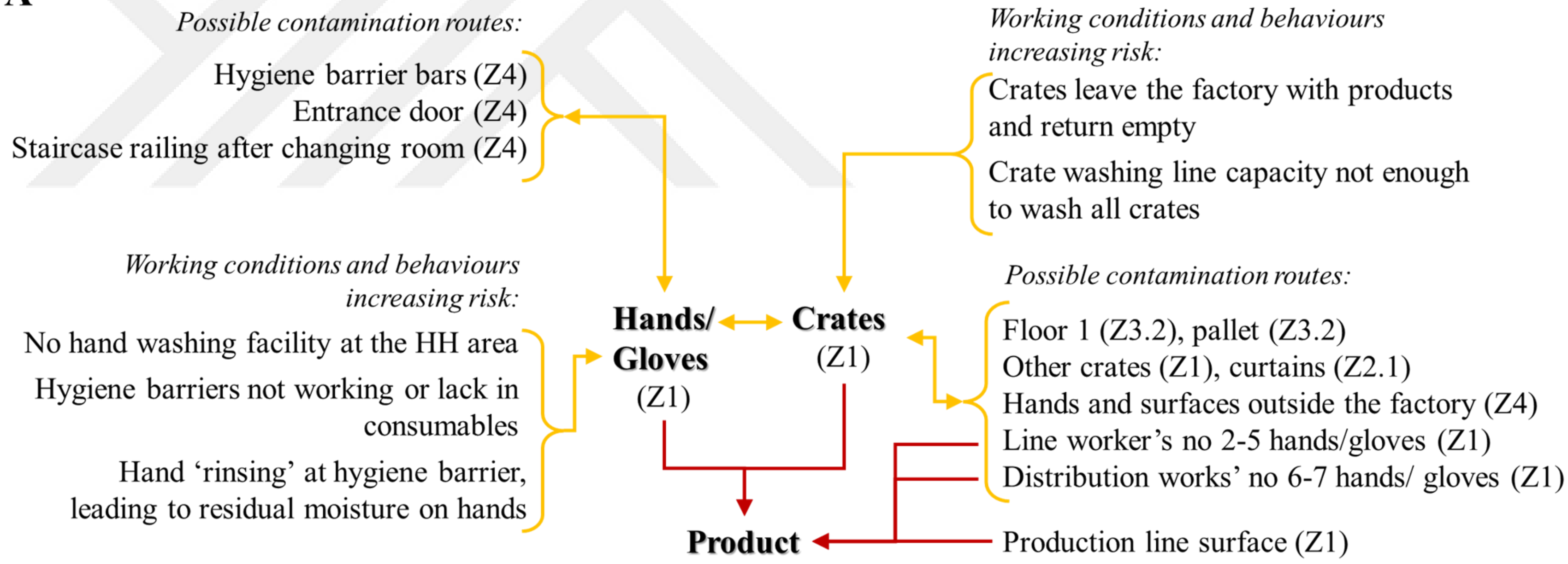
Observations: Curtains were between the open product packaging and distribution areas to prevent the former from being directly opened to the outdoors. The outsourced distribution and packaging staff, especially supervisors, and stacks of crates move through the curtains. The crates were observed to move through the curtains, without pulling them back, with bottoms of the curtains touching the inside of the crates. Regarding clothing, upon entering the company premises, outside, workers were observed sitting or lying on the benches.

- Curtains were positive for EB, CF and ttCF (count).
- HH zone line worker no 3 clothing was positive for EB, CF and ttCF (count).
- HH zone line worker no 5 clothing was positive for EB (enrichment) and CF and ttCF (count).
- Distribution worker no 6 clothing was positive for CF and ttCF (count, EB enrichment had overgrowth).
- Distribution worker no 7 clothing was positive for EB, CF and ttCF (count).

Storyline: Curtains (Z2.1) and clothes (Z2.1)/ crates (Z1)/ hands (Z1) might contaminate each other, as workers and crates pass through them. Like with crates, the outside environment is a direct uncontrollable source of contamination. Further observations are necessary to reveal potential contamination routes from clothes.

A visual summary of the scenario is depicted by Figure 4.13.

A


Possible contamination routes:
Hygiene barrier bars (Z4)
Entrance door (Z4)
Staircase railing after changing room (Z4)
Working conditions and behaviours increasing risk:
No hand washing facility at the HH area
Hygiene barriers not working or lack in consumables
Hand 'rinsing' at hygiene barrier, leading to residual moisture on hands
Hands/ Gloves (Z1)
Crates (Z1)
Product
Working conditions and behaviours increasing risk:
Crates leave the factory with products and return empty
Crate washing line capacity not enough to wash all crates
Possible contamination routes:
Floor 1 (Z3.2), pallet (Z3.2)
Other crates (Z1), curtains (Z2.1)
Hands and surfaces outside the factory (Z4)
Line worker's no 2-5 hands/gloves (Z1)
Distribution works' no 6-7 hands/ gloves (Z1)
Production line surface (Z1)

B

	EB	CF	ttCF	E. Coli
Count	Entrance door Staircase railing Pallet Floor 1 Curtains Crate Production line surface Worker no 2-5 Worker no 6 and 7	Entrance door Staircase railing Pallet Floor 1 Curtains Crate Worker no 6 and 7	Entrance door Staircase railing Pallet Floor 1 Curtains Crate Worker no 6	Floor Worker no 6
Enrichment	Hygiene barrier	Hygiene barrier Worker no 2-5	Hygiene barrier Worker no 2	Pallet

Figure 4.13: Risk map of post-process contamination potential based on scenario analysis 1 in company 4 (C4). A: Contamination routes and microorganism zone transfers. Red arrow – direct contamination possibilities of products. Orange arrow - contamination between surfaces. B: Indicator organism analysis results highlighting aspects of microbiological risk. Light to dark red gradient - highlights risk from lower to higher. *E. coli*: indicator organism *Escherichia coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: high/low hygiene zones, explained in section 4.5.1; Z: Zoning concept, explained in section 4.5.1.

Source: Prepared by the researcher.

4.5.5.2. Scenario 2 – Contamination Routes in the Low Hygiene Zone

Areas and surfaces in the LH area were swabbed, especially the ones which the frontline was observed to touch.

- Vessel handles (Z2.1) were positive for EB and CF (count) and for ttCF and *E. coli* (enrichment).
- Staircase railing (over a production line) (Z2.1) was positive for EB, CF and ttCF (count).
- Mixing machine door handle (Z2.1) was positive for EB, CF and ttCF (enrichment)
- Pallet jack handles (Z2.1) were positive for EB, CF and ttCF (enrichment)
- Utensil 1 (swabbed from the part where workers hold on (Z2.1), other part of the utensil is used to touch products) were positive for EB, CF and ttCF (enrichment)
- Worker's hands (No 8) holding the utensil were positive for EB (count) and CF and ttCF (enrichment).

Storyline: Some of the frequently touched surfaces (Z2.1) at the LH area were contaminated. Both utensil 1 (Z21.) and hands (Z1/Z2.1) holding it were also found to be contaminated. This might indicate poor hygiene practices, as it is a plant-based product processing and especially contamination with indicator microorganisms such as CF and ttCF in not associated with its raw materials. This is worrisome, as same workers might be positioned at both the LH and HH zones. For instance, in this company, workers are placed in tough working conditions at the HH zone, if they are new or as an unofficial disciplinary measure for not following company rules (as discussed in Subchapter 4.3., section 4.3.4.). Thus, staff rotate between the LH and HH zones, bringing with them norms they have adopted in each of the zones, giving way to contamination from hands, clothes and shoes.

Observations: For instance, the door 2 handle of a small room, in which workers were cleaning their clothing before exiting the production area, was found to be positive of EB, CF and ttCf (count).

Storyline: Although it is a door used before exiting production, this demonstrates the contamination of workers' hands during their work, reflecting the results of the LH zone contamination.

Interestingly, HH zone workers' clothing was found to be more contaminated compared to LH zone workers' clothing, with no 8 negative and no 9 positive for EB, CF and ttCF (enrichment) (Appendix 10, Table 6). At the LH area, workers were also observed to use pressurized air to clean their clothes by the production lines.

Storyline: If workers from the HH zone are placed to the LH zone, through pressurized air they might spread contamination from their clothes.

Observations: The utensil washing area at the LH area, including sink, were dirty, filled with residues and had a smell. The area was wet and opened directly to the LH area production

- Sink 2 was positive for EB, CF and ttCF (count).
- Floor 2 was positive for EB, CF and ttCF (count).

Storyline: The sink 1 (Z2.1) being contaminated increases the probability of utensils (Z1) getting contaminated and with that the production surfaces and semi-finished products. Workers might spread microorganisms and residual moisture from the floor (Z3.2) around production, which is especially important as workers might be positioned at either of the zones and the HH zone floor (Z4) is a direct contamination source of crates (Z1).

4.5.5.3. Food Safety Culture Insights

Observation: Upon swabbing a line worker, an outsourced distribution worker approached and said that "*they should wash the pallets at least once a month, we put bread on them, it is a shame*". At a point a near line worker snapped at him quietly saying, "*that is enough*". At that time the QA happened to be further away to ask something from colleagues. Although there is no data on how often the pallets are washed, they were visually dirty.

FSC insight: 'Speaking up' is discouraged, indicating to a FSC maturity stage 1.

Observation: While six workers claimed to have had hygiene training within the last year, worker no 8 who had worked there for 3 years and worker no 9 who had worked there for 2 years, claimed not to have had or not remember having training during this period (Appendix 10, Table 6).

FSC insight: From the findings in Subchapter 4.3 (section 4.3.4.), it became apparent that just as in C1 and C3, C4 also aimed to complete workers' hygiene training before an external audit. Thus, not only is a learning program seen as a tool to increase awareness and induce engagement, the fact that some workers who had been there for years had not had training shows inconsistencies in their system and a FSC maturity stage 2 in the Consistency dimension. These findings support the conclusions on companies' FSC maturity in Subchapter 4.3 (section 4.3.3.), which also demonstrated a stage 2 maturity through managers' expectations of raising awareness and changing behavior with annual hygiene training.

Observation: Crates (Z1) were on the ground and no action was taken. The QA supposed that workers might not have had time to put them on pallets before the break.

Observation: A worker was about to pass the hygiene barrier without washing hands and turned back to rinse his hands upon seeing the responsible staff. The latter did not interfere or take action regarding the lack of consumables in the hygiene barriers.

FSC insights: The responsible staff not interfering to prevent or correct improper situations, shows a lack of willingness to take action and with that a FSC maturity stage 1.

Observation: Upon wanting to sample the outsourced distributing staff, the supervisor asked why this is relevant, as they are not the factory's staff and do not touch the products directly. However, they were touching the crates, which hold the open products and might thus also come in contact with the product. They also bring and place both pallets and crates by the ready product line, where workers manually pack them. The outsourced staff had also not had hygiene training (Appendix 10, Table 5).

FSC insight: Like in C1, outsourced workers were not regarded as a risk. As the company had not analyzed risks regarding outsourced staff, there is a lack of understanding and awareness of risk, indicating to a FSC maturity below stage 3.

4.5.5.4. Halal Food Management

As for Halal food assurance, it is important that during processing, products would not be contaminated with Najis, like feces, even if products go through a processing step to destroy or decrease the count of dangerous microorganisms, making the possibilities of product contamination with *E. coli* at both the LH and HH zone a risk to Halal food assurance.

4.5.6. Company 5

Microbiological test results are displayed in Tables 8 (hands and gloves), Table 9 (clothes) and Table 10 (Surfaces) of Appendix 10. Hands/gloves of workers of no 1, 2 and 6 were positive for EB (Appendix 10, Table 8). No 1 and 6 were additionally positive for CF and no 1 and 3 for ttCF. Clothing of workers no 1, 2, 3, 4, 6 were positive for EB. No 1 and 3 were additionally positive for CF and no 6 for ttCF (Appendix 10, Table 9).

From surfaces, doors 1 and 3 (Z2.2), doors 2 and 4 (Z2.1), product rack handles (Z2.1), sink 2 (Z2.1) and pallet 1 and 2 (Z3.1) and rework crate (2.1) were positive for EB, CF and ttCF (Appendix 10, Table 10). The rework crate (2.1) was additionally positive for *E. coli*. Water dispenser (Z2.1) and utensil 1 (Z1) were positive for EB and CF. Scale buttons were positive only for EB. A screen with buttons and door 5 were negative for any of the indicator organisms. Floors 1 and 2 were positive for EB, CF and ttCF, while floor 1 was additionally positive for *E. coli*.

4.5.6.1. Scenario 1 - Contamination Routes at the Entrance and in the High Hygiene Zone

Observations: The entrance to LH zone 1 had multiple properly working hygiene barriers (meant to disinfect hands and shoes), stacked with consumables. There are two LH zones in total: 1 - the zone before the CCP step; 2 – the zone with packaged ready-to-eat products. To get to the HH zone, workers had to walk through corridors and not any LH production room. However, the corridors were filled with containers, crates and racks from different processing rooms. To enter the HH zone, workers were meant to pass a narrow corridor with a hygiene barrier, pass through curtains and wear protective clothing meant specifically for the HH area. However, beside the narrow corridor a wide door was open, allowing direct entrance to the HH zone. People were seen passing through this door to enter and exit the HH zone. The QMA said that this door should usually be closed and opened only when racks are transported to other areas.

Observations: On the other side of the HH zone was another wide door (no 1) leading to LH zone 2. Workers were opening and closing door 1, to either enter or exit the HH zone. Among the workers entering the HH zone from the LH zone 2 was a QA team member. According to the QMA, the door should be kept closed and opened for transporting packaging materials there.

- Door 1 was found to be positive for EB, CF and ttCF (count).

Storyline: Door 1 (Z2.2) and workers' hands (Z1/Z2.1) /clothes (Z2.1) might contaminate each other, which is especially important, in case a worker moves to the HH zone to work.

Observations: The HH zone had multiple racks, with some filled with products and others empty. Workers were first weighing the racks and during this process touching screens, then pushing the racks near the production line. The workers at the production line emptying the product racks products also touch their handles. Products in the racks were hanging and moving when the rack was moved, resulting in the product touching the rack. Thus the rack might be both Z1 and Z2.1 (Z1/Z2.1).

Observations: Worker no 6 moved from the LH zone 2 to HH zone and did not wash his hands. He pushed the product rack by the production line and touched the scale and screen. Upon swabbing he also reported having touched packaged products, pallets and product racks after last time changing gloves. He reported to have had hygiene training 9 months ago, upon starting to work in the company (Appendix 10, Table 8).

- Gloves of worker no 6 were positive for EB and CF (enrichment).
- Product rack handles were positive for EB, CF and ttCF (count).
- Scale were positive for EB (enrichment).
- Screen was negative for all analysis.

Storyline: Having touched product packages (Z4) and pallets (Z4) at the LH zone 2, worker no 6 might contaminate the product rack (Z1/Z2.1) and through that products and other workers' hands. Although current microbiological results from gloves of worker no 6 do not reflect heavy contamination, the behavior patterns are such, which might lead to food safety risk.

Storyline: Product rack handles (Z1/Z2.1) might contaminate products and workers' hands (Z1/Z2.1), especially the ones at the production line handling products. While behavior would suggest scale and screen to be a contamination route, as workers are constantly touching these surfaces, the microbiological analyses do not indicate to a direct food safety risk.

Observations: At the HH zone, workers were pushing a heavy cold room door (door 4) to open and close it. They also had to be in contact with door 2, leading to the packaging material storage. The packaging materials will be in direct contact with the product. Finally, a water dispenser was available for everyone to use and thus a common surface workers were in contact with.

- Cold room door (no 4) was positive for EB, CF and ttCF (enrichment).
- Door 2 (packaging material storage door) was positive for EB, CF and TtCF (count).
- Water dispenser (surfaces workers might touch) was positive for EB, CF (enrichment).

Storyline: The low temperature of the cold room door 4 (Z2.1) inhibits microorganism growth, decreasing risk. However, the enrichment indicates that the door had been contaminated, which might in turn contaminate hand/gloves and the condensed water on the hands might lead to increase risk. The packaging room door 2 (Z2.1) and hands (Z1/Z2) might contaminate each other and in turn hands might contaminate packaging materials (Z1). Water dispenser surfaces were not heavily contaminated, but further observations could be conducted on what parts of the water dispenser workers touch.

Observations: At the HH zone, near the production lines were rework crates. These move between LH zone 1 and the HH zone. Workers at the HH zone were also handling them, by relocating and stacking them. Upon swabbing, QMA emphasized that these are rework crates and that the rework will pass a CCP processing step.

- Rework crate handles were positive for EB, CF, TtCF and *E. coli* (count)
- Pallet, the rework crates were placed on, were on positive for EB (count) and CF and ttCF (enrichment).

Storyline: The heavy contamination of rework crate handles (Z2.1) might be due to them also being handled at LH zone 1. Interestingly, the QMA did not consider that at the HH zone workers were also handling the crates (Z2.1) and like this contaminating their hands (Z1/Z2) and clothes (Z2.1). The pallet (Z3.1) and bottom of the crates might contaminate each other and in turn these crates might contaminate other crates when they are stacked. Upon further investigation, data might be collected on pallet usage and cleaning practices. For instance, investigate the possibilities of using the pallet under rework crates in other locations, like for storing packaging material, which is elaborated on in the following observation.

Observations: At the HH zone, some of the packaging materials were placed on a carton on a pallet. The former looked visually dirty. QMA reported that this packaging material will be in direct contact with the product. The carton beside the packaging materials was swabbed.

- A pallet had packaging material directly on it was positive for EB, CF and ttCF (count).

Storyline: As the carton (Z3.2/Z4) was contaminated, it might also contaminate the packaging materials (Z1), which might in turn contaminate the products. Furthermore, when workers carry the heavy packaging, hands and clothing might further contaminate it.

Observations: In the HH zone there was a water dispenser, and its surrounding floor (1) was wet. On the wet floor was the full demijohn, which could be placed on top of the dispenser. Upon request the QA asked a frontline staff who lifts the demijohn on the dispenser, the reply was that anyone available.

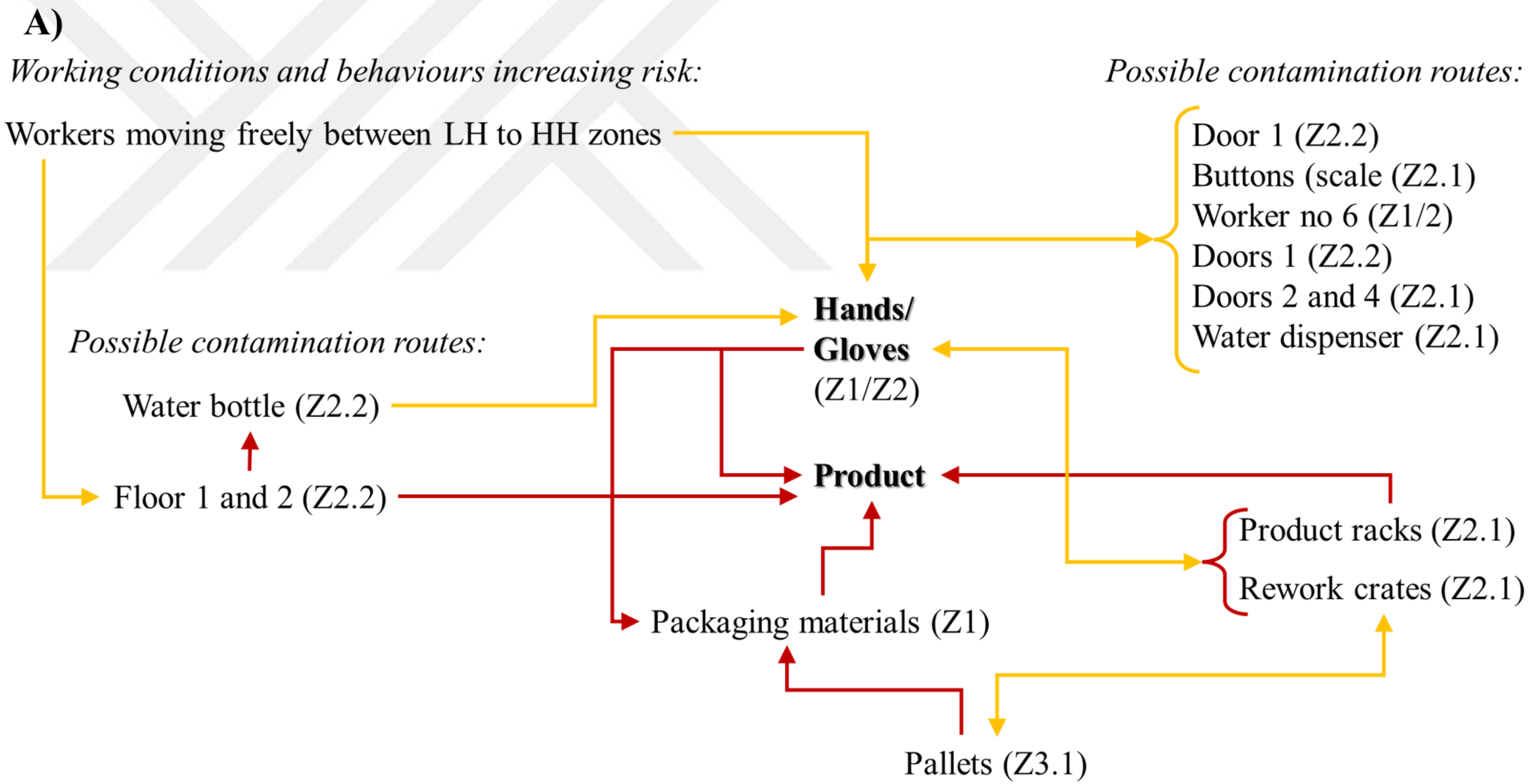
- The floor 1 (wet) was positive for EB, CF, ttCF and *E. coli* (count).

Storyline: Upon lifting the water bottle from the floor (Z3.2) workers' hands (Z1/Z2.1) and clothes (Z2.1) might get contaminated.

Observations: At the HH zone, a product with a cover to be removed before processing and packaging fell to the ground. The worker picked it up and put it on the table where there were other such products. An adjacent line worker saw this and did not interfere. QMA and microbiology responsible nearby were not informed. The floor (no 2) where the product fell was swabbed.

- The floor 2 was positive for EB, CF, ttCF and *E. coli* (count).

Storyline: The product might have been contaminated from floor 2 (Z3.2), leading to contamination of other products as well. Although the casings will be removed, workers' hands (Z1/Z2) might also get contaminated leading to the contamination of products. The risk is increased even more as people freely walk between the LH and HH zones spreading contamination on the floor.


A)
Working conditions and behaviours increasing risk:
Workers moving freely between LH to HH zones
Possible contamination routes:
Door 1 (Z2.2)
Buttons (scale (Z2.1)
Worker no 6 (Z1/2)
Doors 1 (Z2.2)
Doors 2 and 4 (Z2.1)
Water dispenser (Z2.1)
Hands/
Gloves
(Z1/Z2)
Possible contamination routes:
Water bottle (Z2.2)
Floor 1 and 2 (Z2.2)
Product
Product racks (Z2.1)
Rework crates (Z2.1)
Packaging materials (Z1)
Pallets (Z3.1)

B)

	EB	**CF**	**ttCF**	***E. Coli***
Count	Doors 1, 2 and 4 Product rack handles Pallets 1 and 2 Rework crate Floor 1 and 2 (wet)	Doors 1, 2 and 4 Product rack handles Pallet 1 and 2 Rework crate Floor 1 and 2 (wet)	Doors 1, 2 and 4 Product rack handles Pallet 1 and 2 Rework crate Floor 1 and 2 (wet)	Rework crate Floor 1 (wet)
Enrichment	Water dispenser Utensil 1 Buttons (scale) Worker no 6	Water dispenser Utensil (no 1) Worker no 6		

Figure 4.14: Risk map of post-process contamination potential based on scenario analysis 1 in company 5 (C5). A: Contamination routes and microorganism zone transfers. Red arrow – direct contamination possibilities of products. Orange arrow - contamination between surfaces. B: Indicator organism analysis results highlighting aspects of microbiological risk. Light to dark red gradient - highlights risk from lower to higher. *E. coli*: indicator organism *Escherichia coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: high/low hygiene zones, explained in section 4.5.1; Z: Zoning concept, explained in section 4.5.1.

Source: Prepared by the researcher.

4.5.6.2. Scenario 2 – Supervisors' Hands as a Vector for Contamination

Observations: At HH zone's production lines, workers were wearing gloves and packing products or adjusting them in a package. Gloves at the HH zone were stored in a cupboard, from which the operators and/or supervisors take and hand them out to frontline workers.

- Cupboard doors (Z2.2) where gloves were stored were negative.
- Supervisor's hands were found positive for EB, CF and ttCF (enrichment).
- Supervisor room door was positive for EB, CF and TtCF (enrichment).

Storyline: Further observational data is necessary on how responsible staff handle gloves before handing them to the workers the line, as supervisor's hands (Z2.2) were contaminated and might get further contaminated from surfaces, like the supervisor room door (Z2.2), which they usually come in contact. Although the microbiological analysis were positive under enrichment conditions, the products workers touch are a high-moisture product, leading to increase microorganism transfer, resuscitation and growth.

4.5.6.3. Scenario 3 – Contamination of Clothes

Observations: At the HH zone, workers were meant to wear extra protective clothing. However, multiple workers were observed to either not wear it at all or wear it open in front.

- Sink 2 at the HH area was positive for EB, CF and TtCF (count).
- Workers' no 2, 3, 4, 6 clothes were positive for EB (enrichment). Additionally, worker no 2 and 6 clothes were positive for CF (enrichment) and worker no 6 clothes were positive for ttCF (enrichment).

Storyline: Even if the staff wear protective clothing it might get contaminated by washing hands in the one sink (Z2.1) in the HH areas as clothes might touch sink 2, as they change the water bottle of the demijohn, carry packaging material stored on the contaminated pallet and/or stack rework crates.

4.5.6.4. Food Safety Culture Insights

Observations: At the HH area, on multiple occasions workers were observed either not to wear protective clothing at all or do that improperly, like having the front open. Two of the workers swabbed and who had the front of the protective clothing open, one had worked there for 9 and the other 11 months. Two other workers swabbed did not have protective clothing on, with one of them having worked there for 5 years and the other 2.5 years. They did not wear the clothing, despite supervisors and other responsible staff being around. The latter did also not interfere with the situation. Furthermore, upon swabbing the workers without protective clothing the QMA told them that they are swabbed since they do not wear the clothing.

Observations: Workers were seen walking freely between zones LH zone 1 to HH zone and to LH zone 2 and vice versa. Again, this happened despite the responsible being there and even a QA worker was observed to walk from LH zone 2 to HH zone. The QMA told that workers should not be walking like this and that she will take the matter up later with the QA she witnessed.

FSC insight: There is a norm that it is acceptable if some rules are not followed. Based on existing observations, the QMA reacted to the workers not following rules. This indicates to work in silos, not only for QMA and production, but also QMA and QA and to a supply push regarding implementing rules. Furthermore, the QMA was inclined to implement negative consequences, like swabbing as a punishment and warning staff on not following rules. Both cases indicate to a FSC maturity to be between stages 1-2.

Observations: In the case of the product falling to the ground, the worker did not inform the responsible staff. The adjacent worker also did not warn or interfere.

FSC insight: As the staff do not freely speak up and report these kinds of issues, this indicates to a low FSC maturity stage 1. Furthermore, this is an example of how low FSC maturity could directly increase food safety risk, especially as the floor where the product fell was positive for *E. coli* (count).

Observations: Worker no 6 directly revealed the different surfaces he touched at the LH zone 2 and also the HH zone and did not see any issue with this. He had been working for the company for 9 months and had hygiene training in the beginning. Despite the training he was unaware of the food safety risk his behavior might induce. As he was a new worker, this also demonstrates his learning history of the surrounding norms.

FSC insight: The low risk awareness indicated to a FSC maturity under stage 3 in the Risks and hazards dimension. Again, this demonstrates how norms of low maturity FSC might increase food safety risk, as new workers adapt to the existing norms, which in this case contribute to cross-contamination.

Observations: Upon wanting to swab the rework grate, the QMA said that rework will be cooked anyway. However, they missed the nuance that frontline staff were carrying and stacking these, increasing the probability of contaminating their hands, clothes and in return their surrounding surfaces and products.

FSC insight: As the company had missed this risk, there is a lack of understanding and awareness of risk, indicating to a FSC maturity below stage 3.

4.5.6.5. Halal Food Management

Stemming from the type of product (raw meat) that is handled in LH zone 1, there is a higher probability that the *E. coli* found on the floor might be of fecal origin. Thus, a product falling on the ground and contaminating the ready product with *E. coli* would impact Halal food assurance two-fold, by increasing the risk of the product becoming a health hazard and contaminating the product with unwanted substances.

4.5.7. Companies' Microbiological Sampling Plans

The results of the small survey conducted with the accompanying responsible staff on the shop floor regarding their companies' process environment microbiological evaluation is presented in Table 4.37. While companies C2, C3 and C5 had their own microbiological laboratories, C1 and C4 send samples to an external one. To decide sampling locations, all companies use the zoning approach based on the distance to the final product and within these zones also considered surfaces workers might touch. However, no one considered behavior and the concept of zone transfer of microorganisms.

Table 4.37: Results on companies' approach to production environment monitoring,

	C1	C2	C3	C4	C5
How analyses are conducted	No, sends samples to an external laboratory	Micro. lab.	Micro. lab.	No, sends samples to an external laboratory	Micro. lab.
Sampling approach	Z1-4	Z1-4	Z1-4	Z1-4	Z1-4
Consider surfaces workers touch	Yes	Yes	Yes	Yes	Yes
Takes samples from workers hands	Yes	Yes	Yes	Yes	Yes
Consequences for presence of indicator organism/ pathogens on workers hands	Verbally warn	Verbally warn	Verbally warn	Verbally warn	Verbally warn and sample the same worker multiple times.

C1-5: participating company codes; Micro. Lab.: Microbiological laboratory; Z: zoning concept explained in section 4.5.2.
Source: Prepared by the researcher.

All companies took samples of workers' hands and held them directly accountable for any findings. However, the results of this study demonstrate that the contamination could just as well be from the surrounding surfaces or induced by working conditions, like lack of hand washing and drying facilities, and not necessarily due to intentionally ignoring hygiene protocols.

FSC insight: This indicates to companies using negative consequences and reacting to individual incidences, rather than investigating actual root causes, indicating to stage 1 FSC maturity at the People system dimension and stage 2 maturity at the Consistency dimension.

The results of this study demonstrate that risk is determined by an accumulation of conditions and behaviors. For instance, at C3, in addition to hands being contaminated before the HH zone, there was no hand-washing option before or at the HH zone. Surfaces at the HH zone were found, which might contaminate hands even further, in addition to a worker 'rinsing' his hands at a utensil sink, leaving residual moisture on the hands, increasing the probability of microorganism transfer from nearby surfaces and the resuscitation and growth of microorganisms on the hands. Thus, rather than focusing on specific workers or surfaces, companies should consider these multiple aspects regarding root causes behind microbiological findings.

4.5.8. Discussion and Conclusion

4.5.8.1. A New Approach to Shop Floor Environmental Monitoring

Under each company section, microbiological analysis results were presented both individually and together with observations. While microbiological analysis results separately gave insight into the existence of risk, together with observations, it was additionally possible to determine behaviors, which led to cross-contamination and working conditions, which together ultimately increased post-process contamination potential. This was reflected through the scenario analysis, which enabled to bring all the different drivers and their relationships together demonstrating this risk.

In this study, it was found that the companies' scenarios had different nuances leading to food safety risk. While C1, C3 and C4 scenarios were revolving around lack of proper hand washing facilities and practices, C1 additionally showed serious issues with hand drying, C4 with product contact surface contamination and C5 with violations of workers' movements between LH and HH zones. While it was not possible to conduct microbiological analysis at C2, the observations enabled to gain additional insights of company's practices, like having issues with cleaning in the production and hand washing due to broken hygiene barriers, which confirmed the reports of one of the focus groups.

High food safety risk *E. coli* contaminations were identified in C1, C4 and C5 and contaminations directly impacting products were demonstrated in C4 and C5. While at C5, this contamination was an observed incident (the product falling on the ground), at C4 this contamination was directly detected on food contact surfaces (Z1) and through observations could be tied to routine practices (regarding handling product crates), making the latter a higher risk case, compared to the former.

Observations enabled to understand companies' procedures and accordingly determine surfaces' zones (Z1-Z4). Although this kind of zoning is a common approach in developing environmental sampling plans (Bourdichon et al., 2021), determining the zones in conjunction with observations, led to the need to develop the zoning concept regarding workers, utensils and equipment being in contact with different surfaces enabling to better highlight their risk (elaborated in the section above on zoning).

These zones are based on companies' procedures and practices, however, in the end, as the results demonstrated, the actual risk is not related either to the zone being a LH or HH one, nor by the distance from the product (Z1-Z4), but behavior, which leads to transfer of microorganisms between them, and with that increasing the post-process contamination potential. While a sector guideline emphasizes the importance of focusing on both zones and microorganism transfer and entrance into the production regarding environmental monitoring in the production setting (3M & Cornell University, 2019), this study is the first to use this approach in a research setting, demonstrating the importance of combining zoning and behavior when developing an environmental sampling plan.

For instance, C4 placing product crates (Z1) on the pallet as their common practice, makes the pallet Zone 2.1, whereas a pallet in C3, used to store packaged raw materials, would be Z 3.1. Thus, based on the work procedures, these surfaces would have a different risk factor. However, C4 placing product crates (Z1) on the floor (Z3.2) out of habit or lack of pallets, would not make the floor Z2.1, but a behavior leading to cross-contamination, as it is not a suitable place for this kind of storing due to a myriad of risks. However, these behaviors increase the sampling priority of the Z3.2 floor as if it were a Z2.1 surface (Table 4.38). Furthermore, C4, not having proper cleaning practices in place for the pallets (Z2.1), where the Z1 crates were stored, as if it were a Z3 or Z4 surface, does not make it one, but again highlights a behavior leading to cross-contamination (Table 4.38).

Table 4.38: Food safety risk mapping through the zoning approach,

Surface	**Observations on behavior**	**Observations on working conditions**	**Expected zone**	**Sampling priority of …**	**Practices in place as if it were…**
Examples from C4					
Floor	Z1 crates were stored on this floor	Crate and pallet cleaning lacking.	Z3.2	Z2.1	-
Pallet	Z1 crates were stored on this pallet	Crate and pallet cleaning lacking.	Z2.1	-	Z3.2
Examples from C1					
Hygiene barrier metal bars	Hand drying lacking. Workers touching these with wet hands.	No other hurdle to decrease risk: hand washing/ disinfecting possibilities lacking.	Z4	Z2.1	-
Staircase railing	Hand drying lacking. Workers touching these with wet hands.	No other hurdle to decrease risk: hand washing/ disinfecting possibilities lacking.	Z4	Z2.1	-
Curtains	Hand drying lacking. Workers touching these with wet hands.	No other hurdle to decrease risk: hand washing/ disinfecting possibilities lacking.	Z4	Z2.1	-
Examples from C5					
Product rack	Workers moving between LH and HH zones and workers in the HH zone were in contact frequent with this surface.	Workers could move between LH and HH areas without washing/ disinfecting hands.	Z2.1	Heightened priority.	-
Pallet (LH zone)	HH worker touching	Workers could move between LH and HH areas without washing/ disinfecting hands.	Z4	Z2.1	-

'-': not relevant; C1-5: participating company codes; HH/LH: high and low hygiene zones explained in section 4.5.1.; Z: zoning concept explained in explained in section 4.5.1..

Source: Prepared by the researcher.

Another example could be brought from practices in C1. The hygiene barriers (Z4) for hand washing were at the border of the HH zone and were touched by workers exiting the toilet with wet hands (Z1/Z2) as they were pulling them back and passing without disinfecting their hands. Before entering production, the workers might further touch surfaces like the staircase railing (Z4) and curtains (Z4). Thus, the actual sampling priority of these surfaces would not be Z4, as would be according to its location, but Z2.1, as it is a surface with what workers are in contact before starting their work in production. The residual moisture on the hands not only increases microorganism transfer, but the risk of microorganism resuscitation and growth on those surfaces. The risk was increased even further, as the production area did not have a hand washing sink and disinfectant dispensers were empty, which could have been hurdles to decrease the contamination risk of the product, ingredients or production line (Table 4.38).

Another example includes movement between LH and HH zones, as was observed in C5. A worker touched pallets and packaging materials at the LH zone, which are Z4 regarding the HH zone, and then moved to the HH zone and touched product racks and screens, which are Z2.1 (Table 4.38). This would not only increase the priority of sampling the pallet as if it were a Z2.1 surface, but increase the sampling priority of the product rack, since it is a surface which was both compromised through behavior and a surface frequently touched by multiple workers. Like this, the LH zone becomes an extension of the HH zone and the behaviors and working conditions start determining the priority of the surfaces for sampling, no matter what the zone.

As lack of behavioral observations in the environmental monitoring program context might lead to companies missing crucial contamination vectors, the food production sector could use this approach, together with the new zone definitions suggested in this chapter, to both become more conscious of behavior as a risk factor and accordingly more accurately map their food safety risks on the shop floor, ultimately identifying the potential of products' post-process contamination.

This approach might be further supported by using enrichment conditions in addition to or instead of count conditions for sample microbiological analysis, as the discussion in Chapter 3 (section 3.2.3.) demonstrated that the currently widely used count conditions might lead to false negatives and with that missing food safety risks. The discussion in Chapter 3 further elaborated on microorganism resuscitation and growth as a food safety risk, which was also addressed in this study through a combination of observations and indicator organism enrichment. Observations enabled to identify conditions, like residual moisture, which might lead to the resuscitation and growth of microorganisms and with that the probability of the risk and the enrichment approach to confirm the existence of risk. For instance, in C1, an outsourced maintenance worker exited the toilet with wet hands and while analyses with count conditions were all negative, enrichment was positive for all four indicator microorganism groups. This makes the enrichment findings meaningful, as risk might eventually increase due to the residual moisture on wet hands.

Thus, the current study used and suggests a novel approach in combining observations, microbiological analysis, including indicator organism detection, in addition to using scenario analysis as a data analyzing approach in a food production environmental monitoring context and with that extending the literature on process environmental monitoring sampling approaches and priorities (Bourdichon et al., 2021).

4.5.8.2. Shop Floor Environmental Monitoring and Food Safety Culture

All these companies had certified food safety management systems, despite this, they had low FSC maturity (elaborated in Subchapter 4.3, section 4.3.6.) in addition to the serious food safety risk on the shop floor, demonstrated by this chapter.

That these zone transfers and working conditions, leading to the food safety risk, should not take place in the first place, does not change the fact that without effective intervention these food safety risks will remain as they are. For instance, in C1, the QM tried to change existing practices, doing this by reacting to incidents and using negative consequences, which indicates to a supply-push approach, which has low impact on behavior change, in contrast to a demand-pull approach (discussed in detail in Subchapter 4.2, section 4.2.1.). On the other hand, at C4, no action was observed, indicating to the existing practices being an accepted norm. In both cases, there was a lack of an effective approach in changing behavior, which would have mitigated risks, demonstrating the impact of a low FSC maturity.

While companies were already conducting a type of observation in their internal hygiene audit context, these had not been able to mitigate the risks identified in this chapter. This also demonstrates the impact of a low FSC maturity, as these internal observations were compliance based, with a pre-determined expectation of the shop-floor to comply with companies' procedures. If this was found not to be the case, the responsible staff had to deal with this as a non-conformity, with no further instructions on how to change behavior (discussed in Subchapter 4.3, section 4.3.3.), leaving the situation in the hands of individual solutions and common human biases to warn and train more (discussed in Subchapter 4.3, section 4.3.5.), again demonstrating the impact of low FSC maturity on food safety management systems.

Another example demonstrated the importance of FSC maturity in relation to food safety risk. In C5, a product dropped on the ground, the worker picked it up and placed it back on the line. The adjacent worker did not interfere. The nearby supervisor and QA staff were not informed. This indicated a low FSC maturity, in which case workers do not speak up and do not warn/guide other workers in case of a food safety risk. The floor to which the product fell, being contaminated with all indicator organisms, including *E. coli*, further demonstrates the high risk created by such a situation. Such norms, together with low effectiveness of behavior change initiatives at low FSC maturity companies (like described above), highlight the impact of FSC maturity on food safety risks at the shop floor level.

Thus, to mitigate these risks, companies should work on maturing their FSC. A possible start could be to use the environmental sampling approach applied in the current study for companies to become aware of behavior's impact on food safety risk and to guide them towards the 'study' step of the continuous improvement cycle emphasized in the FSC maturity model (Jespersen et al., 2019). Together with proper root cause analysis through self-reflection and use of behavioral science (elaborated on in Subchapter 4.2 and 4.3), companies could take a step towards maturity their FSC.

4.5.8.3. Shop Floor Environmental Monitoring and Halal Food Assurance

Finally, multiple incidences, like contamination of hands with *E. coli* after the toilet (discussed under C1) and contamination possibilities of products with *E. coli* at both the LH and HH zones (discussed under C4) and from the floor (discussed under C5), demonstrate the risk to Halal food assurance, not only from of food safety perspective of making this product hazardous to health, but also regarding fecal contamination, which is regarded Najis and should not be in contact with the product. The lack of proper hand washing facilities (discussed under C1, C3 and C4), lack of following hand washing and drying protocols (discussed under C1, C3, C4) and lack of hand washing (discussed under C5), in addition to the routes leading to post-processing contamination, additionally compromise Halal food assurance by increasing the risk of the product becoming a health hazard. These examples demonstrate how norms of low FSC maturity might increase the risks around Halal food assurance in the production setting. Thus, the Food Safety-Halal food assurance culture (FS-HFA culture) approach (discussed is Subchapter 4.4, section 4.4.6.) could be used by the companies to evaluate and improve food safety and Halal food assurance in conjunction, also at the shop floor level.

Thus, companies might consider observations when setting up their environmental monitoring plans not only to better identify post-process contamination routes to identify and decrease food safety risks, but also pin-point fecal contamination potential more accurately, like this gathering data on both food safety and Halal food assurance performance. This could also be combined with building awareness across and throughout the company of the relationship between Halal food assurance, food safety and hygiene, as discussed in detail in Subchapter 4.4 (section 4.4.7.).

Furthermore, as the values, beliefs and norms of low FSC maturity impact both consider observations and Halal food assurance at a shop floor level, Halal certification bodies (HCB) could focus on 'cultivating a culture of continuous improvement' by using the FS-HFA culture approach (discussed in detail in Subchapter 4.4, under section 4.4.6.), to also work toward mitigating the risks identified at the shop floor.

4.5.8.4. Strengths and Limitations

The enrichment and resuscitation protocols were based on plausible solutions indicated by the literature and thus are not validated methods, which could be the focus of future research.

As sampling locations were determined according to behavioral observations, sampling focus in companies was different. For instance, at C1, issues were seen with behaviors at the entrance to the production, while in C5 issues were identified at the production's HH zone. This is not to say that there are no issues are the entrance in C5, but due to limited time to observe and sample, behavior patterns evident at first sight were pursued for further investigation. Thus, the data on scenarios at each company is not exhaustive, but a sample of some of the issues.

While using observational data together with microbiological analysis enabled to more accurately interpret the obtained data, researcher bias might have been introduced, as the observations were conducted by one person. On the other hand, the researcher's experience and knowledge on food safety requirements and management might have decreased this bias to an extent, as important food safety issues might be less likely missed.

The results presented in this section will be further integrated with findings on FSC (Subchapters 4.2 and 4.3) and Halal food management (Subchapter 4.4) in Chapter 5.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

The overarching aim of this study was to evaluate food safety culture (FSC), Halal food assurance (HFA) and process hygiene in food production companies and explore how these concepts interrelated related with each other. Thus, this study presents novel findings in each of these research strands, in addition to novel insights into the interplay between these concepts. First, the literature review (Chapter 2) put forth research gaps in the three research strands, which enabled to set up the research framework (Figure 5.1), guiding the research accordingly.

While detailed results and discussions on research framework aspects were presented separately in subchapters 4.1-4.5 (Figure 5.1), this chapter brings these together, giving a general overview of how the aims set in the research framework were met, the main findings and accordingly offers recommendations.

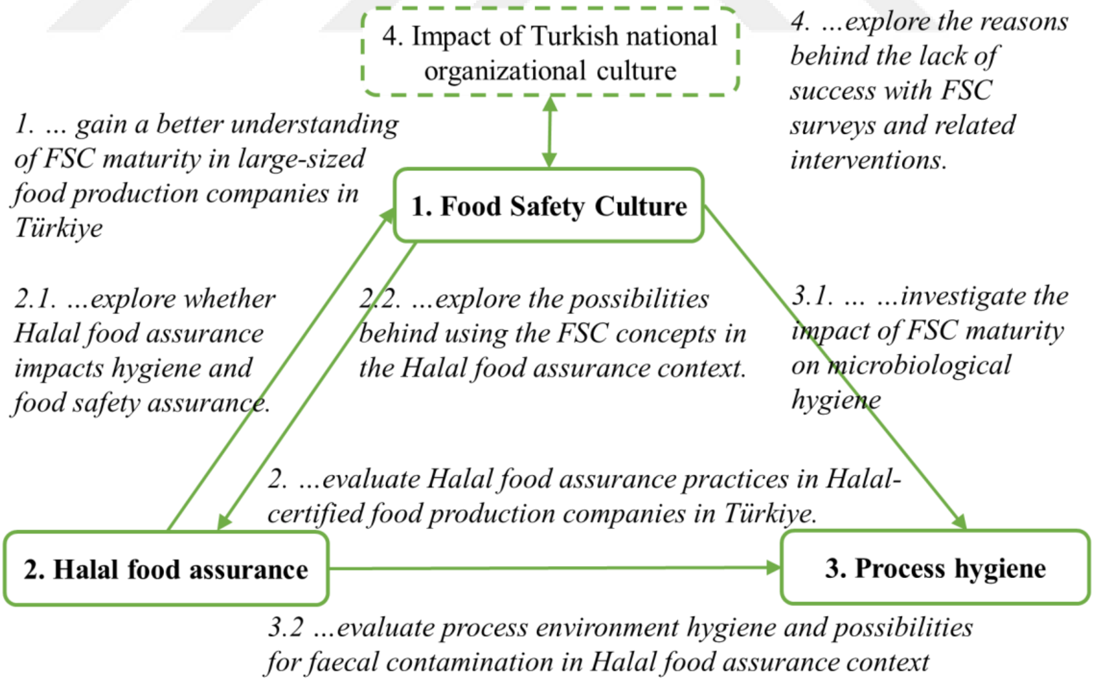


Figure 5.1: Research framework. Green dotted line – additional aim emerging from the research. FSC: food safety culture.

Source: Prepared by the researcher.

5.1. Food Safety Culture Related Research

Aspects 1, 3.1 and 4 from the research framework (Figure 5.1) address FSC maturity and will be elaborated further under this section.

5.1.1. Food Safety Culture Evaluation

This section specifically elaborates on point 1 of the research framework (Figure 5.1).

One of aims of this research was to gain a better understanding of food safety culture maturity in large-sized food production companies in Türkiye. For this purpose, a meta-synthesis (section 4.1) and empirical research (section 4.3) were conducted. The meta-synthesis was conducted using results from existing food safety and hygiene research conducted in food production companies in Türkiye to make conclusions on FSC dimensions and their maturity. The empirical research used a multiple case study mixed-methods approach to collect and analyze data across and throughout different positions in 5 large-sized food production companies to make conclusions on FSC dimensions and their maturity.

5.1.1.1. Food Safety Research in Türkiye

For the meta-synthesis, first a literature review was conducted (section 2.4.1), which revealed the following aspects regarding research conducted in this field,

- main methods used have been surveys and microbiological analysis, with minimum use of the mixed-methods approach.
- main research topics focused on have been hygiene, HACCP and CCPs.
- focus has been on using surveys in the dairy sector of the Aegean region and microbiological hygiene evaluations mainly in the dairy and meat sector of the Marmara region.

Accordingly, recommendations for researchers would be as follows:

- future research in Türkiye should consider the application of multiple methods in the field of food safety management, including qualitative semi-structured interviews, focus group discussions and observations, to commonly practiced methods.
- future research should consider extending food safety management research, including food safety culture related aspects, shifting to a management- and people/behaviour-orientated approach.

- as the existing studies might not give a deep enough insight on food sectors and regions, work is needed throughout Turkish food industries, like with
    - companies with different size,
    - companies from retail, food service and hospitality sector,
    - companies from different food production sectors, like fish, frozen food, food additives etc.

a) research could be conducted to include different regions in Türkiye, to evaluate the relationship between their demographical data and food safety practices

5.1.1.2. Meta-synthesis in Food Safety Culture Research Context

The meta-synthesis (section 4.1) led to grouping existing research findings under relevant FSC dimensions and based on this data infer FSC maturity stages (Figure 5.2). The meta-synthesis enabled to determine the baseline FSC maturity and validate empirical FSC findings. It also put forth research gaps in this research field in Türkiye. Subchapter 4.1 gives an overview of findings from existing research and research gaps and includes a thorough discussion on how these findings were related with FSC maturity.

The meta-synthesis and empirical FSC findings validated each other as there were no contrasting results, both indicating to a FSC maturity around stage 2, also called the 'reactive' stage. This in turn also to some extent addresses the limitation of the small number of participating companies in this multiple case study research (also discussed in section 4.3.8), that similar findings enable to make stronger theoretical generalizations.

Finally, the identified research gaps enabled to shape data collection methods (semi-structure interview and focus group guidelines and the type of performance documents collected from the participating companies), to focus data collection. For instance, existing research on hazard analysis and critical control points (HACCP) and critical control points (CCP) demonstrated instances where the quality assurance department (QA) was responsible for CCP monitoring, indicating work in functional silos (departments within a company working separately in contrast to cross-functional collaboration) and as such minimum distribution of food safety related expectations and responsibilities. Thus, this was also focused on during semi-structured interviews, by adding an additional question, and during performance document analysis, by asking for documents regarding the CCP monitoring.

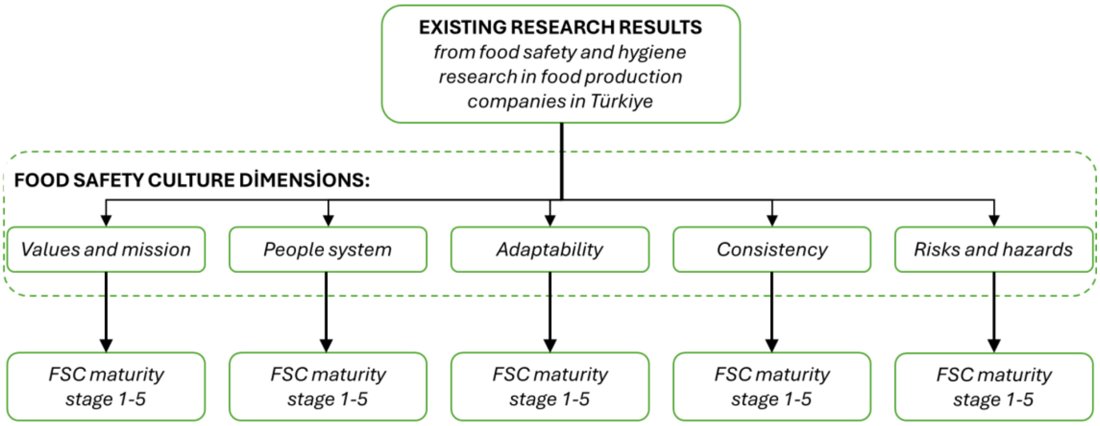


Figure 5.2: Meta-synthesis process in the FSC context. FSC: food safety culture.
Source: Prepared by the researcher

Recommendations for researchers would be as follows:

- Country-based meta-synthesis of food safety research could be used to support empirical FSC findings and put them into context regarding research gaps.
- Meta-synthesis of food safety research could be applied in country-based FSC research to shape data collection methodology.

5.1.1.3. Empirical Food Safety Culture Eesearch

Subchapter 4.3. gave a detailed overview of how conclusions on FSC maturity were reached regarding each FSC dimension for each participating company, offering a transparent data analysis, which could be easily followed and repeated. This subchapter not only enabled to address the existing research gaps in food safety research in Türkiye, but it also enabled to identify challenges and opportunities around improving food safety management practices.

In all companies the espoused beliefs and values, in other words how culture was depicted, reflect the fact that food safety is important. However, looking at cultural artifacts, or in other words the observable structures, processes and especially routine behaviors, which reflect the actual basic assumptions around values, norms and beliefs (both, the espoused beliefs and values and artifacts elaborated under section 2.3.1.), in general, stage 2, reactive, FSC was observed in all companies. In other words, according to the FSC maturity model (elaborated in subchapter 2.3. and Appendix 9), more work could be done to establish beliefs, values and norms, leading to better food safety assurance. Although companies demonstrated some differences regarding their beliefs, values and norms under each FSC dimension, hence the variations in the overall FSC scores (from 1.7 to 2.1) between companies (elaborated in detail in section 4.3.6.), there were overarching similarities regarding each dimension, characteristic to stage 2 FSC maturity, according to which the findings and recommendations for each FSC dimension are described below.

a) Values and mission dimension

The main findings around the Values and mission dimension were that (senior) management was involved when there were food safety related problems or allocating resources was necessary (section 4.3.1). Key performance indicators (KPIs) related to food safety were mainly set by the QA (sections 4.3.1 and 4.3.3). Although investments were made in the name of food safety, companies showed signs of at times having other priorities, like production targets, compromising cleaning practices (section 4.3.1.). There were discrepancies in norms between different departments (e.g. QA and production), around rewarding and recognizing, expectations from frontline and capability building practices (section 4.3.5.), demonstrating lack of direction setting.

<u>Recommendations for companies and guiding 3rd parties (e.g. consultants, auditors, inspectors)</u> could be as follows:

In the process of creating organizational change, Kotter, (2012) brought out establishing a sense of urgency as its first step (Kotter, 2012). Thus, to establish a sense of urgency around food safety among (senior) management, leaders could be made risk aware regarding food safety-related consequences (e.g. reputation and financial), which also overlaps with suggestions in the FSC toolkit by Alliance to Stop Foodborne Disease, (2023). This sense of urgency among the (senior) management could nudge them to get more involved, like

- set key performance indicators (KPIs) for food safety, which cascade throughout different positions of the company, getting other departments than the QA involved and with that involving different departments in the company, moving towards breaking functional silos, as such, also impacting the People system dimension;

- set food safety-related expectations and responsibilities across and throughout different positions in the company;
- set up and take part in specific messaging to set forth and strengthen company's values regarding food safety;
- start considering food safety in company decision-making (e.g. expansion, production planning and cleaning, order amounts)

b) People system dimension

Regarding the People system dimension (elaborated in section 4.3.5), in all participating companies the QA department was the main driver and the main body of governance behind food safety issues, as also discussed under the previous dimension. There was no deliberate effort to induce cross-functional collaboration regarding food safety. Food safety-related communication mainly took place when there are problems or issues to be solved. Food safety-related training was according to minimum standard requirements, namely orientation training to new employees and annual (refresher) training, mainly conducted by the QA. The focus was on negative consequences (e.g. warning, reporting to the boss) upon issues, with a lack of a reward and recognition program.

Recommendations for companies and guiding 3rd parties (e.g. consultants, auditors, inspectors) could be as follows:

- Companies should shift food safety responsibilities and focus from QA to different positions and levels throughout the company, creating an environment of collaboration, where individuals are encouraged and expected to speak up, communicate concerns, ask questions and propose solutions. To start establishing such an environment, after companies have gained management support (discussed under the previous dimension), companies could build a coalition of food safety champions, suggested by Kotter (2012) as a tool for organizational change by the FSC toolkit of Alliance to Stop Foodborne Disease, (2023).
- To further support this, companies could set up an incentives program to daily, weekly, monthly etc. reward and recognize desired behaviors.

- Companies could evaluate employees' training needs and accordingly set up job-specific food safety training and have Operations/Production department leaders set up a coaching program accordingly.
- Instead of the QA, companies could determine other staff with social sciences and organizational culture background to take charge of maturity food safety culture.

c) Consistency dimension

Regarding Consistency dimension (elaborated in section 4.3.3.), companies perceived continuous improvement to be through solving problems and complying with regulatory/standard changes. This was also reflected from companies not using performance data for continuous improvement. Companies had a 'control more, train more' approach within the root cause analysis context and were mainly using lagging (reactive) indicators within food safety management context (e.g. consumer complaints, hygiene audit results).

<u>Recommendations for companies and guiding 3rd parties (e.g. consultants, auditors, inspectors)</u> could be as follows:

- Companies should improve their understanding of both the continuous improvement and root cause analysis concepts and that these are ultimately closely tied together: proper self-reflection in root cause analysis on how 'we' as a company and the system 'we' have set up contributed to an issue in the first place enables to reach the actual root causes, which together with companies' support and being ready to change would enable to get the continuous improvement cycle going.
- For the above-mentioned self-reflection, comprehension of behavioral science (e.g. ABC model, Competency model, Pressure mapping, Lencioni's obstacles to employee engagement) is one of the key aspect in changing expectation towards existing solutions stemming from common behavioral tendencies, like 'train more, control more' and in enabling to shape companies' root cause analysis based on behavioral principles, paving the way towards more realistic expectations and more impactful and sustainable solutions (tangible example given below under Hazards and risk dimension regarding high employee turnover). Thus, companies should accordingly analyze people-related issues

and set up targeted soft-skill training. Regarding the latter, this also demonstrates, how this dimension is closely tied with the Adaptability dimension.

- Companies could use leading (proactive) indicators in addition to lagging (reactive) indicators, explore their relationships and work on leading indicators to achieve goals set through lagging indicators.
- Companies could collect and use food safety-related performance data for continuous improvement, which could also be collected through the above-mentioned leading indicators (e.g. Gemba walks, near-miss programs). This also demonstrated how this dimension is closely tied with the Hazards and Risks dimension.
- For continuous improvement, companies could set up systems for employees to get involved, that they could easily submit (possibly digitally) their recommendations (ABC model: antecedents for getting involved, according to the ABC model) and to which managers/leaders could quickly productively respond, by thanking (or any other way rewarding or recognizing), setting deadlines or giving reasoning behind not going for the recommendation, ensuring the employees feel that they are being heard (ABC model: consequences of the behavior of getting involved). Furthermore, companies could set performance measures for employee involvement rates and tie incentive programs with that.

d) Adaptability dimension

Regarding the Adaptability dimension (elaborated in section 4.3.2.), companies had difficulty with both comprehending what FSC is and what should be done about it, resulting in challenges adapting to FSC requirements currently demanded from them by the international food safety standards. They also had difficulty overcoming challenges, like high employee turnover, and had expectations of employees complying to changes without using change management strategies. There was a lack of a systematic approach to get frontline involved, like reporting and speaking up regarding food safety issues, which was also apparent from a lack of targeted soft-skill training for leaders to facilitate this.

Recommendations for regulators, standards agencies, education institutions and 3rd parties guiding/ evaluating companies (e.g. consultants, auditors, inspectors) could be as follows:

- Companies should improve their awareness regarding what is FSC. It is not enough to set the requirements for FSC and expect companies to properly comprehend and act on it. Different associations, societies and chambers could work towards providing support systems/materials, which are easily available and this also in the Turkish language, to establish a clear understanding of what is FSC and how do existing company values, beliefs and norms reflect this.
- There should be a **platform** where companies could come together and share best practices in both FSC and HFA.

Recommendations for education institutions could be as follows:

- FSC, including organizational culture, behavioral science principles, should be included in university curriculums in Türkiye, like Food Engineering, Food Technicians and various Veteriary programs, the graduates of which might take up positions in the food sector, as currently the food engineers manage the companies' quality assurance departments and are thus directly responsible for comprehending, evaluating and improving food safety culture in their companies.

Recommendations for companies and 3rd parties guiding/evaluating companies (e.g. consultants, auditors, inspectors) could be as follows:

- To both overcome challenges, like food safety risks related to high shop floor employee turnover, companies could use the Competency Model to determine employees' learning stages and accordingly, have employees at the more advanced stages support those in the earlier stages. A has been example has been given below, under the Hazards and risks dimension.
- Companies could use change management strategies, like the predetermined change curve (e.g. the Kübler-Ross change curve) and instead of applying a supply-push approach, work towards a demand-pull to influence people to want to change, in contrast to people having to change according to what others want (the latter elaborated in detail in 4.2.1).

- Companies should work towards values, beliefs and norms around getting the frontline involved, like reporting and speaking up regarding food safety issues (also discussed under People system dimension), as they are one of the key elements facilitating safe food production through their mindset and behavior, enabling to company to more easily adapt to changes and apply the continuous improvement cycle. As such, companies could work on company-wide awareness of the importance of frontline engagement and empowerment and accordingly behavioral science principles and targeted soft-skill training to facilitate this.

e) Risks and Hazards dimension

Details regarding evaluation related to the Hazards and risks dimension are specified under section 4.3.4. Companies were identified to take action to manage food safety-related risks in response to external influence, like 3rd party audits and standard and regulation changes. Multiple unmanaged people-related food safety risks were put forth, like working conditions, placement of employees at different workstations and high employee turnover. Finally, there were unmanaged risks regarding frontline's risk and hazard awareness, reflecting in discrepancies in managers' perception of frontline risk awareness, with some stating it is good, while others poor, coupled by lack of actually verifying frontline's risk and hazard awareness.

The high employee turnover should be separately elaborated, as all the companies brought this out as a challenge, however, at the same time they had not identified this as a possible food safety risk. Namely, according to the Competency Model (elaborated in 2.3.1.), there are four stages to learning and to transfer through these stages, in other words, to become proficient, consistent reminders and application of the knowledge or skill is necessary. Thus, new employees would be at the earlier stages of learning (unconsciously incompetent or consciously incompetent), as such a food safety risk, demanding more training focus. Companies, on the other hand, had in place orientation and/or annual hygiene and food safety training, expecting this to be enough for employees to adapt and behave according to their procedures, and using the 'train more, control more' approach, if this was not the case. This directly demonstrates how lack of awareness and application of behavioral science principles could lead to unidentified food safety risk, not determining root causes and inadequate strategies to deal with the consequences. As also mentioned under the Consistency dimension, comprehension of these kinds of behavioral science principles would lead to more realistic expectations and more impactful and sustainable solutions.

Accordingly, recommendations for companies and guiding 3rd parties (e.g. consultants, auditors, inspectors) could be as follows:

- Instead of relying on external influencers to shape their food safety management systems, companies could demonstrate their internal motivation by searching for data
    - internally within the company, for example by applying leading indicators (e.g. Gemba walks, near-miss programs), to challenge existing systems,
    - externally, by learning from sector experience (e.g. outbreaks, recalls) and incorporating these into the documented management systems.
- Increasing awareness of how people-related aspects could lead to food safety risks, like
    - placing experienced and trustable employees in the high-hygiene zone,
    - over-hours, fast line speed, lack of cleaning time, etc.,
    - high employee turnover (in other words high number of unconsciously incompetent or consciously incompetent employees on the shop floor), coupled by insufficient training programs.
- Verifying frontline risk and hazard awareness, for instance through evaluating confidence in addition to knowledge, using observations and setting up a near-miss program.

Recommendations for companies, governmental regulators, standards agencies, 3rd party auditors and governmental inspectors could be as follows,

- To have realistic expectations regarding training and its impact on employees' risk and hazard awareness, companies should increase awareness regarding learning-related behavioral science, for instance the Competency model and accordingly set up a learning program, as also suggested by in the FSC toolkit by Alliance to Stop Foodborne Disease, (2023).

Recommendations for governmental regulators could be as follows:

- In the end, all the other dimensions impact the Hazards and Risks dimension, reflecting in lack of challenging existing systems, leading to unidentified and unmitigated food safety risks as described above. Thus, to at least nudge companies toward better food safety practices, stemming from values, beliefs and norms, FSC should be included in the Turkish food codex as a legal requirement.

5.1.1.4. Companies' Food Safety Management Systems and Food Safety Culture

Another finding of this study was that the 3rd party food safety management systems' audits, which were conducted according to international GFSI-benchmarked food safety standards, and their high scores did not reflect a high food safety culture (elaborated in detail in section 4.3.7.). This could be expected, as stage 2, reactive, FSC culture maturity also demonstrates a compliance-oriented culture and standard compliance is also the focus in the food safety auditing context (World of Auditing, 2024), as such both having the same approach.

It was also found that high 3rd party audit scores might not even properly reflect food safety management performance, as multiple, especially people-related, food safety risks were uncovered in the participating companies through this study, as described above under Hazards and Risks dimension or in section 4.3.4. In both cases (a detailed discussion from the companies' perspective could be found above, under Hazards and risks dimension), this demonstrates a low awareness of the relationship between people factors and food safety risks.

Recommendations for 3rd parties guiding/evaluating companies, including auditors and governmental inspectors, could be as follows:

- Increase awareness regarding the relationship between people factors and food safety risks and incorporate this into an auditing approach '*cultivating a culture of continuous improvement*', as phrased by the World of Auditing, (2024), which could be used in addition to a compliance-based audit approach. This might not only help companies to better comprehend and take ownership of a continuous improvement approach, but to establish a sense of urgency, necessary to start organizational change (Kotter, 2012), as also discussed above, under the Values and mission dimension.

5.1.1.5. Food Safety Culture Maturity Model from the Competency Model Perspective

This study also interpreted the FSC maturity model's maturity stages from the Competency model perspective (section 2.3.2) to better interpret the collected data (the concept applied on data in subchapter 4.3). For instance, the unconsciously incompetent stage demonstrates the reactive FSC stage, which means that the companies were not at the consciously incompetent stage of learning. Their lack of learning lead to not challenging and not being able to properly identify and mitigate food safety risks (section 4.3.4. and also discussed above under Risks and Hazards dimension). This also overlaps with companies having a compliance-culture, as discussed above, and a reactive approach to continuous improvement. This also reflects from companies using ineffective behavior change techniques (e.g. negative consequences, like warning) and lack of proper root cause analysis, in other words using the same insufficient solutions and expecting a different result (e.g. training again, having the QA conduct more controls).

Recommendations for companies and 3rd parties guiding/evaluating companies, including auditors and governmental inspectors, could be as follows:

- In addition to the maturity model, the Competency model could be applied when evaluating at what stage of learning the company is regarding FSC maturity.

5.1.1.6. Novel Contributions

Through this study the following novel contributions were made to the field of FSC research:

- for the first time a country-based meta-synthesis of existing research findings was performed related to FSC maturity in the food production sector (Subchapter 4.1).
- the results of this research strand are novel, in that it is the first research conducted on FSC in food production companies in Türkiye (Subchapter 4.3).
- this study is also the first in this field in Türkiye to conduct a multiple case study using multiple methods in a mixed methods approach targeting various levels and functions of the companies (research gap elaborated in section 2.4.1.).

- this work also suggested and applied a novel approach using the Competence Model to interpret data collected on FSC regarding companies' maturity, thus also making a contribution to the field of FSC research. The theoretical concepts were discussed in Chapter 3, under section 3.3.2., while their use was demonstrated in Subchapter 4.3.
- this study used an in-depth analysis approach to FSC, combining the findings of different methods, instead of presenting each method's results separately, enabling to more accurately distinguish between individual and organizational learning, in addition to work in functional silos (demonstrated in subchapter 4.3).

5.1.2. Relationship Between Process Environment Hygiene and Food Safety Culture

This section specifically elaborates on point 3.1 of the research framework (Figure 5.1).

One of the aims of this research was to investigate the impact of food safety culture maturity and microbiological hygiene in the processing environment. For this purpose a new approach to process hygiene evaluation was developed, including scenario analysis, observations and indicator organism enrichment (elaborated in detail in sections 3.2.3 and 3.3.5), and applied in 4 food production companies.

5.1.2.1. A New Approach to Process Environment Hygiene Evaluation

The scenario analysis approach used in this study is based on drivers and their relationships with food safety risk, which allow to infer possible consequences, also called storylines, related to increased food safety risk and/or post-process contamination potential through issues with microbiological hygiene (Figure 5.3).

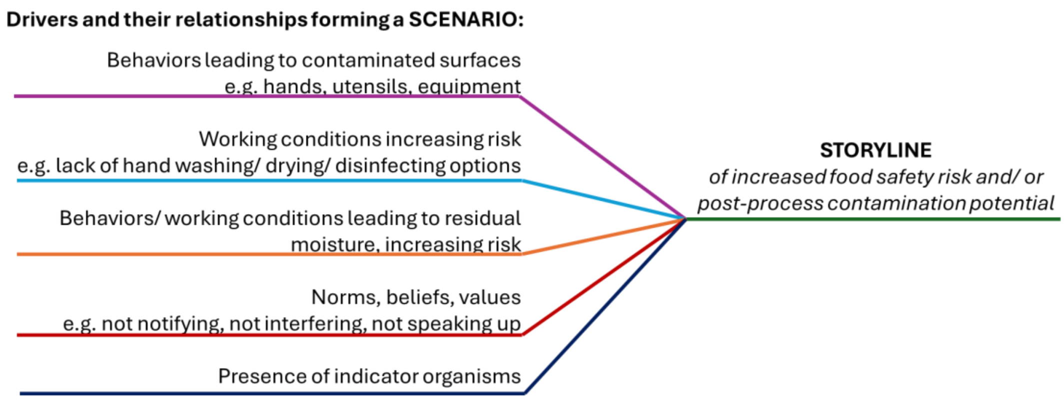


Figure 5.3: Scenario analysis overview in the food safety risk context.

Source: Prepared by the researcher.

The data on drivers was collected through observations and indicator organism analysis. Observations enabled to identify zones (high/ low hygiene; dry/wet; closeness to food-contact surfaces), existence of moisture, people´s behaviors and working conditions. For instance, while the existence of moisture was a driver, its relationship with microorganism resuscitation, growth and transfer was its link with food safety risk. Similarly, employees’ behaviors were connected with microorganism movement between different zones up to the open product and working conditions with increased food safety risk, like lack of hand washing/drying/disinfecting options. Finally, observations also enabled to more accurately interpret positive *E. coli* results. For instance, its presence right after using the toilet would indicate a high probability of the contamination being of fecal origin.

When observations were used to determine the zones in conjunction with behaviors, the need to develop the zoning concept further became apparent. Thus, additional zones were included related to workers, utensils and equipment being in contact with different surfaces (section 4.5.1), as this enabled to better highlight surface priority.

To properly identify food safety risk, in addition to count conditions, indicator organisms were analyzed using enrichment conditions, the protocols of which were set up based on existing literature (section 3.3.5). Analysis under the enrichment conditions enabled to better identify food safety risk by avoiding false negatives (section 3.2.3) and by taking into account that at the presence of residual moisture, microorganisms might eventually resuscitate and proliferate leading to a positive result even under the count conditions and with that increased food safety risk.

5.1.2.2. Results of Process Environment Hygiene Evaluation

Using the new approach, storylines demonstrating increased food safety risk (Subchapter 4.5) were identified in each company. In some of the companies direct post-process contamination of products was identified (sections 4.5.5 and 4.5.6). This is despite the fact that all these companies have documented and certified food safety management systems. This ties in with companies being at the compliance oriented reactive FSC maturity stage and being at the unconsciously incompetent stage from the Competency Model (elaborated in 2.3.3) perspective, as lack of learning regarding food safety is prevailing, leading to not challenging the existing system and not being able to identify and mitigate food safety risks, like demonstrated with the results. For instance, the two companies with the lowest FSC maturities of stage 1.7 in company 1 and stage 1.8 in company 4, had the biggest issues with working conditions and behaviors leading to increased food safety risk and post-process contamination potential (elaborated in detail in sections 4.5.2 and 4.5.5, respectfully).

In contrast to common sector guidelines and practices, the results showed that the actual risk and with that sampling priority, was not related to the zone being a low or a high hygiene one, nor to the zone being at a close distance to the product (Z1-Z4), but behavior, which leads to transfer of microorganisms between the zones and to the presence of residual moisture, a factor in microorganism resuscitation and growth, and with that increasing the post-process contamination potential. This behavior could be based on routine, like out of habit touching specific surfaces or based on an incident, like products falling on the ground and not speaking up about it. In either case these are non-conforming behaviors, which the company has either not connected with increased food safety risk or which they have tried to change using ineffective behavior change strategies (elaborated in section 4.5.8.), which could also be tied to companies having a low FSC maturity.

Interestingly, all companies already conducted observations of their own in the internal hygiene audit context, again demonstrating deficiencies in the existing systems to identify and mitigate food safety risks on the shop floor. While the observations conducted by the companies were focused on compliance to company procedures, the observations conducted within the framework of the scenario analysis focused on the future consequences of the existing practices, which might thus be a useful tool for the companies to switch from a compliance to a preventative mindset.

Furthermore, in all companies the QA conducted food safety-related orientation and/or annual refresher training. Despite this the food safety risks discussed above were identified, demonstrating the need for companies to develop their training plans, which was also suggested above under People system dimension.

In conclusion, it was found that through improper behavior leading to zone transfer of microorganisms, ineffective evaluation practices (compliance-based observations), training programs and solutions around behavior change and poor working condition regarding facilities, low FSC maturity impacted microbiological hygiene in a negative way, leading to increased food safety risk.

Recommendations for companies and 3rd parties guiding/evaluating companies, including auditors and governmental inspectors:

- The case study examples (elaborated in sections 4.5.2-4.5.6) could be used as training materials to increase employees' and managements' awareness regarding the impact of FSC maturity on microbiological food safety risks.
- In addition to the traditional Zoning approach to determine microbiological sampling priority when setting up environmental monitoring programs, behavioral observations focusing on microorganism zone transfers should be included in the system as well.
- The updated Zone definitions, including details on what workers, utensils and equipment are in contact with (presented in section 4.5.1), suggested by this study, could be used in conjunction with observations by companies to better determine sampling priority.
- Indicator enrichment could be a valuable addition to process environment monitoring programs to consider issues like false positives under count conditions and microorganism resuscitation and proliferation, enabling to more accurately identify food safety risks.
- Scenario analysis with the drivers and relationships presented in this study (section 3.3.5) could be used within companies' process environment monitoring or Gemba walks context, as a structured way to take into consideration multiple aspects and their relationships with food safety risk and accordingly possible consequences. This might in turn nudge companies

toward greater awareness and a sense of urgency, needed for organizational change (Kotter, 2012).

Recommendations for <u>researchers</u>

- The scenario analysis method together with observations and indicator enrichment could be used to explore,
  - how this approach could be used for maturing companies' FSC.
  - the use of this approach to determine pathogen sampling priorities by pin-point areas of high Zone transfer, together with working conditions increasing food safety risk.
- The indicator organism enrichment procedures suggested and applied in this study could be validated using microorganism confirmation analysis.

5.1.2.3. Novel Contributions

- a novel combination of observations, microbiological analysis and scenario analysis was used in process environment hygiene evaluation. Observations enabled to identify cross-contamination between sampling zones and working conditions, which led to the increase of food safety risks, indicator organism detection enabled to confirm the food safety risk and scenario analysis enabled to make connections between this collected data and highlight consequences regarding post-process contamination potential.
- novel empirical data on the relationship between FSC and microbiological hygiene was obtained.
- novel findings demonstrated that behavior needs to be included as well as zoning when developing an environmental sampling plan. Stemming from this, the zoning concept used for guiding sampling priority in process environment sampling was further developed by integrating behavior into the existing concepts.

5.1.3. Interpretations from the Turkish Organizational Culture Perspective

This section specifically elaborates on point 4 of the research framework (Figure 5.1).

During the research process, an additional aim emerged to explore the reasons behind the lack of success with FSC surveys and related interventions. Organizational culture aspects, national organization culture tendencies and behavioral models were used to construct a conceptual framework to explain the impact of national organizational culture on behaviors demonstrated by companies' representatives and on factors, which might have promoted or inhibited/limited participation and tendencies toward applying suggested interventions. It was found that the Turkish organizational culture aspects of hierarchical leading and relationship-based trust building, combined with low FSC maturity, might have been among inhibiting factors behind this.

The results demonstrated that as per relationship-based trust building and hierarchical leading tendencies, the quality manager (QM) would not be the most influential communicators for the survey, while direct leaders and people with good relationships among the teams would have been. However, as FSC evaluations showed in Subchapter 4.3 (section 4.3.5.), the quality assurance department was the driver behind food safety and quality issues in the companies (work in silos) and thus also took the lead in communicating the survey. The hierarchical leading tendencies might also be one of the contributing factors to siloed work, as accordingly QA was considered/considered themselves as the food safety expert, shaping companies' food safety responsibility expectations accordingly. This, in addition to hierarchical leading tendencies, would hinder giving input to or regarding upper positions and would have prevented the QM in involving the upper management in survey communications, which was one of the suggested interventions.

Thus, as the hierarchical leading tendencies might impact FSC maturity by having people and teams inclined to work in silos and hinder speaking up, it is important for the companies to work on their awareness of FSC and with that behavioral science, which could lead to them making decisions not according to their national organizational culture tendencies, but according to the most effective approach in influencing people and changing behavior. This led to the finding that FSC should be first matured to a given level in the Turkish organizational culture setting, overcoming common hierarchical and departmental barriers, before using company-wide evaluation methods, such as was the FSC evaluation survey. Like this, the current study builds on existing research by suggesting using multiple methods other than the company-wide survey, including studying national organizational culture, to gain an estimation of existing foundational FSC and the challenges that need to be overcome to build on this foundation. For this purpose, the conceptual framework could be used a learning tool for the companies and an analysis tool in the context of other national organizational cultures.

Recommendations for companies, researchers, 3rd parties guiding/evaluating companies:

- As a first attempt to evaluate FSC, companies and researchers in Türkiye should choose different FSC evaluation methods than company-wide surveys. Companies' food safety certification/inspection bodies should guide them accordingly.
- The conceptual framework (section 4.2.3), bringing together behavioral models and national organization culture, could be used as a learning tool by companies.
- Companies could leverage national organizational culture tendencies to create a demand-pull or in other words influence employees to get engaged with food safety. For instance, in the Turkish organizational culture context
    - due to hierarchical leading tendencies (elaborated in detail in Subchapter 4.2) involving (senior) management instead of the QA would render food safety-related communications more effective;
    - due to relationship-based trust building tendencies (elaborated in detail in Subchapter 4.2) workers with good relationships could be appointed as food safety champions at the shop floor or as members in the food safety coalition suggested above under the People system dimension.
- Applying behavioral science strategies, in addition to increasing awareness of organizational culture tendencies would enable companies to overcome both their natural tendencies of more training and warning (theoretical concept defined in Subchapter 4.2, under section 4.2.1, and discussed in the FSC context in Subchapter 4.3, under section 4.3.5) and national organizational culture tendencies (discussed in detail in Subchapter 4.2, under section 4.2.2) or in other words refrain from making decisions based on these and choose the best strategies to
    - effectively change behavior at the shop floor level, mitigating food safety risks (discussed in Subchapter 4.5, section 4.5.8),
    - work towards breaking silos and influence people towards greater involvement and/or engagement regarding food safety and related projects,

such as the FSC evaluation survey (Subchapter 4.2, section 4.2.2 and Subchapter 4.3, section 4.3.5),

- encouraging people to speak up (Subchapter 4.2, section 4.2.2),

and through this also moving toward maturing FSC.

Recommendations for researchers:

- The conceptual framework (section 4.2.3) including national organization and behavioral models, could be used as an analysis tool in the context of other national organizational cultures and companies FSCs.
- Researchers could have companies conduct a company-wide survey as an additional method to collect data on companies' FSC.

5.1.3.1. Novel Contributions

Through this study the following novel contributions were made to the field of FSC research, which were discussed in detail in Subchapter 4.2:

- a conceptual model was developed, bringing together organizational culture aspects, national organization culture tendencies and behavioral models, which was used to analyze possible foundational challenges and opportunities related to FSC, stemming from the Turkish national organizational culture, which could be used in future research in the context of other national organizational cultures' impact of FSC and as a learning tool for companies.
- a novel finding was that FSC should be matured in the Turkish organizational culture setting to a given level, before using evaluation methods, which encompass majority of companies' employees, such as the survey.

5.2. Halal Food Assurance Related Research

Points 2, 2.1, 2.2, and 3.2 from the research framework (Figure 5.1) address FSC maturity and will be elaborated further under this section.

5.2.1. Halal Food Management

This section specifically elaborates on point 2 of the research framework (Figure 5.1).

One of aims of this research was to evaluate Halal food assurance practices in Halal-certified food production companies in Türkiye. Halal food assurance practices were evaluated in 5 food production companies (C1-C5) and the internal HFA requirements in a multinational enterprise, coded as company 6 (C6). C6 had stringent requirements for HAS, which could also be called the ‘golden’ standard and was thus set as a benchmark to compare other participating companies with.

5.2.1.1. Halal Food Assurance Related Risk Mitigation from Incoming Materials and Suppliers

Companies 1-5 were guided by their Halal certification bodies (HCB) regarding what HCBs their suppliers should get Halal certification from, to how they analyze HFA-related risks stemming from raw materials and their awareness of high-risk ingredients regarding HFA, while C6 had set requirements for the accreditation of their suppliers’ HCBs, had a database of ingredients and related risks and procedures on what documents and data to obtain from the suppliers, which guided the hazard analysis. Interestingly, among C1-5 there were participants, who did not mention some materials sensitive regarding HFA, like enzymes, emulsifiers, vitamins, processing aids, maintenance oils, utensils like brushes, packaging materials, glycerin in cleaning chemicals. On the other hand, C2-C5 emphasized the importance of cleaning chemicals not including ethanol, reflecting the focus on some and lack of focus on other details. Even though HCBs might conduct a detailed analysis, these companies were not engaged as active members of the supply chain to mitigate Halal food related risks.

An aspect demonstrating C6 being an active member of the HFA supply chain, is their use of questionnaire/declaration, which they have each supplier fill in. With these they identified whether any high-risk products were produced on the same or adjacent line, whether the suppliers had fermentation processes or used/had ethanol, animal-source materials or glycerin in the context of both raw and packaging materials. This document was not only crucial for hazards analysis, but as a legally binding document, which was especially demanded to be signed by a person authorized by the company to act on its behalf, potentially increasing the awareness and a sense of accountability of the people in charge at the suppliers. They were the only company to not to only emphasize the importance of having a legally binding document, but had set clear requirements for suppliers to notify about changes, consequences in case of infringement of any of the requirement and a clause to practice the same due diligence towards their own suppliers.

Halal certification body (HCB) accreditation led to the improvement of Halal food management practices in the sector. While C2-C5 worked with recognized HCBs, C1 did not and had to change their HCB, as it did not get accredited, after which they had to start paying attention to some of the Halal food management details like demanding their suppliers to have a Halal certificate from accredited HCBs and conduct a hazard analysis. However, still a worrisome practice is the use of declarations from suppliers regarding their production being Halal, as this study has demonstrated that there are considerable differences in what companies perceive as a Halal food assurance related risk, which puts the risk mitigation impact of declarations under question.

There were noteworthy differences also in how companies 1-5 and C6 went about controlling their Halal certificates from their suppliers. While companies 1-5 focused on controlling everything before their HCB's audit, C6 warned against such practices, demanding their factories to set up a monitoring program for the purpose. Regarding what companies controlled in their Halal certificates differed among companies, with some of the best practices might be highlighted as follow,

- having the exact product name or code on the certificate;
- controlling the authenticity of the certificate;
- verify whether the address on the certificate matches with the address of the producer/ re-packer;
- during reception verify whether the address from where incoming materials come from match with the address on the certificate;
- verify whether the certificate is from the producer or the distributer.

5.2.1.2. Internal Halal Food Management Systems Practices

Regarding companies' internal Halal food management systems practices were varying, with C1-C5, in contrast to C6, not demanding the system to be documented (or is only partially documented through the existence of a guideline), not having Halal-related teams, meeting or audits and training meeting minimum standard requirements. Furthermore, C6 clearly distinguished the activities of reception, R&D and purchasing departments as CCP within the HFA scope and was the only one to elaborate on the importance of Logistics within this context, emphasizing aspect like controlling cleaning records of tankers, condensation formation in trucks and addresses and packaging to understand whether the goods are packed by manufacturers or agents and making sure products are not repacked after the producer. C1-C5 did mention R&D and purchasing as important for HFA, but did not distinguish their importance as clearly as C6. What is more, only C5 mentioned conducting Halal-related training specific to these departments, leaving under question the awareness of these departments in other companies.

Some of the best practices related to internal Halal management system set forth by C6 were as follows,

- Having requirements regarding communicating the Halal policy and team, like setting up visuals on notification boards.
- Having requirements for factories to consistently conduct meetings and audits regarding HFA, pre-determining topics and areas which should be covered. Meeting minutes and audit reports should be publish in the company's internal documentation system, enabling to control whether these activities have been conducted.
- Senior management and Halal team members should all get a thorough HFA-related training and in turn make sure that all relevant staff receive job-specific training.
- Training materials should be renewed annually and comprehension tests should be conducted.

Recommendations for <u>companies and 3rd parties</u> guiding/evaluating the company:

- HFA-related risks identified through the company with the 'golden' standard (C6) could be used to increase risks awareness and mitigate risks accordingly.
- In addition to the best practices mentioned above, companies could include HFA requirements in their foods safety-related supplier audits as a way to take ownership of the Halal food supply chain.
- More stringent requirements should be set for companies producing both certified and non-certified Halal products, regarding documenting, verifying and validating their segregation practices and training relevant staff properly (elaborated under section 4.4.6).
- In countries in which Halal food certification bodies are not required to be accredited, companies should consider working with recognized/accredited

certification bodies or accordingly establish a more stringent system to better mitigate Halal food assurance related risks.

Recommendations for researchers:

- Future research could continue from here with a roadmap of how companies or 3rd party certifiers could improve Halal food assurance practices in food production companies.
- Future research could also focus on working with companies of different size (e.g. micro, small and medium) and food sectors, including additives.

5.2.1.3. Novel Contributions

Through this study the following novel contributions were made to the field of Halal food assurance research, which were discussed in detail in Chapter 4.5:

- gaining insight into Halal food management practices in Türkiye.
- presenting the ‘golden’ standard practices in Halal food management.
- applying a novel research methodology approach in the HFA context using a mixed-methods and multiple case study approach.
- offering insight into the impact of HCB accreditation in Türkiye.
- comparing practices around the OIC/SMIIC 1:2019 and MS1500:2009 Halal food related standards.

5.2.2. Halal Food and Food Safety Assurance

This section specifically elaborates on points 2.1, 2.2 and 3.2 of the research frameworks (Figure 5.1).

5.2.2.1. Process Environment Hygiene and Fecal Contamination in Halal-Certified Companies

This section specifically elaborates on point 3.2 of the research frameworks (Figure 5.1), which aimed to evaluate process environment hygiene and possibilities for fecal contamination in Halal food assurance context and issues were found with both. The identified poor hygiene practices and working conditions (elaborated in Subchapter 4.5) increased the risk of both post-process and fecal contamination, like this impacting Halal food assurance, not only as this increases the possibility of harm coming to the consumer, but through the product being contaminated with unwanted substances.

5.2.2.2. Better Halal Food Management Through the Food Safety Culture Maturity Model

This section specifically elaborates on point 2.2 of the research frameworks (Figure 5.1), aiming to explore the possibilities behind using the food safety culture concepts (e.g. definition, dimensions, maturity stages and methodological approaches) in the Halal food assurance context. It was found that the FSC maturity model's approach could be used to describe HFA related culture, while at the same time being inseparable from FSC, as a more mature FSC would lead to better food safety management and a decreased food safety and fecal contamination risk at the shop floor level, and with that to a better HFA. Thus, a combined Food Safety-Halal food assurance culture (FS-HFA culture) approach was suggested, including defining and evaluating the concept. The following aspects were evaluated in the HFA culture context,

- demonstrating due diligence and taking preventative approach in risk identification, challenging and mitigation (Risks and hazards dimension),
- setting values, involving management and increasing their risk awareness (Values and mission dimension),
- decreasing functional silos and working towards collaboration and distributing responsibility (People system dimension),
- applying behavioral science concepts for successful change (Adaptability dimension),
- and setting up systems for consistency in change and continuous improvement (Consistency dimension).

Like the results around FSC maturity (Subchapter 4.3, section 4.3.6.), companies (C1-C5) were identified to have a reactive HFA-culture maturity at around stage 2. The company with the 'golden' standard (C6) had a HFA-culture related maturity at around stage 4 (Subchapter 4.4, section 4.4.6.). Another noteworthy finding was that C6 also included organizational culture aspects as a part of risk mitigation in Halal food assurance, which further justifies the need for a measurable and improvable FS-HFA culture concept.

5.2.2.3. Better Hygiene and Food Safety Practices Through Halal Food Management

This section specifically elaborates on points 2.1 of the research frameworks (Figure 5.1. This part of the research aimed to explore whether Halal food assurance impacts hygiene and food safety assurance and it was found that HCBs had given the perception of food safety and hygiene being a part of Halal food assurance to the responsible staff in the companies, however this was not translated into a company-wide belief, value or norm, like this, failing to leverage the Food Safety-Halal relationship for better FS and hygiene practices (elaborated in detail in section 4.4.7).

These findings are aligned with findings on FSC (Subchapter 4.3, section 4.3.5.) and HFA-culture (Subchapter 4.4, section 4.4.6.). Just like companies were working in silos regarding food safety, they were also doing so regarding Halal food assurance, in other words, the quality assurance department was the driver and the main governance body behind both. As discussed above (and in Subchapter 4.2, section 4.2.2.), these silos might be impacted by organizational culture tendencies, like hierarchical leading and relationship-based trust building tendencies, which could also be used together with FSC maturity model's dimensions to increase companies' awareness, which would enable companies to simultaneously work to mature their FS-HFA culture.

Recommendations for companies, researchers and 3rd parties guiding/evaluating the company:

- FS-HFA culture concept should be leveraged for improving Halal food assurance.
- The relationship between Halal food assurance, food safety and hygiene could be leveraged in behavior change strategies to induce better food safety management practices and mitigate post-process and fecal contamination risks at the shop floor.

Recommendations for 3rd parties guiding/evaluating the company

- In addition to promoting the connection between food safety, hygiene and Halal food assurance, HCBs should consider setting requirements for and evaluating companies' actions in making this a part of their organizational culture.

5.2.2.4. Novel Contributions

Through this study the following novel contributions were made to the field of Halal food assurance research, which were discussed in detail in Subchapter 4.4:

- gaining insight into process environment and microbiological hygiene and putting forth post-process and fecal contamination risks at the shop floor in Halal-certified food product companies.
- demonstrating the impact of Halal food assurance on food safety and hygiene practices.
- suggesting, defining and evaluating the Food Safety-Halal food assurance culture (FS-HFA culture) concept in Halal-certified food product companies.

5.3. Strengths and Limitations

While strengths and limitations are discussed separately under each of the Results and Discussion subchapters (4.2-4.5). Here, the limitation around making general conclusions based on the findings is emphasized. The low number of participating companies is a limitation, as it prevents making statistical generalization based on the findings. However, as the 5 participating companies (C1-C5) or cases, in the multiple case study approach, had similar results regarding FSC maturity, Halal food management, HFA-culture and process environment and microbiological hygiene, these simultaneously provide evidence of similar patterns of data, forming a strong basis for theoretical generalizations.

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APPENDICES

Appendix 1. Semi-structure interview guide to evaluate food safety culture maturity

Objectives

Identify and analyse aspects of company´s food safety culture.

Introduction

Thank for participation

Explain,

- the purpose and background to the research
- how/why they were selected as a participant

Give details on confidentiality and timing

Have the participant fill the written informed consent form

Ask permission to record

Remind the following:

- There are no right or wrong answers
- This is not a test of knowledge – only interested in opinions and experiences
- They are free to interrupt, ask for clarification, etc.

Warm-up

Let's get to know you a little. Could you tell me about yourself?

How many years have you been working in this company? At his position?

What has changed since you started working in this position? Have you contributed? How?

If it were up to you, what would you like to improve?

Values and mission (invest if we must or improve system?) / Risks and hazards (external pressure?) / Adaptability (approach to implementing and maintaining FSMS)

Has your company done anything regarding food safety culture? Why? Can you share the details? Your contribution?

Adaptability (problem solving, improvement and change management)

What are the difficulties in assuring food safety?

Consistency (leading and lagging indicators) / Values and Mission (company´s food safety direction)

Does your company in any way measure performance? KPIs? How do you reach these goals?

Does your company measure food safety performance? How do you use this data?

(Ask from general manager & food safety manager) **Values and mission ("invest if we must?") / Adaptability ("investing in problem solving or improvement?")**

Does the company have a food safety budget? Who is responsible?

Are food safety related expenses planned? How?

How are decisions made regarding food safety investments/expenditures?

(Ask from food safety manager) **People system – Engagement/Silos**

What are the roles of other departments in food safety? Purchase? Maintenance? R&D?

What is the role of senior management in food safety?

Is senior management aware of food safety hazards? How?

(Ask from general manager and other managers) People system – Engagement/Silos

Are you involved/contributing to food safety issues in any way? Example?

People system – Engagement/Silos

How do you think food safety responsibility should be divided?

Can you share your thoughts on whether the business allocates enough resources for food safety?

People system – communication

How are food safety issues communicated?

Can employees (blue collar) communicate improvement suggestions/problems? How?

Does the company do anything to help the frontline contribute (encouragement, training)?

People system (frontline responsibilities and authority)

What do you expect from employees (blue collar) regarding food safety?

Who has the responsibilities for monitoring CCPs?

Who can stop the production line in case of any food safety issue?

How can you be sure they have the capacity to fulfill these responsibilities?

Who do you think should have this authority?

How does the frontline know what is expected from them?

People system - consequence management (through general rewards/acknowledgement systems)

Do you do anything to ensure that employees comply with food safety rules? What?

Does your company do anything to motivate employees (BLUE? WHITE?)? How?

If there is a reward system, how do they reward it? How often? Who is involved? What awards are given?

People system - Does the company give any kind of feedback to workers?

Do employees receive feedback on what the company is doing regarding food safety?

Have you ever given your employees feedback on how they are doing their jobs? Can you give details?

Have you ever received any feedback on how you're doing your job? Can you give details?

Risks and hazards (training and education)

Can you share your thoughts on whether employees (both WHITE collars BLUE collars) understand food safety risks?

Is there anything the company pays particular attention to in its food safety training plan?

Have you received food safety training? Detail?

People system (capacity building)

Is there anything the company pays particular attention to in its training plan?

Have you received any educator training? How many hours?

Halal food management

Do you need to pay attention to anything regarding halal food?

Have you been involved in the halal certification process in any way?

Appendix 2. Focus group discussion guide to evaluate food safety culture maturity

Objectives

Identify and analyse aspects of company´s food safety culture.

Introduction

Thank for participation

Explain,

- the purpose and background to the research
- how/why they were selected as a participant

Give details on confidentiality and timing

Obtain consent for participation

Ask permission to record

Remind the following:

- There are no right or wrong answers
- This is not a test of knowledge – only interested in opinions and experiences
- They are free to interrupt, ask for clarification, etc.

Warm-up

Could you briefly introduce yourself? What are your responsibilities in the current position?

How many years have you been working in this company? In this position?

Do you have any previous experience in this food industry?

Engagement

Does food safety and hygiene play any role in your daily work?

(If relevant use additional probing questions on what and how)

Food safety hazards and training

What are the risks related to food safety and hygiene? / Are there any food safety and hygiene hazards in your department?

How do you know what are your responsibilities regarding food safety?

Do you and your team get any training? What kind?

(If not already covered by the previous questions) Do you and your team get any training on food safety and hygiene? When was the last time? Did you find it useful? Why or why not?

Can you share your thoughts on whether employees understand food safety and hygiene related hazards?

Communication

Have you made any suggestions for improvement or reported any problems? What? When?

What about your team? What? When? How often?

How do you forward your suggestions?

Have you gotten any feedback regarding your suggestions?

What would you like to improve if you could? Why?

Do you get any feedback on what the company does regarding food safety?

What are the consequences in case hygiene rules are not followed?

(Ask from managers:) Can you tell us a little about the issues you need to communicate between quality and your department?

Halal food management

Is there anything you should pay attention regarding Halal food production?

Appendix 3. Performance document topics' list to evaluate food safety culture and Halal food assurance

Microbiological hygiene

Microbiological sampling plans for 2022 and 2023 - surfaces

Microbiological analysis reports for 2022 and 2023

Reports of corrective actions taken due to the results of microbiological analysis

Halal food management

Halal inspection reports, Halal handbook

Halal-related action plans, project plans, reviews, meeting minutes

Planning, direction setting

Food safety culture action plan for 2022 and 2023

Project reports/plans regarding food safety and quality for 2022 and 2023

Document containing the mission and vision of the company for 2022 and 2023

Document containing food safety and quality policy for 2022 and 2023

Review

Management review meeting minutes for 2022 and 2023

Meeting minutes/reports where food safety is mentioned as a topic

Reports, plans, projects, instructions, procedures regarding rewards and recognition

Documents regarding the determination and evaluation of performance criteria regarding food safety

Studies on root cause analysis for 2023

Control

Internal audit reports and relevant corrective action reports for 2023

External audit reports and relevant corrective action reports for 2022 and 2023

HACCP/ Food safety team

Documents showing team members' titles, responsibilities, training, etc.

Documents related to their work such as action plans, project documents, reports, meeting minutes

HACCP plan containing details about CCPs and their monitoring

<u>Training</u>

Training program for 2022 and trainings held in 2022

Training program for 2023 and trainings held in 2023

Appendix 4. Food safety culture survey demographic questions

Please select the range that best represents your age

- 21 and under
- 22-33
- 34-44
- 45-54
- 55-65
- 66 and over
- Prefer not to answer

Please select the range that best represents your years of employment in the food industry

- One year or less
- 2-4
- 5-9
- 10-14
- 15-19
- 20 and above
- Prefer not to answer

Please select range that best represents your years of employment in the current company

- One year or less
- 2-4
- 5-9
- 10-14
- 15-19
- 20 and above
- Prefer not to answer

Please select the range that best represents your years of employment in current role

- One year or less
- 2-4
- 5-9

- 10-14
- 15-19
- 20 and above
- Prefer not to answer

Please specify your nationality at birth.

- Turkish
- Other (Please specify)

Please specify your current nationality (if different)?

- Turkish
- Other (Please specify)

Please select the option that best represents your current education

- Primary school
- Middle school
- High school
- Bachelor’s degree
- Masters’s degree
- PhD degree
- Prefer not to answer

Does the company have a Halal certificate?

- Yes
- No
- Do not know
- Do not care
- Prefer not to answer

In your opinion, does the company produce Halal food products?

- Yes
- No
- Do not know

- Do not care
- Prefer not to answer

Appendix 5. Food safety culture survey social desirability statements in English and Turkish

English **Source:** Jespersen et al., 2017	**Turkish** **Source:** Prepared by the researcher
Self-deception - Assertion of positives (SD1)	
My behaviour is consistent with my beliefs about food safety issues.	Davranışlarım, gıda güvenliği ve kalite konularındaki inançlarımla tutarlıdır.
I know what actions I should take regarding how best to protect food safety.	Gıda güvenliğini ve kaliteyi en iyi şekilde korumak için ne yapmam gerektiğini biliyorum.
I am always honest with myself about how I really feel about food safety.	Gıda güvenliği ve kalite hakkında gerçekten ne hissettiğim konusunda kendime her zaman dürüstüm.
I do not regret my decisions about food safety issues.	Gıda güvenliği ve kalite konularındaki kararlarımdan pişmanlık duymam.
I have very definite views about what government policy should be regarding food safety.	Gıda güvenliği ve kaliteyle ilgili hükümet politikasının ne olması gerektiği hakkında çok katı görüşlerim var.
I do not know the reasons why I feel the way I do about food safety.	Gıda güvenliği ve kalite hakkında bu şekilde hissetmemin sebeplerini bilmiyorum.
I appreciate other people's opinions regarding food safety.	Diğer çalışanların gıda güvenliği ve kalitesine ilişkin görüşlerine saygı duyarım.
I try to understand other people's views about food safety, particularly when they differ from my own.	Diğer insanların gıda güvenliği ve kalite hakkındaki görüşlerini, özellikle benimkinden farklı olduklarında, anlamaya çalışırım.
I am not concerned about food safety issues.	Gıda güvenliğine dair bir endişem yok.
Image management (IM)	
I never say bad things about people who disagree with my views about food safety.	Gıda güvenliği ve kalite konusundaki görüşlerime aynı fikirde olmayanlara asla tepki göstermem.
I never say anything to hurt the feelings of someone who disagrees with me about a food safety issue.	Gıda güvenliği ve kalite konusunda benimle aynı fikirde olmayan birini incitecek bir söylemde asla bulunmam.
I never get upset when people express opinions about food safety which differ from my own.	İnsanlar gıda güvenliği ve kalite hakkında benimkinden farklı görüşler dile getirdiğinde kendimi asla kötü hissetmem
I am not interested in trying to influence people's thinking about food safety.	İnsanların gıda güvenliği ve kalite hakkındaki düşüncelerini etkilemeye çalışmakla ilgilenmem.
I will not disagree about food safety issues with new people I meet.	Yeni tanıştığım çalışanlarla gıda güvenliği ve kalite konularında fikir ayrılığına düşmem.

Self-deception - Denial of negatives (SD2)	
I try to cover up mistakes I make in conversations about food safety issues.	Gıda güvenliği ve kalite konularındaki sohbetlerde yaptığım hataları örtbas etmeye çalışırım.
I feel resentful when I don't get my own way in a discussion about food safety issues.	Gıda güvenliği ve kalite konuları hakkında bir tartışma istediğim şekilde sonuçlanmazsa rahatsız hissederim.
It bothers me if people dislike me because of my views about food safety.	Gıda güvenliği ve kalite hakkındaki görüşlerimden dolayı insanlar beni sevmezse, bu beni rahatsız eder.
I form opinions about food safety issues without always thinking about the issues thoroughly.	Gıda güvenliği ve kalite konuları hakkında her zaman etraflıca düşünmeden görüş oluştururum.

Appendix 6. Semi-structured interview and document review guide to evaluate Halal food assurance

Objectives

Understand company´s history with Halal production and how they got their certificate.
Explore Halal assurance management in companies and understand whether Halal certification affects companies´ food safety practices.

SECTION 1 - Introduction

Thank for participation
Explain,

- the purpose and background to the research
- how/why they were selected as a participant

Give details on confidentiality and timing
Have the participant fill the written informed consent form
Ask permission to record
Remind the following:

- There are no right or wrong answers
- This is not a test of knowledge – only interested in opinions and experiences
- They are free to interrupt, ask for clarification, etc.

SECTION 2 - Background of the Halal certification process

What is the scope of the company´s Halal certification? Are all the products included?
What certification body (CB) do you use?
When was their last audit? When is the next expected audit?
Why did your company choose this CB?
Has the CB shared with any files with the requirements you need to implement regarding Halal?
Could you describe the certification process?
Did the HCB send an audit report? (Ask to see relevant documents)
What were the corrective actions? What was done about them? Does the company have any documentation on this? (Ask to see relevant documents)

SECTION 3 - Narrative part to let the interviewee describe their Halal management

Could you describe your routine procedures regarding Halal in your company? (alternative question) What does your company do to ensure the products are Halal?

SECTION 4 – Supplier management

4.1 Suppliers´ certification bodies

Does your company set any demands for the suppliers to use a particular CB?

If yes, continue probing:

- Why do you prefer these? Is there a written list of these CB?
- Should the CBs be accredited? Is there a written list of accreditation bodies?
- Does the company update these lists? Who does that? How? How often?
- Does your company take into consideration that HCB might be delisted by accreditation bodies?

(Probe in case of any activity) Who are responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

4.2 Approved suppliers

Does the company have an approved supplier list? (Ask to see relevant documents)

- If yes, what data does it include? Why?
- Who is responsible for updating the document? How often is this done?

What does your company do in case there is a shortage in a raw material?

Probing options:

- Is there a list of alternative suppliers with Halal certification?
- Do high risk (regarding Halal) raw materials/suppliers have alternatives?

(Probe in case of any activity) Who are responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

4.3 First time supplier approval

Could you explain what do you do when approving a supplier for the first time?

How does your company make sure that suppliers´ products are Halal?

Probing options:

- Does your company demand any documents from the suppliers? Halal certificates? Their Halal audit reports? Declarations? Related lab analysis, like DNA, GMO and ethanol? (Ask to see relevant documents)
- Is Halal mentioned in supplier contracts? Raw material specifications? (Ask to see relevant documents)

(Probe in case of any activity) Who are responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

4.4 Suppliers´ certification scope

Does the company demand that all the supplier´s products would be within the Halal certification scope?

If not, does the company have systems in place to understand the risk of contamination at the suppliers (supplier audit, questionnaire, categorizing suppliers by risk)?

(Probe in case of any activity) Who are responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

4.4 Changes at the supplier end

Does the company have any measures in place to make sure whether suppliers have made any changes to their production (regarding production lines, adding new products, temporary changes)?

If yes, about what kind of changes does the supplier have to notify the company?

Probing options:

- Do the suppliers let your company know about all changes or just what they think might affect Halal?

- Does the company have any clauses in a legally binding document (contract, specification, pre-assessment document, supplier declaration) that the supplier must let the customer know of any changes?

(Probe in case of any activity) Who are responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

4.5 Routine controls regarding supplier documents

Are the documents requested from suppliers routinely checked and updated?

If yes, how often? Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

Note: Probing questions on Halal certificate validity checks are specified under 5.3.

SECTION 5 – Raw material risks and Halal certificates

5.1 Raw material risk categorization

Do you in any way identify Halal related risks in raw materials?

If yes, how? Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

5.2 Halal certificates – incoming material certificates

For which received materials does the company demand Halal certificates? Raw materials? Packaging materials? Brushes? Maintenance oils? Processing aids?

What is the company´s approach to GMO?

(Probe in case of any activity) Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

5.3 Halal certificates - validity checks

Is there anything your company controls regarding the Halal certificates?

Some details to look out for and probe, if necessary:

- Whether the supplied product is within the certification scope?
- Expiry date?
- Address (since some companies might have many factories)?
- Check the code/QR code on the certificate?
- Whether the Halal certificates are genuine?

Does the company have any measures in place to find out when supplier Halal certification has been cancelled?

(Probe in case of any activity) Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

SECTION 6 – Material reception

Are any checks done upon raw material reception regarding Halal?

Some details to look out for and probe, if necessary:

- Whether the supplied product is within the certification scope? Address of the Halal certificate (since some companies might have many factories)?
- Halal certificate expiry date? Whether the Halal certificate is genuine?
- Check the integrity of packaging and possible cross-contamination?

Upon reception do you verify that the product received is Halal?

Some details to look out for and probe, if necessary:

- Do they check whether there is Halal labelling on the primary, secondary packages?

What is the <u>water source</u> that your company is using? If they are using their own pump, does the company in any way control the water?

Some details to look out for and probe, if necessary:

- Has the company considered a contamination risk in case it is too close to animal farms or chemical production?

Are there liquid raw materials brought in with <u>tankers</u>?

If yes, how are the tankers checked upon reception? Probing options:

- Does the company have any procedures in place to prevent contamination with non-Halal substances from the tanker?

(Probe in case of any activity) Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

SECTION 7 – Involvement of other departments

7.1 Purchasing

Does purchasing have any role regarding Halal food management?

(Probe in case of any activity) Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

7.2 Logistics

Does your company check how raw materials are

- stored before arriving to the company?
- transported before arriving to the company?

Does your company have any transportation or warehouse requirements for your products regarding Halal?

(Probe in case of any activity) Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

7.3 Product development

Is Halal considered in the product development procedures? If yes, how?

Are they allowed to work with materials, which are not Halal?

If yes, are there any procedures to prevent contamination?

(Probe in case of any activity) Who is responsible? Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

SECTION 8 – Contamination in the production

8.1 Production

Do the company pay attention to anything specific regarding Halal in the production?

Some details to look out for and probe, if necessary:

- Managing pests and waste?
- Are there any rules regarding labelling/ color-coding of Halal-related packaging?
- Hand hygiene? Especially fecal contamination?
- Awareness of contamination with blood, in case of a cut?

Are there any rules around what staff could bring into the factory?

Some details to look out for and probe, if necessary:

- Could workers bring their own food and drink? Where could they consume these?
- Is there any Halal policy that they should not bring non-Halal or doubtful substances?

(Probe in case of any activity) Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

8.2 Subcontractor rules

Does your company use subcontractors?

Are there any rules that the subcontractors should follow regarding Halal?

Some details to look out for and probe, if necessary:

- Cleaning staff should use proper chemicals. They should rinse properly, especially in case of ethanol use.

- Maintenance should use proper oils.

- Distribution should make sure there is not cross-contamination

- Is the company checking the catering company serving lunch?

(Probe in case of any activity) Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

8.3 Visitor rules

Are there any rules in place for visitors regarding Halal?

Some details to look out for and probe, if necessary:

- For outsourced maintenance or technical service who come with their maintenance oils?

(Probe in case of any activity) Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

SECTION 9 – Other aspects

9.1 Halal policy/handbook/procedures

Does the company have any general mission statements or policy regarding Halal?

Does the company have a Halal handbook? Any other documents mentioning Halal?

Ask to see relevant documents**.**

9.2 Halal Team

Does the company have a Halal expert or a team focusing on Halal issues?

Probing options

- What are their responsibilities?
- What is their experience with Halal?
- What is their training regarding Halal?
- How often do they receive refresher training?

(Probe in case of any activity) Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

9.3 System review

Are there any (routine) meetings regarding Halal?

Probing options

- When? How often? Who participates?
- What are the main topics discussed?
- Are they keeping records of those meetings?
- How are the topics followed up?

Is internal auditing conducted on Halal?

Probing options

- When? How often? By whom?
- What does the auditing check-list include?

(Probe in case of any activity) Are related procedures/work descriptions written down or mentioned in any document? If not, how do they know their responsibilities and what to do? (Ask to see relevant documents)

9.4 Training

Does the company conduct Halal-related training? (Ask to see relevant documents)

Probing options

- Who get the training? How often? Why?
- Is senior management included in the training? Purchasing? Reception? Product developers? Subcontractors? If not, are Halal topics discussed during any other training?
- Are new workers incorporated into the training program? How? Which working areas have the highest staff turnover? How critical are these regarding Halal management?
- Are seasonal workers incorporated into the training program? How?
- Are subcontractors incorporated into the training program? How?
- Does the company conduct refresher training? Why?
- Does the company have staff who so not speak Turkish? How are they trained?

SECTION 10 – Additional questions for non-dedicated facilities

Production separation

Is production of Halal certified products in any way separated from production without Halal certification? Verify, whether there is full physical separation.

If there is no complete physical separation, probe further,

- Has a risk analysis been conducted to assess the possibility of cross-contact between certified and non-certified production?

If yes, what aspects were considered (e.g., layout plan, time)? Are these in writing? (Ask to see relevant documents)

- Have any measures been taken to avoid cross-contact?

If yes, what are they? Are these in writing? (Ask to see relevant documents)

- Are there procedures in place to avoid mix ups with rework? Is rework properly inventoried and accounted for during storage and when used.

- Are high pressure washers or compressed air used to clean non-Halal certified production?

If same production lines are used, probe further,

- How often are Halal and non-Halal production switched?

- Does the company use any specific cleaning procedures in between? Are these validated? Are these in writing? Are there cleaning records (Ask to see relevant documents)

Raw material management

Is there a list of halal certified and non-certified items?

Are there raw materials, ingredients and processing aids of animal origin (note: indicates to higher risk) that are not Halal certified?

If yes, probe further

- Is there any in powder form? If yes, are there dust removal or hood systems?

- Is there a list of non-certified animal source materials used? (Ask to see relevant documents)

Are the same types of certified and non-certified raw materials, food additives and processing aids used?

Personnel related risks

Are frontline staff aware of cross-contact risks? How do you know? How often do they receive training on these topics? Are there written procedures? (Ask to see relevant documents)

Are new workers incorporated into the training program? How?

Which working areas have the highest staff turnover? How critical are these regarding Halal management?

Purchasing procedures

When changing suppliers for non-Halal certified ingredients, are any precautions taken to avoid introducing new non-Halal ingredients (especially animal-source) into production? Are there written procedures? (Ask to see relevant documents)

Appendix 7. Data collected on food safety culture presented according to companies

Data collected through semi-structures interviews, focus group discussions and document analysis were presented separately for each company, under food safety culture (FSC) dimensions. Under each dimension, the data was grouped according to the insights they offered. Namely, data from different methods, confirming each other or demonstrating discrepancies regarding a similar topic, were grouped together. This, in turn, enabled to compare the data collected within each company.

Appendix 7. is closely tied to appendix 8., as the data under each company (appendix 7) was combined dimension-wise (appendix 8). Namely, the data under the same dimension of each company were combined. For instance, data under Value and mission dimension gathered from each company were combined, enabling to compare and contrast companies' practices regarding this particular dimension. This was done for each dimension, in the end shaping into appendix 8.

The data in this appendix is not publicly available, due to confidentiality reasons stemming from the nondisclosure agreements (NDAs) signed with the companies.

Appendix 8. Data collected on food safety culture presented according to the dimensions

In appendix 8, data was combined dimension-wise. Namely, data under each company (presented in appendix 7) was gathered under food safety culture (FSC) dimensions, combining companies' similar and highlighting different practices. While appendix 7 enabled to compare and contrast data obtained though different methods under each company, appendix 8 enabled to compare and contrast data company-wise.

The data in this appendix is not publicly available, due to confidentiality reasons stemming from nondisclosure agreements (NDAs) signed with the companies.

Appendix 9. Food safety culture maturity model version 2

Source: Jespersen et al., 2019

Dimension	Value	Stage 1 Doubt	Stage 2 Reach	Stage 3 Know	Stage 4 Predict	Stage 5 Internalize
Values and Mission	*Integrity and trust*	Employees have little trust that management will act on food safety without external pressure	Employees trust that management will act and do the right thing for food safety after an issue have occurred	Everyone trusts that food safety issues are solved because we know it protects our business	Everybody is trusted to invest in food safety information to make future performance stronger	Frontline employees are trusted to act correct and celebrate food safety performance on their line/in their area
	Being responsible	Nobody knows who has the duty to deal with food safety	Everybody readily takes responsibility, but it is unclear what that means	Detailed food safety responsibility is written into job descriptions for everybody	Decision makers are certified food safety professionals and responsible for driving cost out of the food safety system	Frontline is responsible for bubbling improvement plans to leaders, leaders are responsible for incorporating these into long-term business planning
	Ethics	Moral principle … don't look	Moral principle … invest if we must	Moral principle … improve system	Moral principle … reduce cost by taking out variation	Moral principle … grow business
People system	*Reward and recognize*	Individuals complete food safety tasks out of fear for negative consequences	Individuals are recognized sporadically after having solved a food safety problem	Leaders recognize teams and individuals according to a documented system of positive and negative consequences	Leaders reward teams for collectively improving food safety processes/ procedures	Cross functional/level teams nominate other teams for being proactive and thinking strategic around food safety
	Competently communicating	Top-down 'tell' with little 'why' content and understanding of	Individuals are recognized sporadically after having solved a	There is a deep understanding of the food safety system and performance is	Frontline leaders are having regular communications on food safety	Food safety communication cadence is an organizational habit

		the importance of the task	food safety problem	communicated by some functional leaders on a regular basis	performance using data and tracking the teams' improvement actions	that involves everybody in specific team discussions
	Together we make the difference	Silos…	problem communication …	fragmented delivery of information …	Food safety and quality critical conversations …	habit …
Adaptability	*Innovate*	Scrambling to meet changed requirements	Aware of coming change but do not update procedures before last minute	Change is analyzed and incorporated into written food safety system including changes to competencies/job descriptions	Innovation is driven by data internally to reduce food safety costs	Innovation is suggested by frontline teams and bubbling up to impact companywide system. Quick to adapt as they have technology interface in their hands
	Embrace and drive change	Nothing is stable, so it does not matter if we must change … again	We know change is coming and will deal with it last minute …	We know the change and have analyzed the impact on individuals and teams according to a predefined change curve …	We look for cost reduction opportunities and plan these in our continuous improvement program …	Frontline teams have full autonomy to drive change in the food safety system, support teams are responsible for spreading new and best practices across the company …
Consistency	*Data and reporting*	Data are not used to solve problems and mostly sitting in a filing cabinet or in unused reports	It is left to the individual to identify needed data and ways to derive information from these	Leading indicators are used to find root causes of food safety problems and solutions are built into the food safety management system	Leading indicators are continuously updated through precisely and accurately collected data	Frontline teams and supervisors make use of leading indicators to improve food safety systems

	Technology enabled success	Little to no new value placed on buying or adopting technology	Technology is bought in reaction to a specific need e.g., faster pathogen testing results	Technology is seen in the context of the business system to integrate functions, procedures, and capabilities (e.g., Enterprise Resource Planning (ERP) specification system)	Automation is used frequently and seen as an integral part of reducing food safety cost	ERP is used in an integrated way with automated workflows that make the enterprise quick to adapt
	Quality of all we do	Unstructured problem solving to remove the immediate pain	‘plan, do, check, act’ with emphasis on control and expectation of 100% perfect solutions from the start	Structured, documented problem solving with high risk of analysis paralysis	‘plan, do, study, act’ with emphasis on study and an iterative approach to improvement	Identifying risks through horizon scanning and continuous improvement followed by mitigation plans built into the food safety system
Risks and hazards	*Risk perception*	The organization relies mostly on external sources and inspections to understand and act on its risks and doesn't identify risks internally	Actions to manage risks are mostly taken in response to external audits or inspections and internal identification is sometimes incorrect	Risks are understood and continually challenged by a cross functional team through planned risk management	Understanding and reducing risks are an integral part of the organization's continuous improvement efforts	The organization relies on frontline teams to manage existing risks and to identify new ones through peer observations

Appendix 10. Data collected from companies' shop floors and microbiological analysis results

In the following tables microbiological data is presented for C1, C3, C4 and C5. Only observation data was collected from C2. In each company, samples were taken from workers and surfaces at the processing environment, which are presented in separate tables. From the workers, samples were collected from hands and clothes. Depending on the extent of contamination of hands and clothes, the results were either presented in one table or separate tables for hands and clothes, to visually interpret the results more clearly. Additionally, these tables included details of the workers, observation results, where relevant, and the survey results, which were conducted with the workers before or after swabbing their hands (details in Chapter 3, section 2.3.3). In the tables with results on surfaces, the sampled areas were described together with their zones, with additional observation data where necessary.

Results were presented for the following indicator groups EB – *Enterobacteriaceae*, CF – Coliforms, ttCF – thermotolerant Coliforms and *E. coli*, analyzed using both count (C) and enrichment (E) conditions (elaborated in Chapter 3, section 3.3.5.). The following sign were used to describe the results: '+' – presence; '-' – absence; OG – plates had overgrowth with microorganisms turning the plates yellow (elaborated in Chapter 3, section 3.3.5) and thus no result was visible; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself.

Table 1: Company 1: hands/gloves and clothes,

No	Area	Details and/or observations	Work duration in company	Last time to wash/change	Surfaces touched after	Last hygiene training	EB		CF		ttCF		*E. coli*	
							C	E	C	E	C	E	C	E
1	glove	Production line worker (woman) packaging ready open products by hand.	3 months	1 hour	Product, production line	When started to work	-	-	-	-	-	-	-	-
	clothing			1 day			-	-	-	-	-	-	-	-
2	hands		3 months	15 min	Pallet jack,		-	-	-	-	-	-	-	-

	clothing	Storage worker (man), bringing raw materials from the storage through an elevator, which opens directly to the open product area.		2 days	elevator buttons, packaging materials	Did not understand the question	-	-	-	-	-	-	-	-
3	hands	Supervisor assistant (woman), leaning against the production line edge to speak with someone at the other side of the line.	6 months	25 min	Papers, pen, telephone, production line	2 months	-	-	-	-	-	-	-	-
	clothing			1 day			-	+	-	-	-	-	-	-
4	hands	Production line worker (man, foreigner), with spatula feeding a mixture in the production line dispenser.	3 months	20 min	Mixture, vessels, utensils	Did not understand the question	-	-	-	-	-	-	-	-
	clothing			1 day			-	+	-	-	-	-	-	-
5	glove	Production line worker (man, foreigner), feeding raw materials to the production line.	1 year	20 min	Raw material, vessels, utensils	Did not understand the question	-	+	-	-	-	-	-	-
	clothing			2 days			-	+	-	-	-	-	-	-
6	hands	Operator, after finishing production line maintenance. His hands were oily. After swabbing, was seen sliding his hand on the surface of the products on the line.	1.5 year	1 hour	Production line mechanics, maintenance utensils	2 months	-	+	-	+	-	+	-	-
	clothing			2 days			-	-	-	-	-	-	-	-
7	hands	Outsourced maintenance staff assembling a tunnel for the production line.	1 week	5 min	Hygiene barrier	No training	-	+	-	+	-	+	-	+

	Hands (wet) were swabbed after toilet. He did not use disinfectant and told the quality manager that it was ok that he had already been here for a week.				

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms.
Source: Prepared by the researcher.

Table 2: Company 1: surfaces,

Area	Details and/or observations	EB		CF		ttCF		*E. coli*	
		C	E	C	E	C	E	C	E
Entrance/exit (no 1) to the production / HH zone									
Hygiene barrier (no 1) metal bars	Z4. When exiting and entering production, workers were touching the metal bars. When entering they were pulling them back to pass.	-	-	-	-	-	-	-	-
Sink (no 1)	Z4. The part where workers' clothes touch the sink (front) was swabbed. This area was also wet.	OG	+	OG	+	OG	+	-	-
Trash bin by the entrance / exit curtains	Z4. Workers lift the trash bin cover by hand to throw away their gloves and then pass through the curtains to exit. Entering personnel touch the same curtains. There are no hand washing facilities in the production area. Disinfectant dispensers were observed to be empty.	-	+	-	+	-	+	-	-
Entrance/ exit curtains		-	+	-	+	-	+	-	-
Entrance/exit (no 2) to the production (toilet side) / HH zone									
Hygiene barrier (no 2) metal bars / Z4	Z4. When exiting and entering production, workers were touching the metal bars. When entering, they were pulling them back to pass and were doing so with wet hands after exiting the toilet. Hygiene barriers were either not properly working or their disinfectant dispensers were empty.	-	+	-	+	-	+	-	-
Sink (no 2) at the (women's) toilet /Z4	Z4. The part where workers' clothes touch the sink (front) was swabbed. This area was also wet.	OG	+	OG	+	+	+	+	+
Inside the production / HH zone									
Floor (no 1)	Z3.2. Elevator floor coming from the raw material storage, opening to the final unpackaged product area. Pallet jacks were used to transport raw materials with the elevator through the open product packaging area to the raw material mixing area.	OG	+	+	+	+	+	+	-
Floor (no 2)	Z3.2. The floor (wet) in front of the staircase going up to the raw material tanks.	OG	+	OG	+	+	+	+	+
Sink (no 3) for utensils at the raw	Z2.1 The part where workers' clothes touch the sink (front) was swabbed, together with the area where utensils are placed. The sink was wet. The	OG	+	OG	+	OG	+	-	+

material mixing area	sink was normally dedicated to utensils, but also used for handwashing. There was no soap, the disinfectant dispenser was empty and there were no hand drying options.				

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: High/Low hygiene zones, explained in section 4.5.1; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself; Z: Zoning concept, explained in section 4.5.1; OG: plates had yellow overgrowth and thus no result was visible.

Source: Prepared by the researcher.

Table 3: Company 3: hands/gloves and clothes,

No	Area	Details and/or observations	Work duration in company	Time to change hands/clothes	Surfaces touched after	Last hygiene training	EB		CF		ttCF		*E. coli*	
							C	E	C	E	C	E	C	E
HH area														
1	hand	Line worker (outsourced, male)	1 year	30 min	Mixer, telephone, pen	Less than 10 months ago	-	-	-	-	-	-	-	-
	clothing			2 days			-	-	-	-	-	-	-	-
2	hand	Technician. Happy to have himself swabbed	8 years	30 min	Shovel, brush, paper, bags	Less than 10 months ago	-	+	-	OG	-	-	-	-
	clothing			2 days			-	+	-	+	-	+	-	-
3	hand	Line worker at the main production, including CCP step	8 years	15 min	Mixer, pallet jack	Does not remember	-	-	-	-	-	-	-	-
	clothing			1 week			-	-	-	-	-	-	-	-
4	hand	Line worker (male). Disappeared before swabbing. Came back after cleaning his hands.	13 months	5 min	-	Does not remember. 'We join all together'	-	OG	-	OG	-	-	-	-
	clothing			2 days			-	+	-	+	-	OG	-	-
5	hand	Line worker (outsourced, male)	1 week	10 min	Scale, shovel, brush	1 month	-	-	-	-	-	-	-	-
	clothing			2 days			-	-	-	-	-	-	-	-
6	hand	Technician. Hands had residues on them. Had been helping out at the line with an issue.	3 years	1.5 h	Product, utensil, door	2-3 months	+	OG	+	OG	-	-	-	-
	clothing			2 days			-	-	-	-	-	-	-	-
LH area														

7	hand	Senior responsible line worker (woman)	14 years	15 min	Pallet jack, packages, knife	2 months	-	+	-	OG	-	+	-	-
	clothing			2 days			-	+	-	-	-	-	-	-
8	hand	Senior responsible line worker (woman)	8 years	10 min	Telephone, scale, printer	1 month	-	+	-	+	-	+	-	-
	clothing			2 days			-	+	-	+	-	+	-	-

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; CCP: Critical Control Point; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: High/Low hygiene zones, explained in section 4.5.1; OG: plates had yellow overgrowth and thus no result was visible.
Source: Prepared by the researcher.

Table 4: Company 3: surfaces,

Area	Details and/or observations	EB		CF		ttCF		*E. coli*	
		C	E	C	E	C	E	C	E
Before HH area									
Sink (no 2)	Z2.1. Sink at the entrance. The part where workers' clothes touch the sink (front) was swabbed.	+	ND*	+	ND	+	ND	-	-
Staircase railing (no 1)	Z4. Staircase after door 1 heading to the HH area. Swabbed the railing people usually come in contact with.	+	ND	+	ND	+	ND	-	-
Door (no 1)	Z4. Heavy door, which should be pushed open to forward towards the HH area.	+	ND	+	ND	-	ND	-	-
Password/ fingerprint device	Z4. After the staircase (no 1), workers have to identify themselves by a fingerprint or a password, for the automatic door leading to the HH area to open.	-	-	-	-	-	-	-	-
HH area									
Utensil (no 1)	Z2.1. The device to close vessel covers in which products are processed.	+	ND	+	ND	-	+	-	-
Pallet (no 1)	Z3.1. Red pallet at the production area. Weighed out raw materials were stored on it. Washed last week.	+	ND	+	ND	+	ND	-	-
Elevator floor	Z4. Elevator floor coming from the storage (LH zone) and opening to the HH zone. Dry cleaning was done last week.	+	ND	+	ND	+	ND	-	-
Pallet jack handle	Z2.1. Handles of 2 pallet jacks. These are dedicated for the HH zone and used by the workers.	-	+	-	+	-	+	-	-
Demijohn	Z2.1. The areas where people might touch or lean when taking water.	-	+	-	+	-	+	-	-
Pallet (no 2)	Z3.1. Black pallet. On the pallet was a carton and on it weighed out raw materials. The QA told this pallet should not be normally used at the HH area. She also did not know where the cartons on the pallet came from. The carton beside the raw materials was swabbed.	-	+	-	OG	-	-	-	-
Staircase railing (no 2)	Z2.1. Staircase railing, which was used to take samples of products.	-	OG	-	OG	+	OG		
Door (no 2)	Z2.1. (as this door is usually not touched by the production line workers, this should be Z2.2, however, the responsible staff were also seen in contact with the product, making this a Z2.1 surface). Office of the responsible staff, like technicians and QA.	-	OG	-	OG	-	OG		
Exit sensor	Z4. When workers want to exit the HH zone, they should show their hand to the sensor for the automatic door to open. Workers were observed to touch the sensor. The surrounding wall of the sensor was visually dirty.	-	-	-	-	-	-	-	-
HH area - washing room									

Curtain (no 1)	Z2.1. Washed last week. This week vessels were washed, meaning they were in contact with the curtains upon entering and exiting the washing room.	+	ND	+	ND	+	ND	-	-
Curtain (no 1), the part touching the ground	Z2.1. Bottom part of the curtain touching the ground. Equipment to mix products pass the curtains and might come in contact with its bottom part.	-	+	+	+	-	+	-	-
Drain	Z3.2. Long T-shaped drain was swabbed.	+	ND	+	ND	+	ND	+	-
Sink (no 4)	Z2.1. The part where workers' clothes touch the sink (front) was swabbed. Utensil washing sink. Sieves, which are CCPs are washed there. There was no surface where utensils could be placed, there were hangers on the walls for that purpose.	+	ND	+	ND	+	ND	-	-
LH area (packaged products)									
Sink (no 1)	Z4. Sink in the women dressing room. The part where workers' clothes touch the sink (front) was swabbed.	+	+	+	+	-	+	-	-
Sink (no 3)	Z2.1. Sink at utensil washing room. The part where workers' clothes touch the sink (front) was swabbed. There was no surface where utensils could be placed, there were hangers on the walls for that purpose, however utensils could get (re)contaminated through contact with the sink.	-	+	-	+	-	+	-	-
Crate handles	Z2.1 The crate was upside down, with one side leaning on the baseboard and the other on the floor. The crate was visually wet and swabbed from both handles. The responsible senior said they washed it with water and it was drying. Once a week it is disinfected. Products within secondary packaging are stored inside.	+	ND	+	ND	-	ND	-	ND

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: High/Low hygiene zones, explained in section 4.5.1; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself; Z: Zoning concept, explained in section 4.5.1; OG: plates had yellow overgrowth and thus no result was visible.

Source: Prepared by the researcher.

Table 5: Company 4: hands/gloves,

No	Area	Details and/or observations	Work duration in company	Last time to wash hands/ change gloves	Surfaces touched after	Last hygiene training	EB		CF		ttCF		*E. coli*	
							C	E	C	E	C	E	C	E
HH area														
1	Hand	Supervisor	4 years	5 min ago	Phone, walky talky, pen, crate	6 months	-	-	-	-	-	+	-	-
2	Special thick gloves	Line workers at the HH area. They wear gloves to pack products in crates. There are separate storage areas for the gloves of each worker.	5 months	That day	Line, crate, brush	At previous job	+	+	-	+	-	+	-	-
3			17 years	2 days ago		5-6 months	+	+	-	+	-	-	-	-
4			3.5 months	That day		4 month ago, before starting work	+	+	-	+	-	-	-	-
5			5 years	3 days ago		Last year	+	ND	+	ND	+	ND	-	-
6	Special thick gloves	Outsourced distribution staff	8 months	Changes daily	Pallet, crate, pallet jack, walky talky	No training	+	ND	+	ND	+	ND	+	ND
7	Hand		1 year	1.5h			+	+	+	+	-	-	-	-
8	Hand	Line worker at the LH area While swabbing no 8, others nearby started disinfecting their hands.	3 years	10 min	Utensils (Table 4.2 sopa)	At previous job	+	+	-	+	-	+	-	-

9	Hand	Line worker at the LH area. Swabbed after disinfecting hands.	2 years	-		Does not remember	-	-	-	-	-	+	-	-
10	Hand	Supervisor. Shift leader.	10 months	30 min	Computer, phone, pen	10 months	-	-	-	-	-	-	-	-

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: High/Low hygiene zones, explained in section 4.5.1; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself.
Source: Prepared by the researcher.

Table 6: Company 4: clothes,

No	Details and/or observations	Work duration in company	Last time to wash clothing	EB		CF		ttCF		*E. coli*	
				C	E	C	E	C	E	C	E
1	Supervisor	4 years	Daily	-	-	-	-	-	-	-	-
2	HH zone line workers	5 months	Daily	-	+	-	-	-	-	-	-
3		17 years	2 days	+	+	+	+	+	+	-	-
4		3.5 months	2 days	-	-	-	-	-	-	-	-
5		5 years	2 days	-	+	+	+	+	+	-	-
6	Outsourced distribution staff	8 months	Daily	-	OG	+	+	+	+	-	-
7		1 year	2 days	+	ND	+	ND	+	ND	-	-
8	LH zone line workers	3 years	Daily	-	-	-	-	-	-	-	-
9		2 years	Daily	-	+	-	+	-	+	-	-
10	Supervisor. Shift leader.	10 months	Daily	-	-	-	-	-	+	-	-

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: High/Low hygiene zones, explained in section 4.5.1; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself; OG: plates had yellow overgrowth and thus no result was visible.
Source: Prepared by the researcher.

Table 7: Company 4: surfaces,

Area	Details and/or observations	EB		CF		ttCF		*E. coli*	
		C	E	C	E	C	E	C	E
Entrance/exit to the production									
Door (no 1)	Z4. Entrance/exit door to the workers' resting area and toilet.	+	ND	+	ND	+	ND	-	-
Hygiene barrier's metal bars	Z4. The 3 metal bars of the hygiene barrier leading to the resting area and toilets. The supervisor said that workers have a habit of touching the metal bars when passing the hygiene barrier.	-	+	-	+	-	+	-	-
Staircase railing (no 1)	Z4. Staircase leading to the workers' dressing room and opening to both the LH and HH zones.	+	ND	+	ND	+	ND	-	-
Sink (no 1)	Z2.1 Sink at entrance. The part where workers' clothes touch the sink (front) was swabbed.	+	ND	+	ND	+	ND	-	-
HH area									
Metal transfer line	Z1. After the CCP step, product more to packaging through that spiral, which is closed to the outer environment. The QA suggested this sampling location	-	-	-	-	-	-	-	-
Production line band	Z1. After the metal spiral products move to the production line band, which transports the product in front of the workers for packaging. The QA said they do not wash or clean this surface, but change it when it is worn out. The QA suggested this sampling location	-	+	-	+	-	+	-	+
Pallet	Z2.1 Pallet where the product crates were put on.	+	+	+	+	+	+	-	+
Floor 1	Z3.2 Floor by the crates.	+	+	OG	+	OG	+	+	+
Crate	Z1. Product is packaged directly into these crates. Some crates were on the floor. Crates with open bread were placed on top of each other.	+	+	+	+	+	+	-	-
Curtains	Z2.1 Between the HH zone and distribution area. Crates pass these upon entering and exiting the HH zone..	+	ND	+	ND	+	ND	-	-
LH area									
Staircase railing (no2)	Z2.1.Staircase for the workers to move over the production line.	+	+	+	+	+	OG	-	-

Utensil (no 1)	Z2.1. A stick which is used to remove non-standard products from the line. The QA suggested this sampling location	-	+	-	+	-	+	-	-
Utensil (no 2)	Z2.1. Handles of 3 vessels. These are the main working equipment. The QA suggested this sampling location	+	+	+	+	-	+	-	+
Pallet jack	Z2.1. Handles of 2 pallet jacks. Used to transport raw materials from the storage to the production area. Used also in gluten-free production.	-	+	-	+	-	+	-	-
Door (no 2)	Z2.1. A door of a small room by the exit in which the workers use pressurized air on themselves to clean their clothes before exiting.	+	ND	+	ND	+	ND	-	-
Door (no 3)	Z2.1. A door of a machine. The QA suggested this sampling location.	-	+	-	+	-	+	-	-
Floor 2	Z3.2. Floor at the utensil washing room. The floor was wet and the area had a bad smell. The water pipes for washing were on the floor. There were also residues on the floor.	+	ND	+	ND	+	ND	-	-
Sink (no 2)	Z2.1 Sink at utensil washing room, meant for utensils. The sink looked dirty inside. The part where workers' clothes touch the sink (front) was swabbed. There was no surface where utensils could be placed. There is no data on how they dry the utensils.	+	ND	+	ND	+	ND	-	-

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: High/Low hygiene zones, explained in section 4.5.1; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself; Z: Zoning concept, explained in section 4.5.1; OG: plates had yellow overgrowth and thus no result was visible.

Source: Prepared by the researcher.

Table 8: Company 5: hands/gloves,

No	Area	Details and/or observations	Work duration in company	Last time to wash hands/ change gloves	Surfaces touched after	Last hygiene training	EB		CF		ttCF		*E. coli*	
							C	E	C	E	C	E	C	E
Supervisor at HH zone														
1	Hand	Was looking at the cell phone before swabbing	1 year	40 min	Cell phone	2 years	-	+	-	+	-	+	-	-
Line worker at HH zone														
3	Glove		2.5 years	1 hour	Product, production line	1 year ago, probably	+	+	-	ND	-	+	-	-
4	Glove	Happy to have herself swabbed	11 years	1 hour	Utensil no 1 (also swabbed), product	5 moths	-	-	-	ND	-	-	-	-
5	Glove		14 months	10 min	Product rack, production line	Could not remember	-	-	-	-	-	-	-	-
6	Glove	Walked from the LH zone 3 to HH zone	9 months	1.5 hour	Packaging, pallet, product rack	When starting to work	-	+	-	+	-	-	-	-

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; HH/LH zone: High/Low hygiene zones, explained in section 4.5.1; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself.

Source: Prepared by the researcher.

Table 9: Company 5: clothing,

No	Details and/or observations	Work duration in company	Last time to wash clothing	EB		CF		ttCF		*E. coli*	
				C	E	C	E	C	E	C	E
1	White clothing.	1 year	Daily	-	+	-	+	-	-	-	-
2	Did not wear mandatory protective clothing	5 years	Daily	-	+	-	+	-	-	-	-
3	Did not wear mandatory protective clothing	2.5 years	Daily	-	+	-	ND	-	-	-	-
4	Properly dressed	11 years	Daily	-	+	-	ND	-	ND	-	-
5	Wore protective clothing, but opened in front	1 year	Daily	-	-	-	-	-	-	-	-
6	Wore protective clothing, but opened in front	9 months	Daily	-	+	-	ND	-	+	-	-

+/-: presence or absence of the targeted microorganisms; C/D: indicator organisms analyzed under count/enrichment conditions; *E. coli*: indicator organism *Escherichia Coli*; EB: indicator organism *Enterobacteriaceae*; CF: indicator organism Coliforms; ttCF: indicator organism thermotolerant coliforms; ND - No data: analyses were either not conducted, as the count was already positive or there were issues with the analysis itself.

Source: Prepared by the researcher.

Table 10: Company 5: surfaces,

Area	Details and/or observations	EB		CF		ttCF		*E. coli*	
		C	E	C	E	C	E	C	E
Before HH zone									
Sink (no 1)	Z4. Sink in the women's dressing room. The part where workers' clothes touch the sink (front) was swabbed.	+	ND	+	ND	+	ND	-	-
Curtain	Z4. Curtain at the HH zone entrance/exit. It seemed visually clean.	-	-	-	-	-	-	-	-
At the HH zone: surfaces workers touch									
Door (no 1)	Z2.2. A door between the HH and LH 2 zones. Workers were pushing it open to pass from the LH zone 2 to HH zone.	+	+	+	+	+	+	-	-
Door (no 2)	Z2.1. Packaging material storage door, which is a separate room from where workers take packaging material for the line. There is no handle, so line operators push the door open.	+	+	+	+	+	+	-	-
Product rack handles	Z1 or Z2.1 (Z1/Z2.1). Handles and nearby surfaces, where workers were observed to hold, of the rack were swabbed. At the moment of swabbing, it was empty of products. It had been emptied of products and was ready to be transported out of the HH area.	+	+	+	+	+	+	-	-
Sink (no 2)	Z2.1. The only sink in the HH zone, besides the one at the entrance to HH zone. There was no disinfectant dispenser there, but there were at each production line.	+	+	+	+	+	+	-	-
Pallet (no 2)	Z3.1. At the HH area there was a pallet with a carton on it and on the carton there were packaging materials, which were meant to be in direct contact with the product. The carton was visually dusty. Adjacent pallet also had a carton and packaging material on it, but the packaging material was in a transparent plastic bag.	+	ND	+	ND	+	ND	-	-
Door (no 3)	Z2.2. Supervisor's room door.	-	+	-	+	-	+	-	-
Door (no 4)	Z2.1. Big heavy door leading to the cold room.	+	+	-	+	-	+	-	-

Water dispenser	Z2.1. Water dispenser buttons and surrounding surfaces workers might touch.	-	+	-	+	-	-	-	-
Utensil (no 1)	Z1. Shovel, used to take products off the production line to be packaged again. According to the workers, it was disinfected 1 hour ago.	-	+	-	+	-	-	-	-
Buttons (scale)	Z2.1. Buttons of scale, which workers were observed to be in contact with.	-	+	-	-	-	-	-	-
Screen with buttons	Z2.1. Touch screen, which workers were observed to be in contact with.	-	-	-	-	-	-	-	-
Door (no 5)	Z2.2. A metal cupboard door, from where supervisors took gloves to give to the worker. The cupboard had a lock on it.	-	-	-	-	-	-	-	-
At the HH zone: rework related									
Pallet (no 1)	Z3.1. Rework crates were on the pallet and the remining area of the pallet was swabbed.	+	+	-	+	-	+	-	-
Rework crate	Z2.1. Handles of empty rework crates were swabbed. This crate was in line to be used in the HH area.	+	ND	+	ND	+	ND	+	-
At the HH zone: floors									
Floor (no 1)	Z3.2. Wet floor beside the demijohn and refill water bottle.	+	ND	+	ND	+	ND	+	+
Floor (no 2)	Z3.2.Wet floor where a product (with a cover to be removed before packaging) fell and the worker picked it up and put it on the table where there were other such products. Adjacent line worker saw this and did nothing. QMA and microbiology responsible nearby and they were not informed	+	ND	+	ND	+	ND	+	-

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Source: Prepared by the researcher.

CV

Marin NEIO DEMIRCI

Languages:

Estonian, Native
English, TOELF iBT score 113/120
Turkish, Working knowledge, Level C1
Russian, Level B1

Competent in:

Microsoft Office and Outlook
IBS SPSS Software

W O R K   E X P E R I E N C E / A S S I G N M E N T S

2022 *January* **– 2015** *January* ***PhD researcher,*** *Food Engineering Department*, Istanbul Sabahattin Zaim University, Istanbul, Türkiye.

- In 2022 received a PhD merit scholarship from Ilim Yayma Foundation.
- Working with 7 medium/large and 9 micro food production companies in Türkiye to evaluate their food safety culture maturity and Halal food production management systems and to work towards their improvement.
- Lecturing and instructing laboratory sessions in English: Dairy Technology and Technology of Meat and Meat products.

2016 *September* **- 2021** *August****, Lecturer,*** *Food Engineering Department*, Istanbul Sabahattin Zaim University, Istanbul, Türkiye.

- Designing courses and lecturing in English: Food Analysis, Food Chemistry I & II, Introduction to Food Engineering, General Biology, Academic English.
- Designing courses and lecturing in both Turkish and English: Statistical analysis with SPSS, Occupational English, Basic Computer Skills (Microsoft Office and document formatting).
- Designing and instructing laboratory sessions in English: General Chemistry, Food Analysis, Instrumental Analysis.

2012 *January* **- 2013** *December*, ***Quality Specialist,*** AS Kalev (under Orkla Group), Tallinn, Estonia.

- Right at the start under the supervision of the Quality Manager I took lead in implementing the food safety management system in their subsidiary Maiasmokk OÜ according to Orkla Group´s internal food safety standard based on the BRC standard.
- Took lead of an auditing team and participated as a member in other auditing teams for weekly hygiene audits in different production departments.
- Monthly conducted food safety procedure and hygiene trainings.
- Reviewed food safety procedures and conducted HACCP system verification.

2011 *September - December*, ***Food Engineer, Erasmus Intern***, Çağla Gıda San.Tic. Ltd. (eng. Çağla Chocolate Company), Adapazari, Türkiye.

- Received an Erasmus scholarship. Took part in food safety audits and organized hygiene training. Initiated a project on improving waste management to decrease contamination risks.

2009 *September –* **2010** *December*, **2011** *June-August*, ***Researcher***, Centre of Food and Fermentation Technologies (TFTAK), Tallinn, Estonia.

- Took part in a project called "Molecular Effect of cheese microstructure on biochemical and microbial processes during ripening of cheese". The project required conducting cheese protein analysis with LC-MS/MS and aromatic compound analysis with Olfactometer, in addition to analyzing and reporting data.

2007 and **2008,** *May – September*, ***Quality Control***, Saku AS, Tallinn, Estonia.

- During high season, worked in the Quality Control Laboratory and conducted a wide range of analysis (brix, minerals, cloudiness, chemical residues, pH etc.) on a variety of beverages.

2006 *September –* **2008** *April*, ***Food Engineer,*** OÜ Kehra Bakery, Tallinn, Estonia

- Working in our family´s micro-sized baked goods factory, responsible for establishing food safety management system, including HACCP, documentation and developing new bakery products.
- Throughout the years, I have remained as their external specialist to do their product labelling, verify the HACCP system and other food safety management system documentation.

E D U C A T I O N

2020 *January –* **2025** *January*, ***PhD***, *Food Engineering Department*, Istanbul Sabahattin Zaim University, Istanbul, Türkiye.

PhD Thesis title: *Interaction between food safety culture, Halal food assurance and process hygiene in food production companies: a multiple case study in Türkiye*.

- evaluate food safety culture maturity in food production companies in Türkiye using the globally accepted GFSI approach and related science-based measurement tools.
- analyze the impact of Turkish national culture on food safety culture maturity.
- evaluate production environment microbiological hygiene and Halal food management practices in food production companies in Türkiye.

Supervisors: Prof. Dr. Carol A. Wallace, *University of Central Lancashire, UK* Prof Dr. Hasan Yetim, *İstanbul Sabahattin Zaim University, Türkiye*

2013 *February* **- 2016** *February, **MSc, Food Safety Management,*** University of Central Lancashire, UK.

- Peer-reviewed publication: **Neio Demirci, M**., Mei Soon, J. & Wallace, C. A., 2016. Positioning food safety in Halal assurance. Food Control, Volume 70, pp. 257-270.
- Graduated with DISTINCTION.

2009 *September* **- 2012** *June, **MSc, Food Technology and Product Development,*** Tallinn University of Technology, Estonia.

- Master´s Thesis title: *Quantitative Cheese Ripening Proteomic – mass balance equations of amino acids.*
- Weighted average grade: 4.0 / 5.0

2011 *January – June**, MSc, Erasmus Exchange Student,*** Food Engineering, Ege University, Türkiye.

2006 *September* **- 2009** *June,* **BSc**, ***Food Technology and Product Development,*** Tallinn University of Technology, Estonia.

- Weighted average grade: 4.5 / 5.0

T R A I N I N G

Communication, consulting and collaboration skills and interpersonal skills

2016-2017 Master Trainer, 320 hours of training, in addition to taking part in collaboration projects, making presentations, leading training sessions and organizing events in various organizations, like schools, universities, companies. Deneyimsel Tasarım Öğretisi Institute, Türkiye.

2015 Success Psychology, 2x48 hours of training, on fundamental principles regarding strategies for achieving goals and using these for personal growth and consulting. Deneyimsel Tasarım Öğretisi Institute, Türkiye.

2015 Mastery in Relationships, 2x48 hours of training, in addition to workshops on personality profiling, communication and learning styles, finding root-causes to relationship problems, conflicts and understanding internal vs. external motivation. Deneyimsel Tasarım Öğretisi Institute, Türkiye.

Professional skills

2016 Principles and practices of auditing (Türkiye, KOSGEB)

2016 Transition to ISO 9001:2015 (Türkiye, KOSGEB)

2015 ISO 22001 general principles (Türkiye, KOSGEB)

2013 The Main Principles of the Cleaning Operation Managers (Estonia)

2012 HACCP System Verification (Estonia)

2012 HACCP Principles (Estonia)

2012 "24 Hour Food Hygiene Training" by Tallinn University of Technology (Estonia)

SCIENTIFIC WORK

Research Grants

2022 and 2023 received two competitive Scientific Research Grants from Istanbul Sabahattin Zaim University to fund the PhD project part of food safety culture and microbiological hygiene.

Scientific Publications

1. Lee, C.-C., **Neio Demirci, M.,** 2023. Different types of fryers for the food industry. In: S. M. Jafari, ed. High-temperature Processing of Food Products, Unit Operations and Processing Equipment in the Food Industry. Cambridge: Woodhead Publishing, pp. 293-322.

2. Raheem SFU, **Neio Demirci M**. *Assuring Tayyib from a food safety perspective in Halal food sector: a conceptual framework*. MOJ Food Process Technol. 2018;6(2):171–180. DOI: 10.15406/mojfpt.2018.06.00161.

3. **Neio Demirci, M.**, Mei Soon, J. & Wallace, C. A., 2016. *Positioning food safety in Halal assurance*. Food Control, Volume 70, pp. 257-270.

Poster Presentations

1. **Neio Demirci**, M., Wallace, C. A., Lee, C.-C., Yetim, H. (2023, November 22). Trends in Scientific Publications on Food Safety Management in Türkiye. 20th Annual UK Association for Food Protection Conference, Cardiff, UK.

   - Poster presentation rewarded as Highly Commended.

2. **Neio Demirci, M.**, Wallace, C. A., Lee, C.-C., Yetim, H. (2023, May 3-5). Trends in Scientific Publications on Food Safety Management in Türkiye [Poster presentation]. IAFP European Symposium, Aberdeen, Scotland, UK.

3. **Neio Demirci, M.**, Wallace, C. A., Lee, C.-C., Yetim, H. (2022, November 3-4). Food Safety Culture in Türkiye: an Insight Through Systematic Review and Meta-synthesis [Poster presentation]. 7th International Food Safety Congress, Istanbul, Türkiye.

Oral Presentations

1. **Neio Demirci, M.,** Wallace, C. A., Lee, C.-C., Yetim, H. (2023, June 16-17). *A Case Study of Food Safety Culture in A Food Production Company in Türkiye* [Oral presentation]. IV. IZU Graduate Student Congress, İstanbul, Türkiye.

Other Projects

2016 acknowledged for the contributions in the risk assessment and technical writing in a project to evaluate the Halal status of enzymes used in food.

- Output of the project: Ermiş, E., 2017. Halal status of enzymes used in food industry. Trends in Food Science & Technology, Volume 64, pp. 69-73.

A D D I T I O N A L   I N F O R M A T I O N

2016-… A member of International Association of Food Protection.

2011 Received scholarship for Erasmus Intensive Language and Culture Program in Kocaeli University, Türkiye.

2003 Diploma in Fine Arts from Kehra School of Fine Arts.