

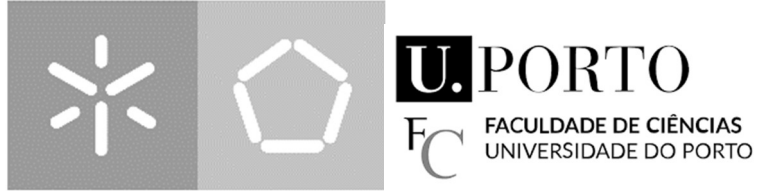


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Worldwide diffusion of Food Safety Management System Standards

Fevereiro de 2022



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Dissertação de Mestrado
Mestrado em Tecnologia e Ciência Alimentar

Trabalho efetuado sob a orientação do
Professor Doutor José Pedro Teixeira Domingues

Fevereiro de 2022

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ACKNOWLEDGEMENTS

First of all, I am very grateful for the presence of God and Our Lady in my life, for helping me to overcome obstacles, for all resources and for the special people around me who make this search a more flowery path.

I would like to thank all the professors at the University of Porto and the University of Minho who dedicate their lives to spread knowledge and to qualify professionals. I would like to offer my special thanks to my professor and advisor, Doctor Pedro Domingues. His support, guidance, and insights in this field have made an inspiring experience for me.

I also like to thank everyone involved in solving the research questions for this dissertation. Thank you, IFS, for providing important information, and all the professionals and companies who, with great dedication and patience, answered the questions that support the conclusions presented here.

I am not able to choose the best words to thank my family and special friends for their immeasurable support and love. Distance teaches us to value what matters. You are both home and heart for me. Love you all.

Last but not least, I hope these years of dedication contribute to better understanding both concepts and the necessity of standardization and quality. I also hope to help to spread the relevant role of Food Safety Management System Standards in progress in the world, which supports the sustainable development goals and the achievement of both food safety and security.

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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WORLDWIDE DIFFUSION OF FOOD SAFETY MANAGEMENT SYSTEM STANDARDS

Abstract

The overall goal of this dissertation was to present the current clear picture on how are the worldwide diffusion of FSSC 22000, ISO 22000 and IFS Food standards. Available information regarding the numbers of Food Safety Management System certifications were provided and the worldwide diffusion of the studied standards were analyzed encompassing the macroregions: Africa, Central and South America, Central and South Asia, East Asia and Pacific, Europe, North America and Middle East. In addition, forecasting models based on Gompertz model were developed to forecast the behavior of worldwide ISO 22000 certification for the next years. Aiming at clarifying the main motivations, benefits, and obstacles that currently impacts the expansion of the studied FSMS standards, empirical research was carried out. The current diffusion of FSMS may be considered unequal because of its wide dissemination among different countries and macroregions. Based on the relative basis *per capita*, Europe leads the spread of worldwide FSMS certification. The majority of defined macroregions is covered by two studied standards, FSSC 22000 and ISO 22000. The Americas and Africa are mainly covered by FSSC 22000 certification, while ISO 22000 certification is the major adoption by Asia, the Pacific and the Middle East. The only exception is Europe that has IFS Food as the main adopted standard. Concerning the forecasting model of worldwide ISO 22000 certification, it was predicted that the ISO 22000 diffusion around the world reached the inflection point. Moreover, similarities were found by analyzing the forecasting models, which predict the behavior of ISO 22000 certification in European countries. This present study confirmed similar behavior between ISO 14001 and ISO 22000 standard diffusion processes reported by Granja *et al.* (2021). Nevertheless, there is a possibility that these results have not yet been reached due to the lack of available data. Regarding drivers FSMS certification, companies presented not only different reasons but also expected benefits that define the process of adoption of a FSMS. Deal with external pressures was the main motivation among the surveyed companies. Increased customer confidence and enhanced reputation were considered as main benefits achieved through FSMS certification. On the other hand, employee resistance to change and certification costs represent obstacles that companies need to overcome. Aiming at contributing to reduce the research gap encompassing the decertification process of a FSMS standard, the main reasons that led this process were analyzed from an experience reported by surveyed companies. Lastly, it was interesting to approach the positive contribution of FSMS encompassing the improvement of the food supply chain within sustainability and food security issues.

Keywords: diffusion model, food safety; food safety management system standards; food security; Gompertz model.



DIFUSÃO GLOBAL DE NORMAS DE SISTEMAS DE GESTÃO DA SEGURANÇA ALIMENTAR

Resumo

O objetivo geral desta dissertação foi apresentar o retrato atual da difusão global das normas FSSC 22000, ISO 22000 e IFS Food. Dados disponíveis sobre estas certificações foram obtidos e estudados compreendendo as macrorregiões: África, Américas Central e do Sul, Ásia Central e do Sul, Leste da Ásia e Pacífico, Europa, América do Norte e Oriente Médio. Modelos de previsão baseados no modelo de *Gompertz* também foram desenvolvidos para prever o comportamento da ISO 22000 nos próximos anos. Para facilitar a compreensão das motivações, benefícios e obstáculos que atualmente impactam a expansão das normas estudadas, foi realizada uma pesquisa entre empresas da área alimentar. A atual difusão dos SGSA é considerada desigual, uma vez que apresenta ampla disseminação entre diferentes países. Considerando a base relativa *per capita*, a Europa lidera a propagação global da destas normas. A maioria das macrorregiões definidas são abrangidas por duas normas estudadas, a FSSC 22000 e a ISO 22000. As Américas e a África são abrangidas principalmente pela certificação FSSC 22000, enquanto a certificação ISO 22000 possui a maior adoção em toda a Ásia, regiões do Pacífico e do Oriente Médio. A única exceção é a Europa, que possui a certificação IFS Food como a mais importante. Em relação aos modelos de previsão da ISO 22000, foi observado que os pontos de inflexão já foram alcançados. Além disto, similaridades foram encontradas entre os modelos estabelecidos para analisar o comportamento desta certificação na Europa. Este presente estudo confirmou o comportamento similar entre os processos de difusão da ISO 14001 e da ISO 22000 reportados por Granja *et al.* (2021). No entanto, há a possibilidade destes resultados ainda não terem sido alcançados por conta da falta de dados reais disponíveis. Sobre os determinantes das certificações de normas de SGSA, as empresas apresentaram que não apenas diferentes razões, mas também expectativas definem a adoção de uma certificação do SGSA implementado. Lidar com as pressões externas do comércio alimentar foi a maior motivação dentre as empresas que participaram da pesquisa. O aumento da confiança do cliente e o aprimoramento da reputação da empresa foram considerados os principais benefícios alcançados por meio do SGSA certificado. Por outro lado, a resistência dos funcionários e os custos referentes ao processo de certificação foram os principais obstáculos a serem enfrentados. Objetivando contribuir para a redução da lacuna que existe sobre o processo de decertificação de normas de SGSA, razões que norteiam este processo foram analisadas a partir de experiências das empresas respondentes. Por fim, foi interessante abordar a positiva contribuição dos SGSA no tocante à sustentabilidade e *food security*.

Palavras-chave: *food security*, *Gompertz*, modelos de difusão, normas de sistema de gestão da segurança alimentar, segurança alimentar.



INDEX

ACKNOWLEDGEMENTS	iii
STATEMENT OF INTEGRITY	iv
ABSTRACT.....	v
RESUMO	vi
INDEX	vii
LIST OF FIGURES	ix
LIST OF TABLES	x
LIST OF ABBREVIATIONS	xi
1. INTRODUCTION	12
1.1 Background	12
1.2 Objectives and Research Methodology	13
1.3 Structure of the Dissertation	14
2. LITERATURE REVIEW	15
2.1 Food Safety Management Systems and their current worldwide importance	15
2.2 Main Food Safety Management Standards	17
2.2.1 IFS Food	17
2.2.2 ISO 22000	19
2.2.3 FSSC 22000	20
2.3 Forecasting models of FSMS standards	21
2.4 Benefits and obstacles of the FSMS implementation	23
3. RESEARCH METHODOLOGY	25
3.1 Data collection	25
3.2 Diffusion of Food Safety Management System certifications	26
3.2.1 FSSC 22000	26
3.2.2 ISO 22000	27
3.2.3 IFS Food	29
3.3 Analysis of current benefits and obstacles of FSMS implementation	29
3.4 Limitations	30
4. RESULTS	32



4.1 Diffusion of Food Safety Management System Standards - Overview	32
4.2 FSSC 22000	37
4.3 ISO 22000	41
4.3.1 Forecasting models of ISO 22000 certification	44
4.4 IFS Food	47
4.5 Analysis of current benefits and obstacles of FSMS implementation	52
4.5.1 Social-demographical characteristics of the sample	52
4.5.2 Presentation and analysis of the results of the online survey	56
4.6 Current socio-economic importance of worldwide FSMS certification	60
5. CONCLUSIONS	64
5.1 Retrospective and soundest conclusions	64
5.2 Limitations and opportunities for further studies	67
REFERENCES	68
APPENDIXES	76
Appendix I - FSSC 22000, ISO 22000 and IFS Food Top 30 Countries	77
Appendix II - Selected countries based on FSSC 22000, ISO 22000 and IFS Food certification	78



LIST OF FIGURES

Figure 1. Worldwide evolution of ISO 22000 certification through the years	20
Figure 2. Important chronological events of the FSSC 22000 history based on Soares <i>et al.</i> (2016) and FSSC 22000 (2020)	21
Figure 3. Current worldwide diffusion of FSSC 22000 (yellow), ISO 22000 (red) and IFS Food (green) (Source: author)	32
Figure 4. Number of worldwide FSSC 22000, ISO 22000 and IFS Food certificates through the years based on available data (Source: author)	35
Figure 5. Dissemination of FSSC 22000 certification among macroregions of the world (Source: author)	37
Figure 6. Evolution of FSSC 22000 based on Havinga (2013) and current available data (Source: author)	39
Figure 7. Qualification of worldwide FSSC 22000 certifications based on the 14 Food Chain Categories (Source: author)	40
Figure 8. Dissemination of ISO 22000 certification among macroregions of the world (Source: author)	42
Figure 9. Forecasting model of worldwide ISO 22000 diffusion based on available data (Source: author)	45
Figure 10. Forecasting model of European ISO 22000 diffusion based on available data (Source: author)	46
Figure 11. Suggested intervals based on both ISO 9001 and ISO 14001 to analyze ISO 22000 certification by Granja et al. (2021) updated with additional data from more recent years (Source: author)	47
Figure 12. Dissemination of IFS Food certification among macroregions of the world (Source: author)	49
Figure 13. Average IFS Food audit results among the defined macroregions (Source: author)	50
Figure 14. Business size of the surveyed companies (Source: author)	53
Figure 15. Maturity of the FSMS based on its implementation over the years (Source: author)	53
Figure 16. Economic activities of the surveyed companies based on CAE (2007) (Source: author)	54
Figure 17. FSMS certification among surveyed companies (Source: author)	55
Figure 18. Integrated management systems among surveyed companies (Source: author)	56
Figure 19. Main motivations that lead a standard adoption (Source: author)	56
Figure 20. Main benefits achieved by companies due to the FSMS certification (Source: author)	58
Figure 21. Main obstacles within FSMS certification that need to be overcome by surveyed companies (Source: author)	59
Figure 22. Economic levels of selected countries by simultaneous FSSC 22000, ISO 22000 and IFS Food certification (Source: author)	62



LIST OF TABLES

Table 1. Top 10 countries by the number of certificates sites in 2013 reported to Mohammed and Zheng, (2017)	17
Table 2. IFS Food Scoring System Version 7 available on IFS official website	18
Table 3. Provided information for each studied standard	25
Table 4. Available data of FSSC 22000 certification used for analyzing its worldwide diffusion	26
Table 5. Food chain categories (FCC) based on FSSC 22000	26
Table 6. Available data of ISO 22000 certification by macroregion based on ISO Survey	28
Table 7. Available data of ISO 22000 certification used for constructing forecasting models	28
Table 8. Data provided by IFS used for analyzing the worldwide diffusion of IFS Food certification	29
Table 9. IFS Food scoring from audit results data provided by IFS	29
Table 10. FSSC 22000, ISO 22000 and IFS Food: Top Ten Countries by the current number of issued certificates	33
Table 11. Geographic distribution of countries selected by the criteria minimum of ten issued certificates or a minimum of ten passed audits by <i>country</i>	35
Table 12. Geographic distribution of selected countries, which present simultaneously FSSC 22000, ISO 22000 and IFS Food certification	36
Table 13. FSSC 22000 Top Ten Countries by the current number of issued certificates <i>per capita</i>	38
Table 14. ISO 22000 Top Ten Countries by the current number of issued certificates <i>per capita</i>	42
Table 15. Parameters and statistics for the Gompertz fitting of available ISO 22000 data	45
Table 16. IFS Food Top Ten Countries by the current number of issued certificates <i>per capita</i>	48
Table 17. IFS Food Top Ten Countries by the average audit results considering the IFS Food scoring (2017 to 2020)	51
Table 18. Evolution of IFS Food audit results from 2018 to 2020 among the defined macroregions	52
Table 19. Enterprises by business size based on OECD (2021)	52
Table 20. Top Ten Countries by simultaneous FSSC 22000, ISO 22000 and IFS Food certification	61



LIST OF ABBREVIATIONS

BRC - British Retail Consortium

BSE - Bovine Spongiform Encephalopathy

CAE - Classification of Economic Activities

FAO - Food and Agriculture Organization of the United Nations

FFC - Food Chain Category

FSMS - Food Safety Management System

FSSC - Food Safety System Certification

GDP - Gross Domestic Product

GFSI - Global Food Safety Initiative

GlobalGAP - Global Good Agricultural Practices

HACCP - Hazard Analysis and Critical Control Point

IFA - Integrated Farm Assurance

IFS Food - International Featured Standards Food

ISO - International Organization for Standardization

OECD - The Organization for Economic Co-operation and Development

PAS - Publicly Available Specification

PC - *per capita*

PrimusGFS - Primus Global Food Safety

PRP - Pre-requisite Program

SGSA - Sistema de Gestão da Segurança Alimentar

SQF - Safe Quality Food

UNDP - United Nations Development Programme

UN SDGs - United Nations Sustainable Development Goals



1. INTRODUCTION

1.1 Background

Regarding safety in the food trade, a constantly growing concern is the quality of the products. The risk of incidents related to food safety hazards is real since food products are produced using different techniques of cultivation, handled and transported all over the world before coming consumer's home (Gil *et al.*, 2017).

According to the Food and Agriculture Organization of the United Nations (FAO), three main factors facilitate the understanding of the food trade's expansion and diversification in the last years. First, the improvement of food science and technology is continuously providing new available safer and fewer perishable products, which are developed by modern processing techniques. Thus, the products are more attractive to the consumer because of their guaranteed safer conditions. Second, the growing concern about transport and handling methods supports the new solutions of time management to transport food products to long distances and, consequently, to achieve new markets. And third, the increased demand for new foods from other regions due to the new tastes and new food habits of the consumers (FAO, 1998).

In addition to the aforementioned third factor, a new health-conscious are improving issues related to sustainable products and practices in the food chain. Thus, aiming for both farmers and consumers welfare, food safety is also a current concern among the consumers of sustainable agricultural products (Mohamed *et al.*, 2016).

Moreover, current concerns about loss and waste are global issues irrespective of the country economy's level (World Bank, 2021a) once the modern world is struggling with a huge problem of food waste (Bergström *et al.*, 2020). Currently unsustainable for both people and planet, the trade food and its processes are complex. Comprising socio-economic issues, market factors and the inefficient supply chains, the shape of the current agricultural system led the huge quantity of food that is lost on farms and wasted at retail and consumption levels (Food Action Alliance, 2021).

Related to that and aiming at strengthening food security, a fortified and solid food industry is recognized as a very important food supplier to the population (FAO, 1998). Since food trade is headed by large retailers, wholesalers, foodservice companies and their required private food safety management standards (Herzfeld *et al.*, 2011), the majority of achievements related to the mentioned factors of food trade's expansion is due to the implementation of these standards.

The international benchmarking institution GFSI (Global Food Safety Initiative) recognizes some food safety standards, such as Food Safety System Certification 22000 (FSSC 22000) and International



Featured Standards Food (IFS Food). The private food safety certifications aforementioned added to other standards (BRC, GlobalGAP, SQF, PrimusGFS, etc.) compose a huge influential regulatory mechanism encompassing the current agri-food system (Mohammed and Zheng, 2017).

Contextualizing ISO 22000, it is a renowned international food safety management system standard based on good manufacturing practices and HACCP (Hazard Analysis and Critical Control Point) and it is not recognized by GFSI. However, this FSMS was lined up with the ISO 9001 in the latest revision in order to enable a company in compliance with the requirements of this standard to manage the food safety risks in a transparent manner (Fernandez-Segovia *et al.*, 2014).

The consequences of producing food that does not compliance legal requirements can be very serious (Kiss *et al.*, 2019). That is why researchers emphasize (Gaaloul *et al.*, 2011; Zimon and Domingues, 2020) that to implement food safety management standards is a good tool to help organizations identify and control food safety hazards. Furthermore, besides responsibility for producing safe food, food industries must evidence the way that food safety is planned and assured (Fotopoulos *et al.*, 2009).

Therefore, it emphasizes that the dissemination of standards supporting the care of food quality at every stage of the supply chain is a necessity. Moreover, mastering motivations, benefits and, difficulties associated with the implementation and predicting the behavior of FSMS diffusion in the coming years is an important strategy for planning and organizational management (Hikichi *et al.*, 2016).

Several researchers (i.e., Teixeira and Sampaio, 2013; Escanciano and Santos-Vijande, 2014; Cantanhede *et al.*, 2018; Zimon and Domingues, 2020; and Rodriguez-Arnaldo and Martinez-Lorente, 2020) have focused on investigating what has led organizations in countries to adopt or not a certification and what are the main achieved benefits and obstacles that the companies have to overcome.

1.2 Objectives and Research methodology

With the above in mind, the main goal of this research is to analyze the worldwide behavior of ISO 22000, FSSC 22000 and IFS Food certification based on available data for answering the follow research questions: 1- What is the current clear picture on how are the worldwide diffusion of the aforementioned certifications? 2- Which countries lead these certifications on a relative basis? 3- Encompassing each standard, which macroregions had the highest growth rates? 4- How was the worldwide evolution of these standards in recent years? 5- What are the future prospects for the worldwide diffusion of these certifications?

Particularly, a study aiming at forecasting the worldwide behavior of ISO 22000 certification for the next years is presented encompassing the available data from 2007 to 2020. Moreover, this dissertation also



intends to extend the study carried out by Granja *et al.* (2021) since additional data obtained from more recent years (2019 and 2020) were used to update the established forecasting model.

To conclude, as a result of a conducted survey among companies related to the food chain, the main motivations, benefits, and obstacles of the FSMS implementation are reported in order to support the comprehension within the spread of these standards once they present very different geographical coverage (Mohammed and Zheng, 2017).

1.3 Structure of the Dissertation

This dissertation is structured as follows: the Introduction section is followed by the Literature Review section, which address and dissects the latest published contributions concerning implementation and diffusion of food safety management system standards as well as the main factors that impact this dissemination. The Research Methodology is described in the following section and the Results section performed an analysis of the worldwide implementation of ISO 22000, FSSC 22000 and IFS Food standards based on available data. Findings encompassing the main drivers of the implemented food safety management systems mainly in surveyed Portuguese companies are also reported in this section. Finally, the Conclusions, suggestions for future work and references used in this dissertation are presented.



2. LITERATURE REVIEW

2.1 Food Safety Management Systems and their current worldwide importance

Once quality standardization processes are crucial in defining the quality of a product and the trustworthiness of a company, worldwide economic globalization processes and the international trade's development need to implement quickly these processes (Kussaga *et al.*, 2014). Moreover, the perspective of quality in the food industry is much more subjective than quality in the industry of durable goods. In the food industry, quality is generally defined as a matter of taste and preference, therefore, quality specifically in the food industry is often based on consumer's buying decision, but not on the judgement of experts (He and Hayya, 2002).

During the last decade, the importance of the implementation and certification of Food Safety Management Systems have significantly increased. Several food scares and incidents such as BSE and bacterial infections (i.e., *Salmonella*, *Listeria* and *Escherichia coli*) forced governments to improve regulations and their enforcements as well as created public concern about food safety (Havinga, 2013). Thus, the necessity of implementing related standards in activity sectors involved in the food chain is getting stronger throughout the years by companies of all types and sizes (Gil *et al.*, 2017), and new stakeholder requirements are directly associated with current company's concerns. Aiming at earning the trust of partners and consumers, the competitive context also determines the adoption of these international standards (Bello-Pintado and Merino-Díaz-de-Cerio, 2013).

The globalized food supply chain and the impact of its expansion is an issue to be stressed once food products are produced, transformed and consumed in completely different parts of the world (FAO, 2011) and for a company to be accepted in the international food trade it is necessary to comply with international management standards (Gil *et al.*, 2017).

This compliance becomes a mandatory item when the company aims at being part of the current global food supply, which includes different types of intermediaries operating under different food quality and safety regulations (Bonanno *et al.*, 1994). The increased and strong influence of multinational food retailers also contribute to the development of the food trade and the evolution of food governance (Havinga, 2013).

In addition to economic and business issues, the population growth, the food demand, and high levels of food waste emphasize the importance of sustainable practices implementation in the food systems (Jurgilevich *et al.*, 2016). FAO (2011) stated that food losses impact food quality and safety and this same Organization already stated in 1998 that the improvements in the food industry support the food security



achievement (FAO, 1998). It must be emphasized that global food systems have a huge environmentally friendly impact at all stages of the food chains (Garnett, 2013).

To corroborate the current necessity of diffusion of food safety management standards, the UN Sustainable Development Goals, also known as the Global Goals, includes in its goals targets issues related to ensure the implementation of sustainable production systems and reduce global food waste at both retail and consumer levels, including the reduction of food losses along production and supply chains (UNDP, 2021).

Regarding welfare of both farmers and consumers, the consumption of sustainable agricultural products is increasing due to the modern new health-conscious, which requires not only sustainable practices in the food chain, but also be involved in issues from food safety to environmental protection (Mohamed *et al.*, 2016). In companies that have implemented specific standards, the reduction of food loss and waste is real (Merican and Bucak, 2013). It means that a proper implementation of quality management systems, including processes running in harmony with specific standards and generated waste management, encourage the increased awareness and the sustainable development (Sliškovic *et al.*, 2018).

Regarding the quality management standards, several required FSMS standards is recognized by GFSI, an international benchmarking institution, and standards such as FSSC 22000, BRC, GlobalGAP and IFS Food are one of the recognized standards (Mohammed and Zheng, 2017). Together, they lead the international food trade once these standards are required by large retailers, wholesalers, foodservice companies (Herzfeld *et al.*, 2011). However, despite the renowned ISO 22000 standard is not recognized by GFSI, this standard has significant collaboration with the diffusion of FSMS once it can be adopted by any organization, directly and indirectly, involved in the food chain, meeting both consumer and market requirements (Wang *et al.*, 2011).

Concerning the spread of FSMS standards, it has very different geographical coverage. Mohammed and Zheng (2017) analyzed the six major private food safety standards and their cross-national adoption. The authors concluded that the majority of these standards is adopted by their own and surrounding countries, while other have a significant worldwide adoption. To support that, the authors identified that European countries had the highest numbers of Europe-based standards certificates (BRC, FSSC 22000, GlobalGAP and ISO 22000 – IFS had no available data), whilst FSSC 22000 and ISO 22000 have also a better dissemination outside Europe (i.e., United States, India, and China). Considering ISO 22000 and FSSC 22000 certification, Table 1 evidences the above mentioned with the Top 10 countries by the number of certificates sites in 2013.



Table 1. Top 10 countries by the number of certificates sites in 2013 reported to Mohammed and Zheng, 2017.

FSSC 22000				ISO 22000			
Nº.	Region	Country	2013	Nº.	Region	Country	2013
1	North America	United States	951	1	East Asia	China	9406
2	East Asia	China	775	2	Europe	Greece	1720
3	East Asia	Japan	701	3	South Asia	India	1489
4	South Asia	India	491	4	Europe	Romania	1014
5	Europe	Netherlands	367	5	East Asia	Japan	825
6	North America	Mexico	353	6	Europe	Italy	781
7	Europe	Germany	299	7	Europe	Turkey	733
8	Europe	Russia	263	8	Europe	Poland	640
9	Africa	South Africa	259	9	Europe	Spain	525
10	South America	Brazil	237	10	East Asia	Malaysia	389

Other achieved goals of this study above mentioned are to conclude that the number of domestic certification bodies and the *per capita* GDP also impact the company's decision that seeks a certification of food safety management system standards. Regarding both food safety and security, these conclusions may explain why food waste is generated in the consumer phase mostly in food chains of high-income countries, while in low-middle-income countries high levels of food loss occur during the food production processes (FAO, 2011). Concerning the last reported group of countries, the World Bank (2021a) states that there is a lack of infrastructure to ensure adequate food storage.

Related to that, a study concerning the diffusion of ISO 9001 standard, Clougherty and Grajek (2014) evidence a trade barrier for low-middle-income countries in comparison with high-income countries. With the above in mind, it is possible to state that the stricter requirements of food safety standards imposed by stakeholders based on developed countries may limit the food trade expansion from developing countries (Jongwanich, 2009).

2.2 Main Food Safety Management Standards

2.2.1 IFS Food

The International Featured Standards have different food and non-food standards, but all certifications cover the processes along the supply chain. At least four of these standards comprise uniform guidelines on food product safety and quality issues, as follows: IFS Global Markets Food, IFS Wholesale/Cash & Care, IFS Logistics and IFS Food (IFS Certification, 2021).

Regarding food safety, IFS Food is a GFSI recognized standard focused on quality of processes/products during primary packing, thus this standard may be applied in processing companies and companies that pack loose food products. From production to marketing issues, IFS Food tightly supports the brand once the mentioned standard was developed by certification bodies, retailers, food industry and food service companies in a full active collaboration (IFS Food, 2021).



Still according to IFS Food (2021), the certification of this standard has a scope that encompasses six primary areas of the business in its topics of requirements, such as senior management responsibility, quality/food safety management system, resource management, operational process, measurements, analysis, improvements, and the last one, food defence. The compliance with these requirements aims at guaranteeing the safety and quality of products from effective processes audited based on the IFS Scoring System (Table 2) .

Table 2. IFS Food Scoring System Version 7 available on IFS official website.

Result	Explanations	Points
A	A indicates full compliance and perfect implementation of the requirement	20 points
B <i>Point of Attention</i>	B is a point of attention observed by the auditor, indicating compliance without a significant negative impact on the result. The intention is to give the business a signal to monitor the requirement. This way, the company can avoid a deviation or even a non-conformity in future. Note: a point of attention is not a deviation as no corrections or corrective actions are requested, and it is not meant to recommend specific solutions or improvements.	15 points
C <i>Deviation</i>	C means that part of the requirement is not implemented and that improvement is needed.	5 points
D <i>Deviation</i>	D means that the implementation of the requirement is not sufficient or not done at all, but there is no impact on food safety related to products and services.	-20 points
MAJOR <i>Non-conformity</i>	An auditor can give a Major for all requirements not being defined as KO. It indicates a substantial failure usually relating to product safety or legal issues, and results in a subtraction of 15% from the total amount of points. During a follow-up assessment, the company needs to show it has implemented the corrective actions. Only then it is possible to award an IFS Certificate at foundation level.	Major non-conformity will subtract 15% of the possible total amount, the certificate cannot be awarded
KO <i>Scored with a D</i>	Knockout (KO) requirements are defined in the standard and can only be scored with an A, C (deviation) or D. The scoring of a KO requirement with a D indicates a non-implementation of the requirement. It leads to a subtraction of 50% of the total amount of points. A final score of less than 75 % results in a failure of the assessment. Consequently, the IFS Certificate will not be awarded.	KO non-conformity will subtract 50% of the possible total amount, the certificate cannot be awarded.

The initial versions of this standard were developed by three retail federations from Germany, France and Italy. Thus, IFS Food certification is generally demanded by stakeholder engagement predominantly from German, French and Italian retailers (Baines, 2010). However, considering the increased global demand, stakeholders from North and South American as well as Asian currently collaborate with this standardization (Mangelsdorf and Tolksdorf, 2014).

In a case study of multiple food safety management systems in food industry, Muhammed Rafeeqe and Mini Sekharan (2018) identified that the implementation of IFS Food standard in a seafood factory located in the Maldives (South Asia) occurred due to the commercial pressure from a potential dealer in Belgium,



which his end customer was one of the largest retailers in Europe that established the condition of buying food products only from companies IFS Food certified.

Furthermore, Guerreiro (2019) analyzed food fraud and his study stated the contribution of the implementation of IFS Food standard in a company in order to avoid fraud on raw materials. Through vulnerability assessment and fraud risk management, the company's reputation is reinforced and thus its access to new international markets, besides significant advantages in terms of quality and safety.

2.2.2 ISO 22000

A FSMS standard based on good manufacturing practices and HACCP (Hazard Analysis and Critical Control Point) was published in 2005 by International Organization for Standardization. ISO 22000 standard aims at enhancing the security of the global food supply chain through the control of food safety hazards (ISO 22000, 2021).

Different from the other international FSMS standards, ISO 22000 certification is not recognized by GFSI. This standard comprises both market and consumers requirements and can be applied by any organization involved in the food chain, directly and indirectly (Wang *et al.*, 2011). ISO 22000 certified organizations can guarantee that their products are safe since highest safety guidelines are followed (Păunescu *et al.*, 2018).

Furthermore, from food supply chain (Mahajan *et al.*, 2016; Zimon *et al.*, 2020) to enterprises (Varzakas and Arvanitoyannis, 2008; Fernandez-Segovia *et al.*, 2014) processes, studies emphasize that ISO 22000 standard supports a proper implementation in both scenarios. Fernandez-Segovia *et al.* (2014) also stated that the compliance with the ISO 22000 requirements allows a company to evidence the food safety risk management. Related to that, this FSMS was lined up with the ISO 9001 in the latest revision to clarify risk concepts of both operational and strategic levels (ISO 22000, 2021).

ISO 22000 standard also acts as an effective tool to provide a better understanding of the requirements throughout the food chain (Zimon, 2018). It must be emphasized once expectations of markets and consumers have changed over the years and the companies have been faced with new food safety requirements.

The current situation of the food trade corroborates the increased number of ISO 22000 issued certificates over the last years (Figure 1). It reflects the competitive context and the necessity of these companies to improve their image and to achieve new markets, besides improvements of food quality. ISO 22000 can be used as a potential business tool due to the uniform language with stakeholders (Escanciano and Santos-Vijande, 2014).

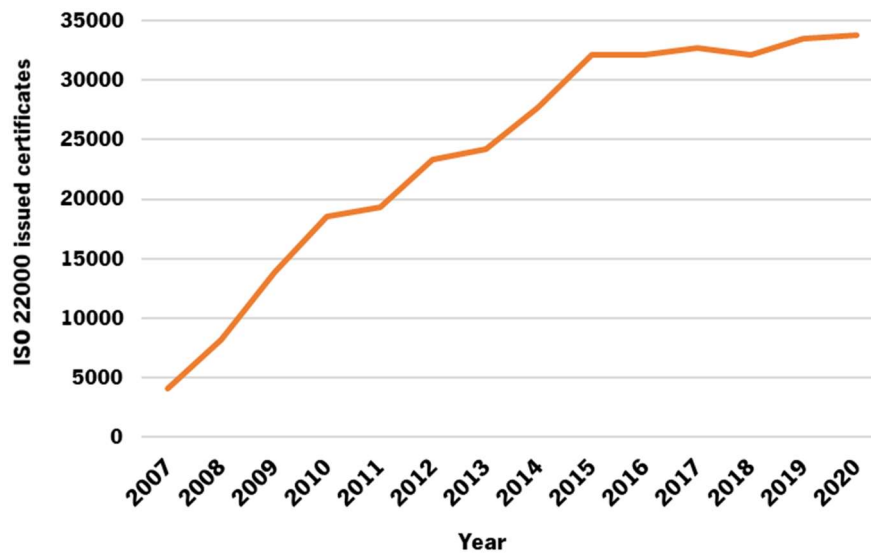


Figure 1. Worldwide evolution of ISO 22000 certification through the years (Source: author).

Besides the wide international spread of ISO 22000 certification, Zimon and Domingues (2019) suggested that standard has not a wide implementation. It is probably related to the current power of multinational food trade lead by food retailers, which influence the diffusion of global food safety management system standards. Even though ISO 22000 is Europe-based standard, according to Havinga (2013), the majority of European FSMS certifications is distributed over three international standards also Europe-based, such as GlobalG.A.P., BRC and FSSC 22000.

2.2.3 FSSC 22000

The recent history of the Food Safety System Certification (FSSC) 22000 is based on big manufacturers that aimed for “a common set of prerequisite programs that can be used by any manufacturer who wishes to establish an ISO 22000 certified food safety management system” (Soares *et al.*, 2016).

FSSC 22000 scheme was recognised by GFSI in 2010 and this food safety standard was elaborated to meet the requirements of the food industry companies. Producers of materials used in food packaging and producers of feed and food for animals are also part of the scope of FSSC, in conformity with PAS 223:2011 and PAS 222:2011, respectively (Condrea *et al.*, 2015).

According to FSSC 22000 (2020), FSSC 22000 contains a complete certification scheme for food safety management systems based on existing standards for certification, such as ISO 22000, ISO 9001 (FSSC 22000-Quality), ISO/TS 22003 and technical specifications for sector PRPs (Pre-requisite Programs). Furthermore, a certified FSMS against ISO 22000 can be upgraded to FSSC 22000 through the combination with technical specifications for sector PRPs and additional FSSC requirements.



The Figure 2 describes some chronological events of the FSSC 22000 history.

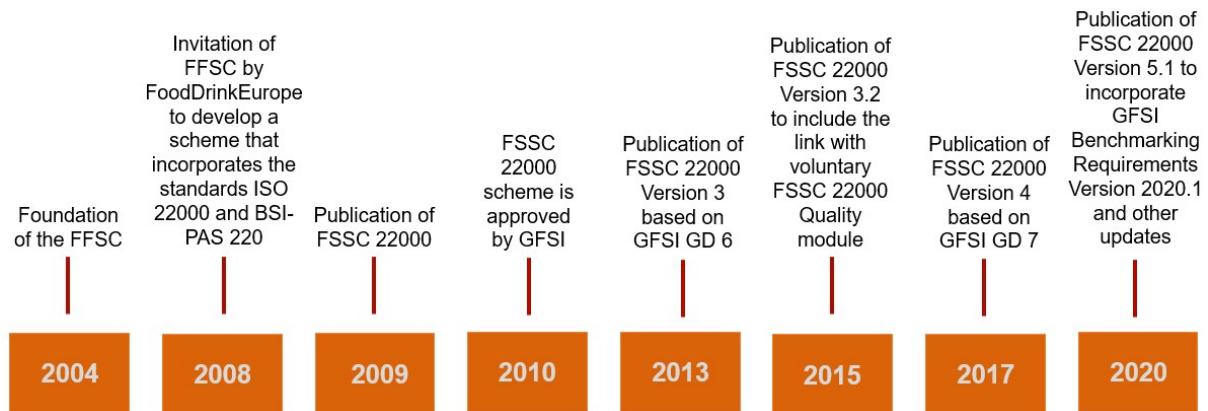


Figure 2. Important chronological events of the FSSC 22000 history based on Soares *et al.* (2016) and FSSC 22000 (2020).

As also occur with other standards, the main reasons that define a company to seek FSSC 22000 are to improve competitiveness and to achieve customer retention (Cantanhede *et al.*, 2018). Based on the current scenario, which organizations require the proof of certain certifications when looking for suppliers, these authors concluded that the assured quality of products is not enough to maintain the customer's satisfaction.

Moreover, considering the ability to compliance with new worldwide consumer requirements and also the supplier's qualification, FSSC 22000 certification can be used as a business management tool that encompasses not only business processes but also food security (Baurina and Amirova, 2021).

2.3 Forecasting models of FSMS standards

The modelling of the diffusion of innovations such as international standards certification is one of the topics of great practical and academic interest in recent decades. Since there are a variety of forecasting models available in the literature, to identify the method that fits better is not an easy task (Meade and Islam, 1998).

Based on the study carried out by Teixeira and Sampaio (2013), there are some researches related to Food Safety Management Systems. However, the researches related to the diffusion of FSMS are rare when compared to the renowned ISO 9001 standard and other international standards, such as ISO 14001.

Nevertheless, current researches within the diffusion of quality management systems were reported by Granja *et al.* (2021) and Cabecinhas *et al.* (2020), regarding food safety management systems and



integrated management systems, respectively. The initial researchers related to studies of diffusion models of management systems are Corbett and Kirsch (2001).

The lack of available data regarding FSMS certifications does not allow a consistent analysis through the years and it must be emphasized the necessity of comparison with other widely implemented quality management standards, such as ISO 9001 and ISO 14001.

Cabecinhas *et al.* (2020) reported the latest countries and standards studied in the domain of standardized management systems diffusion. The authors summarized the published researches addressing dissemination of different standards and management tools.

Statistic models with S-Shaped behavior are used in several researches to describe the phenomenon of standards diffusion (Cabecinhas *et al.*, 2018; Marimón *et al.*, 2008; To and Lee, 2014; Marimón *et al.*, 2009; Alonso-Almeida *et al.*, 2013). Initially, S-Shaped models were used to study the bio-population growth and the implementation of technologies (Chen and Liu, 2009; Franceschini *et al.*, 2004). The specific curve that represents a process of diffusion is also known as a sigmoidal curve (Carrilo and González, 2002).

Buchanan *et al.* (1997), Franceschini *et al.* (2004) and Martino (1993) reported different phases to clarify the behavior of the curve in standards diffusion based on bio-population growth:

- 1) Lag phase: the beginning of the diffusion process. Organizations are confronted with the initial difficulties of the standards implementation.
- 2) Exponential phase: the curve results in a “steep” gradient, thus this phase exhibits a subsequent increase of the growth rate (Stoneman, 1995). After overcome the difficulties from the first phase, the companies consider the certification attractive due to the benefits of standardization (Franceschini *et al.*, 2010).
- 3) Stationary phase: maturity stage of the diffusion process, thus the number of certifications tends to remain constant before to reach the saturation point (Franceschini *et al.*, 2006). The authors stated that when occurring the saturation effect, the certification is devalued.
- 4) Decline phase: being a recent stage, Franceschini *et al.* (2010) and Marimón *et al.* (2009) reported this fourth stage that means the decertification stage.

The mentioned phases corroborate the study of Marimón *et al.* (2008) that considers three types of standard expansion behaviors: expansionist, mature and retrocessive. Once the number of certifications tends to stabilize at a lower level, Mastrogiacomo *et al.* (2020) suggest a new diffusion phase titled post-decline. Issues encompassing the new phase are novelty, thus future researches are necessary to update the existing literature.



2.4 Benefits and obstacles of the FSMS implementation

Several studies encompassing the standardization in different sectors of activity evidence that organizations implement FSMS for different reasons (Herath and Henson, 2010). It should be noted that, as an important result of globally food safety management, its common language properties minimize the communication frictions among food chain organizations (Clougherty and Grajek, 2014).

Based on the literature review carried out by Escanciano and Santos-Vijande (2014), there are some researches related to reasons and constraints of implementing FSMS at both internal and external levels, the latter being the most important that define the FSMS standard adoption by organizations.

Related to above, a study carried out by Zimon and Domingues (2020) reported external and internal benefits from ISO 22000 implementation, such as compliance with legal requirements and regulations, the guarantee of safer food products and staff awareness increase of their impact on food quality and safety. To evidence that, since ISO 22000 certification was implemented in a specific food industry, the company reported not only increased customer trust, but also enhanced both food protection and cost efficiency (El-Rouby *et al.*, 2020).

However, difficulties regarding both diffusion and application of this standard are related to high costs and the fact that, currently, an organization covered by ISO 22000 is not seen as a prerequisite for doing business (Escanciano and Santos-Vijande, 2014).

Aiming at developing both international trade and improvements in the company's processes issues, the implementation of FSSC 22000 also brings benefits to the organization (Cantanhede *et al.*, 2018). The authors reported the mainly benefits obtained due to the FSSC 22000 certification, as such reached new customers and markets, the awareness of employees, enhanced company's reputation and improvement of both quality and safety of the products.

Encompassing the employee's perception of the IFS Food implementation among small, medium and large sized companies, Schulze *et al.* (2008) stated that large companies lacked intrinsic motivation due to the similarities to other already implemented management standards. On the other hand, the certification of IFS Food was considered a costly and enforced process by medium sized companies. The authors also stated that smaller companies lacked higher intrinsic motivation and it may be related to the fact that microenterprises do not face yet delegation of responsibilities issues among sectors of the company.

Muhammed Rafeeqe and Mini Sekharan (2018) analyzing multiple food safety management system implemented in a specific food industry concluded that all the five implemented FSMS were adopted to overcome external pressure on the organization (i.e., commercial pressure and both customer and



regulatory requirements). Even obtaining further business opportunities, this study also concluded that all the FSMS standards have similar consequences for the organization.

To conclude this section, the organizations need to realize benefits and costs related to the specific standardization process to define a standard adoption (Zhu *et al.*, 2006). Furthermore, organizations consider that a proper implementation of quality management system is positive to support supply chains with efficiency (Zimon, 2017) once, beside the several reasons that led an organization to seek an FSMS certification, the main one is to improve competitiveness and customer retention (Cantanhede *et al.*, 2018).



3. RESEARCH METHODOLOGY

3.1 Data collection

Available information regarding the worldwide numbers of Food Safety Management System certifications were provided from the ISO 22000 Survey (2017) and ISO Survey (2018 to 2020) and FSSC 22000 database. ISO yearly publishes on ISO Survey official website data encompassing worldwide ISO standards certifications and these surveys are widely used as a basis for research by academic communities (i.e., Marimón *et al.*, 2009., Salgado *et al.*, 2015; Cabecinhas *et al.*, 2018). Related to FSSC 22000 certification, some data were founded available on the FSSC official website.

Regarding IFS Food certification, the data were directly requested to IFS marketing manager once the IFS official website has not available data. Table 3 summarizes all types of collected information as well as the source for each studied standard.

Table 3. Provided information for each studied standard.

FSSC 22000			IFS Food			ISO 22000		
Information	Period	Source	Information	Period	Source	Information	Period	Source
Number of worldwide certificates	2021	FSSC official website	Number of worldwide certificates*	2017 to 2020	IFS Marketing Services manager	Number of worldwide certificates	2007 to 2020	ISO 22000 Survey + ISO Survey 2018 ISO Survey 2019 ISO Survey 2020
						Number of certificates by macroregion	2007 to 2020	ISO 22000 Overview 2017
Number of certificates by country	2021	FSSC official website	Number of certificates* by country	2017 to 2020	IFS Marketing Services manager	Number of certificates by country	2007 to 2020	ISO 22000 Survey + ISO Survey 2018 ISO Survey 2019 ISO Survey 2020
						Number of worldwide certified sites**	2007 to 2020	ISO 22000 Survey + ISO Survey 2018 ISO Survey 2019 ISO Survey 2020
Food chain categories by country	2021	FSSC official website	Audits results by country	2017 to 2020	IFS Marketing Services manager	Number of certified sites** by macroregion	2007 to 2020	ISO 22000 Survey
						Number of certified sites** by country	2007 to 2020	ISO 22000 Survey + ISO Survey 2018 ISO Survey 2019 ISO Survey 2020

*Based on the number of passed audits; **Number of sites covered by ISO 22000 certificates is not available in 2017.



The worldwide diffusion and diversification of both studied standards were analyzed considering macroregions defined by ISO Survey, as follows:

1. Africa;
2. Central and South America;
3. Central and South Asia;
4. East Asia and Pacific;
5. Europe;
6. North America and;
7. Middle East.

3.2 Diffusion of Food Safety Management System certifications

3.2.1 FSSC 22000

Table 4 presents the raw data collected and adopted to analyze the distribution of FSSC 22000 certification among defined macroregions.

Table 4. Available data of FSSC 22000 certification used for analyzing its worldwide diffusion .

Year	Number of worldwide certificates	Africa	Central and South America	North America	Europe	East Asia and Pacific	Central and South Asia	Middle East
2020	24876*	-	-	-	7894	-	-	-
2021.1	25256**	1492	1605	2740	8151	8757	1991	484
2021.2	27707***	1645	1733	2863	8647	9954	2315	549
Current %		<i>6%</i>	<i>6%</i>	<i>10%</i>	<i>31%</i>	<i>36%</i>	<i>8%</i>	<i>2%</i>

*Raw data were collected on 24 January 2021; **Raw data collected on 9 March 2021; ***Data available data on 08 December 2021.

The qualification of current FSSC 22000 certifications around the world was implemented based on the established food chain categories (Table 5), as follows:

Table 5. Food chain categories (FCC) based on FSSC 22000.

FCCs	
1	Farming of animals for meat/milk/eggs/honey
2	Processing of perishable animal products
3	Processing of perishable plant products
4	Processing of perishable animal and plant products (mixed products)
5	Processing of ambient stable products
6	Production of feed
7	Production of pet food (only for dogs and cats)
8	Production of pet food (for other pets)
9	Catering
10	Retail / Wholesale
11	Provision of transport and storage services for perishable food and feed
12	Provision of transport and storage services for ambient stable food and feed
13	Production of food packaging and packaging materials
14	Production of (Bio) Chemicals



To evaluate the dissemination of FSSC 22000 certification among macroregions, it was implemented a criterion to select significant ones of each macroregion in order to minimize possible white noises from countries that are at the beginning of the certification process (Sampaio and Saraiva, 2010). Thus, aiming at a consistent analysis, it was established a minimum of ten issued certificates by country in 2021.2.

3.2.2 ISO 22000

The current dissemination of ISO 22000 certificates and the sites covered by this standard were analyzed considering both worldwide and macroregions levels. In addition, a forecasting model was developed to forecast the behavior of worldwide ISO 22000 certification for the next years encompassing the available data from 2007 to 2020. The methodology adopted by Cabecinhas *et al.* (2020) was used in this study for constructing the forecasting model.

Moreover, a forecasting model encompassing European countries builds on Granja *et al.* (2021) was established aiming at updating the diffusion of ISO 22000 certification in Europe. The data sample was collected from the aforementioned study with additional data obtained from more recent years (2019 and 2020).

Considering well-known S-shape curves in population dynamics, the Gompertz growth curve was adopted because of its widely adoption among scientific community (Berny, 1994). Furthermore, Cabecinhas *et al.* (2018) stated that this forecasting provides better performance when applying in regions that have not yet reached the maximum level of saturation.

“SGompertz” function from the “growth/sigmoidal” category of the software OriginPro® 2022 was used for elaborating the model’s curve. As the solution of the Gompertz model equation (1), the maximum of certificates that may be issued is reported as a value, also called saturation value (Cabecinhas *et al.*, 2020).

$$y(t) = a \cdot e^{-e^{-k \cdot (t-t_c)}} \quad (1)$$

Other studies adopted the Gompertz model (Carrillo and González, 2022; Wu and Chu, 2010; Zwietering *et al.*, 1990) and considered k value as the time when the point of inflection is reached. Nevertheless, to identify the point of inflection on the y -axis, Winsor (1932) considered the value of, approximately, 37% of the final growth or the equation below (2):

$$y = k/e \quad (2)$$



Regarding the growth curve of Gompertz model, the results are affected by the amount of data and the inclusion of the inflection point (Meade and Islam, 1998). One important characteristic of this model is the asymmetry of the point of inflection (Meade and Islam, 2006).

Provided by ISO Survey, Table 6 presents the raw data collected to analyze the distribution of ISO 22000 certification among defined macroregions, while Table 7 presents the data used for constructing the forecasting models based on Gompertz model.

Table 6. Available data of ISO 22000 certification by macroregion based on ISO Survey.

Year	Africa	Central and South America	North America	Europe	East Asia and Pacific	Central and South Asia	Middle East
2007	133	92	49	2749	704	281	114
2008	266	247	48	4865	1541	960	258
2009	356	257	103	6050	5247	1393	432
2010	717	414	181	7083	8271	1414	500
2011	637	451	231	7361	8906	1330	435
2012	802	585	321	8307	11,085	1522	656
2013	941	639	344	9357	10,306	1936	684
2014	1125	739	533	10,181	12,007	2370	730
2015	1276	740	534	11,181	14,666	2772	887
2016	1056	576	278	11,083	15,505	2636	1002
2017	1131	513	320	10,342	16,559	2789	1068
2018	1023	523	279	9666	16,788	2718	1118
2019	1119	547	388	10,239	16,976	3031	1194
2020	917	493	335	9808	18,234	2636	1224
Current %	<i>3%</i>	<i>1.5%</i>	<i>1%</i>	<i>29.1%</i>	<i>54.2%</i>	<i>7.8%</i>	<i>3.6%</i>

Table 7. Available data of ISO 22000 certification used for constructing forecasting models.

Year	Counter	Number of worldwide certificates	Number of certificates in Europe
2007	1	4122	2749
2008	2	8185	4865
2009	3	13,838	6050
2010	4	18,580	7083
2011	5	19,351	7361
2012	6	23,278	8307
2013	7	24,207	9357
2014	8	27,685	10,181
2015	9	32,056	11,181
2016	10	32,136	11,083
2017	11	32,722	10,342
2018	12	32,120	9666
2019	13	33,502	10,239
2020	14	33,741	9808

To evaluate the dissemination of ISO 22000 certification among macroregions, it was implemented a criterion to select significant ones of each macroregion in order to minimize possible white noises from countries that are at the beginning of the certification process (Sampaio and Saraiva, 2010). Thus, aiming at a consistent analysis, it was established a minimum of ten issued certificates by country in 2020.



3.2.3 IFS Food

Based on data provided by IFS, Table 8 presents worldwide numbers of passed audits from 2017 to 2021. In this study, we considered “passed audits” status as issued certificates to analyze the distribution of IFS Food certification among defined macroregions.

Table 8. Data provided by IFS used for analyzing the worldwide diffusion of IFS Food certification.

Year	Worldwide number of passed audits	Africa	Central and South America	North America	Europe	East Asia and Pacific	Central and South Asia	Middle East
2017	16,222	153	166	47	15,306	473	65	11
2018	4888	42	63	17	4580	167	19	0
2019	18,064	195	207	48	16,986	523	93	11
2020	17,881	149	148	31	16,937	519	85	5
Current %		<i>0.83%</i>	<i>0.83%</i>	<i>0.17%</i>	<i>94.76%</i>	<i>2.90%</i>	<i>0.48%</i>	<i>0.03%</i>

Data regarding the performance of audited organizations also was provided by IFS and are reported in the Table 9 considering the defined macroregions.

Table 9. IFS Food scoring from audit results data provided by IFS.

Year	Africa		Central and South America		North America		Europe		East Asia and Pacific		Central and South Asia	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
2017	96.22	1.10	96.46	1.00	96.71	-	96.36	1.16	95.01	0.90	96.00	0.78
2018	93.86	4.81	95.90	2.31	98.22	-	95.73	1.92	95.16	1.16	94.66	1.99
2019	96.05	1.04	96.43	0.44	98.11	-	96.13	1.35	95.01	0.92	94.77	1.22
2020	96.51	0.80	97.34	0.85	98.24	-	96.37	1.15	95.16	0.92	95.05	1.51
Global	95.66	1.66	96.53	0.70	97.82	0.64	96.15	0.31	95.09	0.11	95.12	0.44

Two criteria of selection were implemented to select significant countries of each macroregion in order to minimize possible white noises from countries that are at the beginning of the certification process (Sampaio and Saraiva, 2010). Thus, aiming at a consistent analysis, it was established a minimum of ten carried out audits by country in 2020 to evaluate the audits results and a minimum of ten passed audits by country in 2020 to analyze the dissemination of IFS Food certification among macroregions.

3.3 Analysis of current benefits and obstacles of FSMS implementation

To clarify the behavior of both expansion and diversification of the studied food safety management systems standards, empirical research was carried out in the end of 2021 and covered the implemented food safety management system activities. An online questionnaire was used as a research tool and, in order to achieve the assumed goals, the full questionnaire encompasses both open and closed questions, which include social-demographical issues and specific topics, such as main motivations, benefits and,



obstacles of the FSMS implementation and decertification process. The following research questions were formulated:

1. How many employees does the company employ?
2. What is the economic activity of the company?
3. Where is the company geographically located?
4. How many years does the company have an implemented food safety management system (certified or not)?
5. Which of these food safety management system certifications does the company have?
6. Is the implemented food safety management system integrated with another quality management system standard? If the answer is yes, which standards are integrated with the implemented FSMS?
7. What are the motivations for obtaining certification?
8. In the company, what were the main benefits of certification?
9. In the company, what are the main difficulties for obtaining certification?
10. Has the company already opted for the decertification process? If the answer is yes, which standards were decertified by the company? Indicate some reasons for the occurrence of this process.
11. Open question to the company expresses some opinions concerning implementation of FSMS (experiences, difficulties, positive impacts, etc.).

The research process covered mainly Portuguese organizations within food chains and the survey forms were sent to the representatives of the implemented management systems. Furthermore, aiming at extending the survey reach, an English version of the questionnaire was shared to a largest professional network.

3.4 Limitations

The research methodology adopted in this study presents some limitations. First, to overcome the difference in scale among the evaluated countries, it must be emphasized that the absolute numbers were used on a relative basis encompassing the number of inhabitants (*per capita* indicator). Thus, both IFS Foodpc, ISO 22000pc and FSSC 22000pc indicators consider the number of certificates issued *per* 1000 inhabitants.

Regarding the ISO 22000 certification, the available data are related to the restricted period from 2007 to 2020 and this fact impairs the full assessment of the complex diffusion process. Furthermore, the



number of issued certificates or sites covered by ISO 22000 may contain errors once these data are provided by certification bodies that voluntarily participate of the ISO Survey (ISO Survey, 2020).

Related to FSSC 22000, information encompassing number of certificates by country from the last years to date were directly requested through the official website. However, the requested data have not been made available, thus an extensive analysis could not be performed.

On the other hand, although the IFS has made available the requested information, data of IFS Food certification from 2017 to 2020 are not enough to evaluate the diffusion process through a forecasting model. Moreover, during the analysis of the provided IFS Food data, it was also noticed large variation between information by year (i.e., number of reported countries by year) and this fact impacts the results not allowing a better understanding of the worldwide IFS Food dissemination.

About the analysis of current drivers of FSMS implementation, the low percentage of collected survey forms is due to the short period of research. However, the collaboration of all involved organizations contributes to clarify the current scenario of both implementation and maintenance of FSMS certification, regarding benefits and difficulties.

Although the uncertainty predicted due to explained limitations, it is possible to assume that the understanding of the worldwide FSMS diffusion process still is a current challenge. The uncertainties associated with the empirical results will be minimized by updating new data from forthcoming years in order to overcome these limitations.



4. RESULTS

4.1 Diffusion of Food Safety Management System Standards – Overview

The worldwide dissemination of FSSC 2200, ISO 22000 and, IFS Food certifications were analyzed and the current distribution of these international food safety management standards all over the world is presented in Figure 3. The distribution of sites covered by FSMS certifications is considered unequal because of its wide dissemination among different countries and regions. However, despite FSMS certifications cross borders, their behavior still demonstrates the geographic pattern related to the origin of the standards (Havinga, 2013).



Figure 3. Current worldwide diffusion of FSSC 22000 (yellow), ISO 22000 (red) and IFS Food (green) (Source: author).

Some patterns within the scope of this study emerge from the data by looking at the world map above, such as the geographic distribution of each standard. The majority of defined macroregions is covered by two studied standards, FSSC 22000 and ISO 22000. The Americas and Africa are mainly covered by FSSC 22000 certification, while ISO 22000 certification is the major adoption by Asia, the Pacific and the Middle East. The only exception is Europe that has IFS Food as the main adopted standard.

The current power of multinational food retailers not only enables the changing food governance system, but also supports the globalization of food supply chain, which became increasingly international due to the improved techniques of food processing and transportation (Havinga, 2013). As a result of this, FSSC 22000 and ISO 22000 standards have a high international adoption even though they are Europe-based. In their study of worldwide FSMS diffusion, Mohammed and Zheng (2017) evidenced that some food safety management system standards cover primarily surrounding countries, as is the IFS Food certification. To support this, Havinga (2013) also stated that European food retailers mainly adopt retail-driven food standards such as, BRC (British Retail Consortium) and IFS.



To reinforce the above mentioned, Table 10 shows the Top Ten Countries by the current number of issued certificates, considering both standards. The evidenced absolute data in that table not only update the numbers of issued certificates by country for the year of 2013 presented by Mohammed and Zheng (2017), but also add data concerning IFS Food certification.

Table 10. FSSC 22000, ISO 22000 and IFS Food: Top Ten Countries by the current number of issued certificates.

FSSC 22000				ISO 22000				IFS Food			
Nº.	Macroregion	Country	2021	Nº.	Macroregion	Country	2020	No.	Macroregion	Country	2020
1	East Asia and Pacific	China	3257	1	East Asia and Pacific	China	12,929	1	Europe	Italy	3704
2	East Asia and Pacific	Japan	2865	2	Europe	Greece	2069	2	Europe	Spain	2982
3	Central and South Asia	India	1776	3	Central and South Asia	India	1767	3	Europe	Germany	2335
4	North America	USA	1465	4	East Asia and Pacific	Japan	1503	4	Europe	France	1918
5	East Asia and Pacific	Korea, Republic of	1079	5	Europe	Italy	929	5	Europe	Poland	915
6	North America	Mexico	989	6	Europe	France	804	6	Europe	Netherlands	806
7	Europe	Netherlands	931	7	East Asia and Pacific	Taiwan	763	7	Europe	Belgium	630
8	Africa	South Africa	901		Europe	Turkey	763	8	Europe	Hungary	489
9	Europe	Russian Federation	802	8	Europe	Spain	583	9	Europe	Greece	432
10	Europe	Turkey	699	9	Europe	Romania	581	10	Europe	Austria	395
				10	East Asia and Pacific	Viet Nam	570				

Even after almost ten years, the majority of countries remains the same, only with different ranking positions. The United States of America dropped down three ranking positions and the follow countries became the new Top 3, China (1^o), Japan (2^o), and India (3^o) regarding FSSC 22000 certification. The countries Republic of Korea and Turkey are the novelties on the list, replacing Germany and Brazil. Encompassing ISO 22000 standard, the Top 3 remains exactly the same (China, Greece, and India) and countries, such as Malaysia and Poland were replaced by France, Taiwan and Viet Nam.

Among the worldwide number of certifications, China leads both Top 10 FSSC 22000 and ISO 22000, attaining an amount of 3257 and 12,929 issued certificates, respectively. Regarding the diffusion of ISO 9001 and ISO 14001, the same ranking positions of China (1^o) and Japan (2^o) were founded by Sampaio and Saraiva (2010). Italy also had a significant contribution in both studies by holding the 2^o ranking position of ISO 9001 certification as well as the highest worldwide number of IFS Food certifications, reaching an amount of 3704 issued certificates.

It is important to emphasize that two macroregions have significant expressions in the presented rankings.



East Asia and Pacific and Europe represent 60% and 91% encompassing FSSC 22000 and ISO 22000 certification, respectively. Europe represents 100% of the IFS Food ranking, which the current Top 4 countries corroborate the stakeholder demands are predominantly required by retailers from Germany, France and Italy (Baines, 2010). A strong growth of the East Asia and the Pacific and Central and South Asia, particularly China, Japan and, India may be supported by Albuquerque *et al.* (2007) and Franceschini *et al.* (2010), who stated that commercial pressures increased interest in standardization, such as ISO 14001 certification in China.

With the above in mind, food exports activities have positive effects on a country by creating a huge demand for food safety certification (Mohammed and Zheng, 2017). Related to this, the number of exporting and importing countries has increased and it contributes to the expansion and diversification of the food trade (FAO, 1998).

Analyzing the Top 30 Countries encompassing FSSC 22000, ISO 22000 and IFS Food certification (Appendix I), they only represent respectively 19.11%, 19.35% and, 33.33% of the total of countries covered by each standard. However, considering absolute numbers of issued certificates, these countries lead the current FSMS diffusion scenario encompassing FSSC 22000, ISO 22000 and IFS Food once their certification represent 81.86%, 87.80% and, 97.92% of the total amount of worldwide issued certificates, respectively. Similar results were found by Sampaio and Saraiva (2010) in a study that presented a global analysis of management systems. Based on data from the year 2009, these authors evidenced that the Top 30 countries covered by ISO 9001 and ISO 14001 hold, respectively, 90% and 87% of the worldwide issued certificates, even these countries in each Top 30 represent only 17% of the total amount regarding ISO 9001 certification and 19% when related to ISO 14001 certification.

Official data related to FSMS standards and their dissemination are scarce and relatively recent, since the first edition of ISO 22000 was published in 2005 and the recognition of the IFS Food and FSSC 22000 standards by GSFI occurred in 2003 and 2010, respectively. These facts do not allow a consistent analysis of the studied FSMS behavior through the years and it must be emphasized the necessity of comparison with other widely implemented quality management standards, such as ISO 9001 and ISO 14001.

Considering the current available data, Figure 4 shows the certification of both studied standards through the years. As mentioned in the topic 3.5 of this dissertation, some uncertainties are ascribed to the results since the official data are not enough to evaluate clearly the diffusion process of both standards. With that in mind, FSSC 22000 reached a total of 27,707 issued certificates in 2021, while in the year of 2020, ISO 22000 and IFS Food Certification reached an amount of 33,741 and 17,881 worldwide issued certificates, respectively.

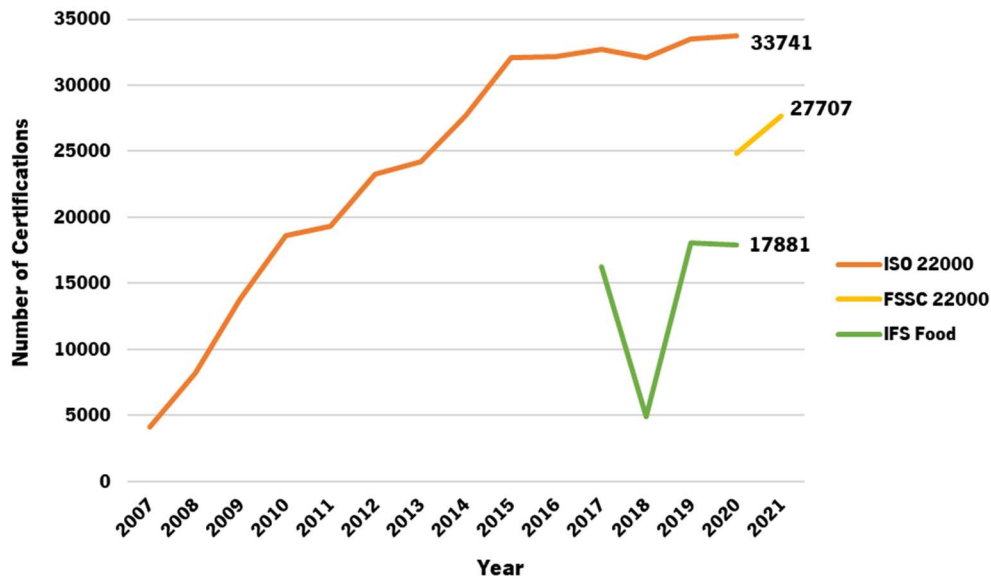


Figure 4. Number of worldwide FSSC 22000, ISO 22000 and IFS Food certificates through the years based on available data (Source: author).

Considering the current available data, it is possible to state that FSSC 22000 certification holds the highest global growth rates. The absolute number of FSSC 22000 certificates increased by +9.86% in 2020-2021. ISO 22000 certification had a growth rate of +3.13% in 2019-2020, while IFS Food certification had a negative growth rate reaching -1.05% over the same period. It must be highlighted that IFS Food data present variation as mentioned in the topic 3.5 of this dissertation and the uncertainty associated with these results will be minimized by updating new data from forthcoming years.

Aiming at overcoming the difference in scale among the evaluated countries, the follow analysis consider the number of certificates issued per 1000 inhabitants (Sampaio and Saraiva, 2010; Sampaio *et al.*, 2011 and Saraiva and Duarte, 2003). Thus, both FSSC 22000pc, ISO 22000pc, and IFS Foodpc indicators represent the relative basis *per capita*. Furthermore, criteria of selection were applied to select countries that present a minimum of ten issued certificates or a minimum of ten passed audits by *country*. As a result, 119 countries were selected. Tables 11 shows the geographic distribution of selected countries based on defined macroregions.

Table 11. Geographic distribution of countries selected by the criteria minimum of ten issued certificates or a minimum of ten passed audits by *country*

Macroregion	N ^o Countries	%
Africa	17	14%
Central and South America	19	16%
Central and South Asia	11	9%
East Asia and Pacific	16	13%
Europe	42	35%
North America	3	3%
Middle East	11	9%



Beside Africa has a significant number of countries that hold FSSC 22000 or ISO 22000 certification, 35 and 38 countries, respectively, this macroregion only represents 14% of the selected countries. Encompassing Asia, Middle East, Central and, South America, the low percentages presented may be supported by To and Lee (2014). These authors stated that the dissemination of certification is recent among companies in South America and Euro-Asia, when analyzing the global diffusion of ISO 14001 certification.

On the other hand, Europe represents 35% and these selected countries comprises the majority of the European countries. From an average of 45 European countries that hold at least one certification encompassing the studied standards, an amount of 42 were selected. These findings largely corroborate the findings of Mohammed and Zheng (2017), which stated that Africa tends to have lowest numbers for any FSMS standard, whereas Europe holds highest number of certifications among the Europe-based standards.

In addition, only 45 selected countries present current data encompassing all three standards studied in this dissertation (Appendix II). Table 12 shows the geographic distribution of selected countries based on defined macroregions.

Table 12. Geographic distribution of selected countries, which present simultaneously FSSC 22000, ISO 22000 and IFS Food certification.

Macroregion	N ^o	%
Africa	3	7%
Central and South America	5	11%
Central and South Asia	3	7%
East Asia and Pacific	3	7%
Europe	30	67%
North America	1	2%

Analyzing the macroregions of selected countries that present both FSSC 22000, ISO 22000 and IFS Food certifications, North America has only one representative country (USA) and no Middle Eastern countries were selected. It must be emphasized that all selected countries have economies considered as high or middle-income (World Bank, 2021b) and some studies regarding global diffusion of management standards (i.e., Albuquerque *et al.*, 2007 and To and Lee, 2014) evidenced that the economic development of countries is directly related to worldwide diffusion processes. Other aspect that must affect this selection is related to the certified sites. Countries which present limited number of certified sites are focused on adoption of only one standard (Mohammed and Zheng, 2017).

However, some high-income and middle-income countries were not selected by the established criterion, such as Mexico, which is considered upper-middle-income country as well as countries, such as Canada, Saudi Arabia and United Arab Emirates that are considered high-income countries (World Bank, 2021b).



It suggests that other aspects also affect the adoption of an international standard and its spread, such international food trade issues and specific requirements of retailers. Regarding the FSMS implementation in developing countries, the European retailers require from African or Asian suppliers the guarantee of safe and quality products (Havinga, 2013). Thus, retailers have currently a powerful role in the food safety regulation and certification.

Furthermore, Chkanikova and Mont (2012) consider these retailers as change agents toward more sustainable food systems once greening the supply chains are a strong concern and a challenge in 21st century for businesses and logistics management (Diabat and Govindan, 2011).

4.2 FSSC 22000

Currently, an amount of 157 countries are covered by FSSC 22000 certification. Europe and East Asia and Pacific represent together 67% of the absolute number of certificates, reaching, respectively, 8647 and 9954 issued certificates (Figure 5). A minor contribution was evidenced by Middle East, reaching an amount of 549 certificates among 15 countries. Based on the established criteria, 109 countries were selected for the followed analysis.

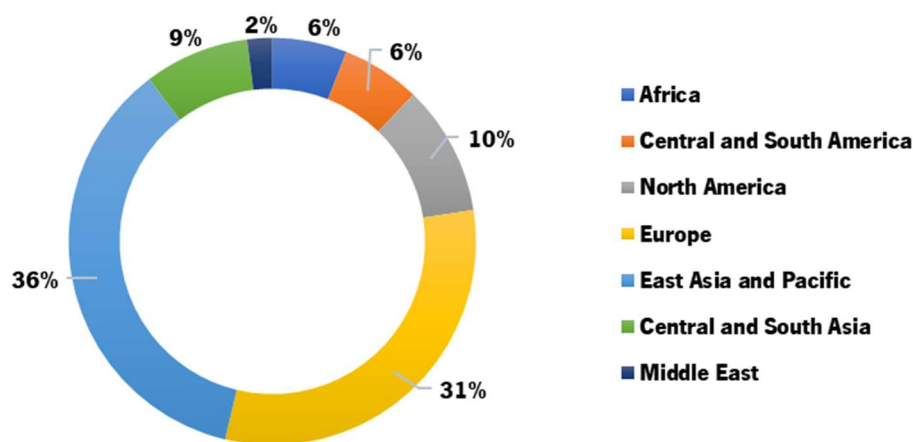


Figure 5. Dissemination of FSSC 22000 certification among macroregions of the world (Source: author).

Considering the relative basis *per capita*, a new FSSC 22000 Top 10 Countries was elaborated (Table 13). As a result, Europe lead the spread of worldwide FSSC 22000 certification and China reached the 66^o ranking position, in opposition to its 1^o position when analyzed the absolute numbers of certificates. Through a comparison between FSSC 22000 Top 10 and FSSC 22000pc Top 10, the first has a wide coverage of macroregions, encompassing Africa, Central and South Asia, East Asia and Pacific, Europe and North America. FSSC 22000pc Top 10 covers only 3 macroregions, one of which is new (Central



and South America). Europe represents 81.8% of the FSSC 22000pc Top 10, evidencing the positive effect of standard's origin once FSSC 22000 is a Europe-based standard (Mohammed and Zheng, 2017). FSSC 22000pc values vary between 0.0254 (Costa Rica) and 0.0538 (Netherlands). Netherlands, which holds the 7^o ranking position in the Top 10 Countries by FSSC 22000 absolute number of issued certificates, now lead the list of countries with highest FSSC 22000pc values followed by Switzerland and Finland, reaching 0.0467 and 0.0376 FSSC 22000 issued certificates *per capita*, respectively.

Table 13. FSSC 22000 Top Ten Countries by the current number of issued certificates *per capita*.

Nº	Macroregion	Country	FSSC 22000pc
1	Europe	Netherlands	0.0538
2	Europe	Switzerland	0.0467
3	Europe	Finland	0.0376
4	Europe	Greece	0.0339
5	Europe	Sweden	0.0282
6	Europe	Norway	0.0275
7	Europe	Serbia	0.0270
8	Europe	Cyprus	0.0258
9	Europe	Bulgaria	0.0257
	East Asia and Pacific	New Zealand	0.0257
10	Central and South America	Costa Rica	0.0254

Therefore, it must be emphasized that an amount of 6 countries that are present in the Top 10 Countries by FSSC 22000 absolute number of issued certificates do not have ranking positions in the Top 30 Countries (Appendix I) by FSSC 22000pc: India (0.0013), China (0.0023), USA (0.0045), Russian Federation (0.0056), Mexico (0.0078) and, Turkey (0.0084).

Considering macroregion-level, Europe also has the highest number of issued certificates *per capita* (0.0102) followed by North America (0.0058), East Asia and Pacific (0.0043), Central and South America (0.0037), and Middle East (0.0032). Africa evidenced 0.0018 FSSC 22000 issued certificates *per capita* followed by the lowest number of issued certificates *per* 1000 inhabitants related to Central and South Asia, reaching an amount of 0.0012.

The result above seems controversial once North America was not presented in FSSC 22000pc Top 10 even though holds the second ranking position in the macroregion-level analysis. Canada is the only North American country that represents its macroregion in the FSSC 22000pc Top 30 (Appendix I), reaching 0.0109 issued certificates *per capita* and holding the 26^o ranking position. Mexico holds the 38^o (0.0078) and USA evidenced 0.0045 issued certificates *per capita*, representing the 52^o ranking position.

There is a lack of available information about the number of FSSC 22000 certifications through the years. Based on data from Havinga (2013) and current available absolute data, Figure 6 shows the evolution of



worldwide FSSC 22000 certifications as well as the evolution of this standard in Europe, encompassing the years of 2012, 2020 and 2021.

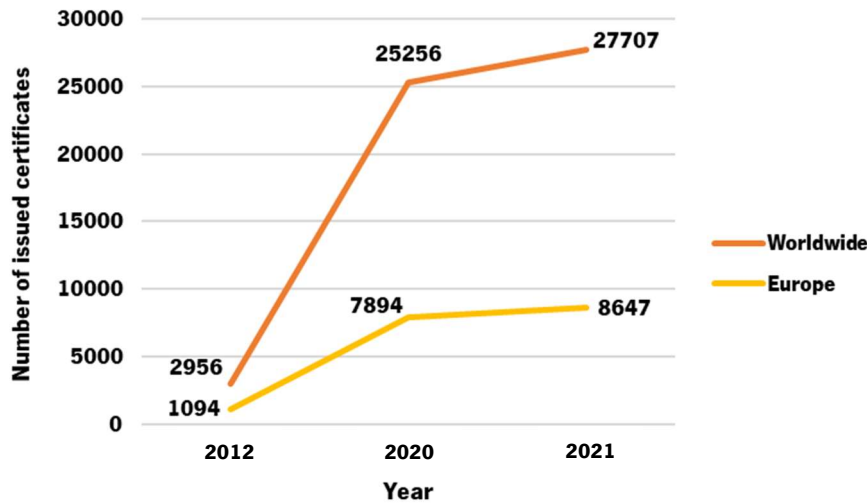


Figure 6. Evolution of FSSC 22000 based on Havinga (2013) and current available data (Source: author).

Covering companies from 109 countries, in the year of 2012 Europe represented 37% of the total FSSC 22000 issued certificates, while the macroregions Africa, Asia and South America represented together 39% of the worldwide certification (Havinga, 2013). When compared with the current data, it is possible to evidence an increase of 44% of covered countries by FSSC 22000 certification.

Encompassing the number of issued certificates in 2012 and 2021, respectively a global amount of 2956 and 27,707 certificates were reached, indicating a worldwide growth rate of +837% during the last decade. The evolution of FSSC 22000 certification in Europe considering the same period, 2012 and 2021, also has a high growth rate reaching +690%. These analyzes support the current dissemination of the FSSC 22000, since its number of issued certificates continues to increase. In the last year, Europe had a growth rate of +10%, following the worldwide growth that also presented a growth rate of +10%.

However, still considering the last year, the macroregions Central and South Asia and East Asia and Pacific had the highest growth encompassing the FSSC 22000 certification and its absolute numbers of issued certificates. Their growth rates represent, respectively, +16.27% and +13.67%. The minor contribution was presented by North America (+4.49%).

Representative countries from these aforementioned macroregions, such as Hong Kong (+28.57%) and Singapore (+24.39%) hold the highest growth rates, followed by India (+19.03%), China (+18.87%), and Indonesia (+18.36%). Japan and Republic of Korea, despite having lower growth rates, contributed significantly to the absolute number of issued certificates, reaching 245 and 130 new issued certificates



in the last year, respectively. Regarding cross-country effects, the results mentioned above may be supported by Albuquerque *et al.* (2007). Through an analysis of spatio-temporal global diffusion of ISO 9000 and ISO 14000 certification, the authors stated that in some countries, such as India, the initial process of diffusion are guided by innovation and bilateral trade issues. Therefore, trade relations with USA, Japan, United Kingdom, Hong Kong and United Arab Emirates have significant influence on standards adoption processes.

In order to qualify the current certification of FSSC 22000 among defined macroregions, a food chain categories analysis was elaborated and the results were summarized in the Figure 7. FFCs, such as Processing of ambient stable products, Processing of perishable animal products, Production of food packaging and packaging materials, and Production of (Bio) Chemical's had the highest global percentages, presenting respectively 46.5%, 13.1%, 12.5%, and 10.4%, followed by Processing of perishable plant products (8.3%) and Processing of mixed perishable animal and plant products (6.1%). Considering the certified scope of each macroregion, the major FFC, Processing of ambient stable products, reached an average of 48.5% with a minimum of 42.8% (Europe) and a maximum of 57% (Central and South Asia). These results evidence the main focus of the worldwide FSSC 22000 certification.

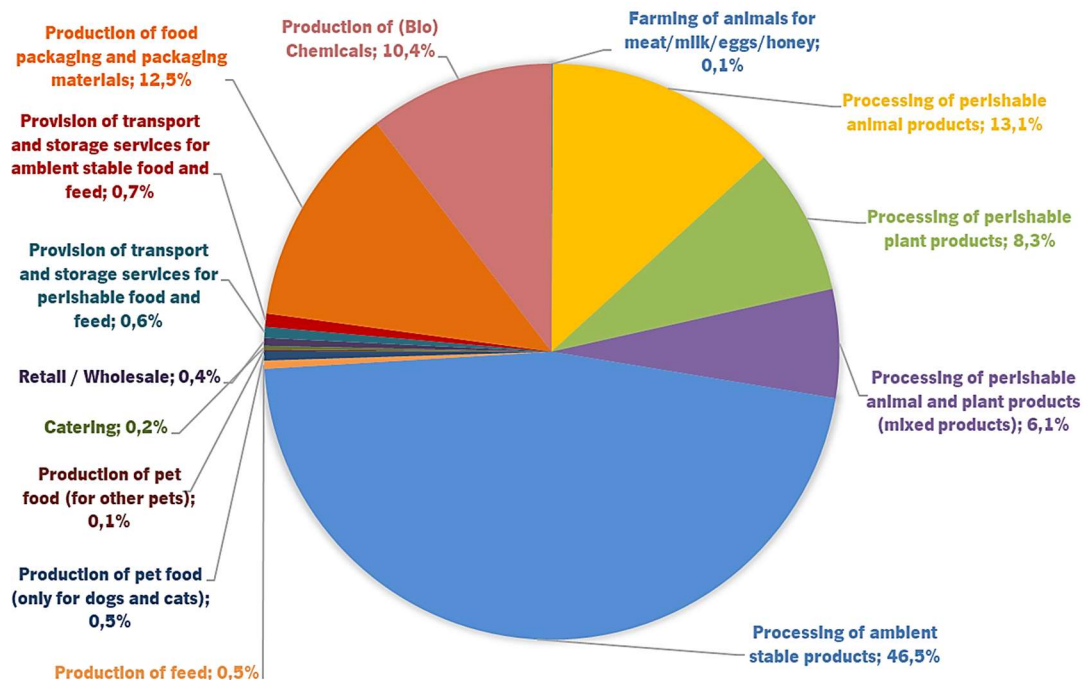


Figure 7. Qualification of worldwide FSSC 22000 certifications based on the 14 Food Chain Categories (Source: author).

It must be emphasized the significant contribution of Europe and East Asia and Pacific among the presented main FFCs encompassing the absolute number of certifications by category. However, when



analyzing the distribution of FSSC 22000 issued certificates among the food chain categories, such as Production of food packaging and packaging materials, the Americas have highest numbers of companies that hold a FSSC 22000 certification encompassing this scope. To evidence this, Central and South America presented an amount of 16% and North America presented 15.8% of certified scope for the activities of food packaging and packaging materials production, while Europe presented 9.1%.

Similar results were found regarding the Production of (Bio) Chemical's category. East Asia and Pacific and Europe also have a huge positive impact on global analysis (1219 and 1013 FSSC 22000 issued certificates, respectively), however, it represents an amount of 9.3% and 9.9% among the FFCs, respectively. In contrast, North America and Central and South America presented 17.5% and 13.1% of the total certified scope intended to companies within activities of (Bio) Chemical's production.

The findings suggest that these certifications in American continent mentioned above are relatively related. Beside the vertical effect caused by stakeholder's requirements, the horizontal and positive impact of geographic distance allows surrounding countries to observe and share information related to management practices issues (Albuquerque *et al.*, 2007).

To conclude this section, the categories "Farming of animals for meat/milk/eggs/honey; Production of feed; Production of pet food (only for dogs and cats); Production of pet food (for other pets); Catering; and Retail/Wholesale" had the lowest participation and together represent an amount of 1.8% of the total FSSC 22000 issued certificates in 2021 all over the world. Interestingly, only Africa has companies certified by FSSC 22000 encompassing the FFC Farming of animals for meat/milk/eggs/honey. The powerful worldwide spread and the wide adoption of GLOBALG.A.P. in European countries (Havinga, 2013) may be important aspects that affect FSSC 22000 certification encompassing that scope. GLOBALG.A.P is a GFSI recognized trademark focused on good agricultural practices that had in 2020 206,418.000 producers under the Integrated Farm Assurance certification, which is the most widely used product of this trademark. Europe has the majority of certified producers, followed by Africa, reaching in 2020 59.9% and 17.9% of the total number producers under IFA certification, respectively (GLOBALG.A.P., 2020)

4.3 ISO 22000

According to ISO Survey (2020), ISO 22000 certification reached an amount of 33,741 worldwide issued certificates distributed among 155 countries. Figure 8 shows the dissemination of these certificates among the defined macroregions and it is possible to state that similar results were found related to the



major macroregions within FSSC 22000 certification. East Asia and Pacific and Europe represent, respectively, 54% and 29%, reaching an amount of 28,042 issued certificates.

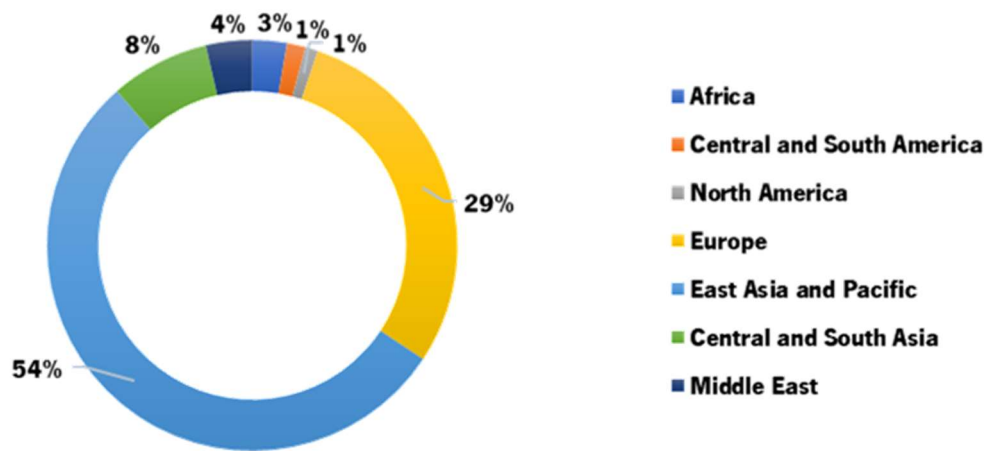


Figure 8. Dissemination of ISO 22000 certification among macroregions of the world (Source: author).

It must be emphasized that similarities within ISO 22000 behavior in the Americas were again noticed. Considering a spatio-temporal analysis of the global diffusion of both ISO 9001 and ISO 14001 certifications, Albuquerque *et al.* (2007) stated that both trade flows and diffusion processes of certifications are associated with countries, which present geographic proximity or cultural similarity. In particular, the number of ISO 22000 certified sites in China as well as BRC and GlobalG.A.P., are positively related to the export-oriented path encompassing food exports to the USA (Zheng *et al.*, 2013). Nowadays, China reached an amount of 12,929 issued certificates. It represents 71% of the certification in the macroregion East Asia and Pacific and 38% concerning global ISO 22000 certification. However, even China holding the first ranking position of the Top 10 countries by the absolute number of issued certificates, this country is not present in the Top 30 countries, considering the relative basis. Table 14 shows the Top 10 countries based on the number of ISO 22000 issued certificates *per capita*. Based on the established criteria, an amount of 105 countries were selected for the followed analysis.

Table 14. ISO 22000 Top Ten Countries by the current number of issued certificates *per capita*.

Nº	Macroregion	Country	ISO 22000pc
1	Europe	Greece	0.1934
2	Europe	Cyprus	0.1567
3	Central and South Asia	Maldives	0.0560
4	East Asia and Pacific	Singapore	0.0526
5	Europe	Macedonia	0.0524
6	Europe	Bulgaria	0.0420
7	Central and South America	Suriname	0.0417
8	East Asia and Pacific	Macao, Chinese	0.0328
9	East Asia and Pacific	Taiwan	0.0323
10	Europe	Netherlands	0.0310



Since European countries started processes regarding ISO standards implementation much earlier than other parts of the world (To and Lee, 2014), and in addition to FSSC 22000 certification, Europe also represented a significant contribution to ISO 22000 diffusion process all over the world. An amount of 50% of ISO 22000pc Top 10 countries are European countries, which 4 are presented in both Top 10 FSSC 22000pc and ISO 22000pc countries, as follows: Bulgaria, Cyprus, Greece and Netherlands.

Encompassing the defined macroregions, Europe also has the highest number of issued certificates *per capita* (0.0117) followed by East Asia and Pacific (0.0079) and Middle East (0.0071). Africa and Central and South America represent both 0.0010 and the lowest contribution was evidenced by North America, reaching only 0.0007 issued certificates *per* 1000 inhabitants.

Concerning country-level, ISO 22000pc values range between 0.0310 (Netherlands) and 0.1934 (Greece). Greece leads this ranking followed by Cyprus that evidenced 0.1567 ISO 22000 issued certificates *per capita*. These results are considered extremely low when compared with ISO 9001 worldwide issued certificates also on a relative basis. Sampaio and Saraiva (2010) evidenced results reaching 2.16 ISO 9001 issued certificates *per capita* in Italy, followed by Switzerland (1.50), Czech Republic (1.34), Spain (1.30) and Israel (1.03). However, when compared the difference between Top 10 Countries and Top 10 Countries *per capita*, both studies identified that significant countries with highest absolute number of issued certificates do not comprise the Top 10 based on a relative basis. Seven countries with the highest absolute number of ISO 22000 issued certificates have not been evidenced even in the Top 30 countries *per capita* (Appendix I), as follows: France, Japan, Spain (both 0.012), China, Turkey (both 0.009), Viet Nam (0.006), and India (0.001). Encompassing ISO 9001pc certification, four countries were not identified in the Top 30, as follows: China (0.19), Russia (0.37), India (0.03), and USA (0.09).

Concerning the evolution of ISO 22000 certification in the last year, a global amount of new 239 certificates were reached, indicating a worldwide growth rate of +3.13%. Africa presented the lowest growth rate (-18.05%), followed by North America (-13.66%) and Central and South Asia (-13.03%). The macroregion East Asia and Pacific is the largest and only macroregion that evidenced a significant positive growth rate reaching +13.18%. Among the countries of this last mentioned macroregion, Thailand presented the highest growth (+45.14%), followed by Australia (+41.18%), Viet Nam (+21.28%), and Indonesia (+18.73%). However, when compared with the absolute number of issued ISO 22000 certificates, China evidenced the major contribution by means of 785 (+6.46%) new certifications in contrast to 49 new issued certificates in Australia.



The above contribution of East Asia and Pacific to ISO 22000 diffusion may be related to the international private retailers, which drive the adoption of certification in Asia as well as Africa and Latin America (Reardon *et al.*, 2003). Related to this, Mohammed and Zheng (2017) stated that the behavior of worldwide FSMS is positively affected by food export activities to North America and Europe, which own standards are popular in Europe as well. The authors also stated that suppliers in developing countries adopts certifications aiming at gain market access to developed countries and strengthen their competitive advantage.

In comparison with the other studied FSMS standards, ISO 22000 certification has more traceable and available data. Concerning the period from 2007 to 2018, Granja *et al.* (2021) provided a cross-sectional portrayal of the European diffusion of ISO 22000 certification. Through a forecasting models, the authors suggested that the saturation point of the diffusion process was already reached and the evolution of ISO 22000 issued certificates may keep constant until to attain the decertification stage. It corroborates the findings evidenced in this present study since European countries presented a negative growth rate of -4.21% in the last year, representing a reduction of 431 certificates issued in Europe.

Even though the wide spread of ISO 22000, Zimon and Rodrigues (2020) considered the popularity of this standard relatively unpopular in European countries, such as Portugal, Poland and Slovakia. The ISO 22000 poor popularity in Europe is probably related to the adoption of other specific and required standards used by different and specific areas in the food chain. Furthermore, the diffusion process of ISO 22000 probably is limited due to the non-recognition by GFSI as well as the lack of specificity (Granja *et al.*, 2021) once this standard is applicable to all types of producer and organizations within the global food supply chain, regardless size or sector (ISO 2000, 2021). In agreement with that, Escanciano and Santos-Vijande (2013) identified a constraint within ISO 22000 certification in Spain that is related to aforementioned standard's coexistence. Once they are often demanded by major distributor chains, companies do not see ISO 22000 standard as a current necessity.

4.3.1 Forecasting models of ISO 22000 certification

Currently reaching an amount of 33,741 issued certificates around the world (ISO Survey, 2020), forecasting models established to predict the behavior of ISO 22000 certification were developed using the OriginPro® software encompassing the data in Table 7. The parameters of each model are reported in Table 15.

Good fitting of data was evidenced by observing the statistic parameters. Figure 9 and 10 present a graphical representation of the obtained data.



Table 15. Parameters and statistics for the Gompertz fitting of available ISO 22000 data.

Curve parameters	Worldwide	Europe
a	34,958	10,565
xc	3.0518	1.6307
k	0.3177	0.3941
R^2	0.9859	0.9456

Considering the forecasting model based on worldwide ISO 22000 certification, it is possible to state that the inflection point was reached in 2009, representing an amount of 12,852 certifications and a maximum saturation level of 34,958 issued certificates. Figure 9 shows the predicted behavior of worldwide ISO 22000 certification through the years.

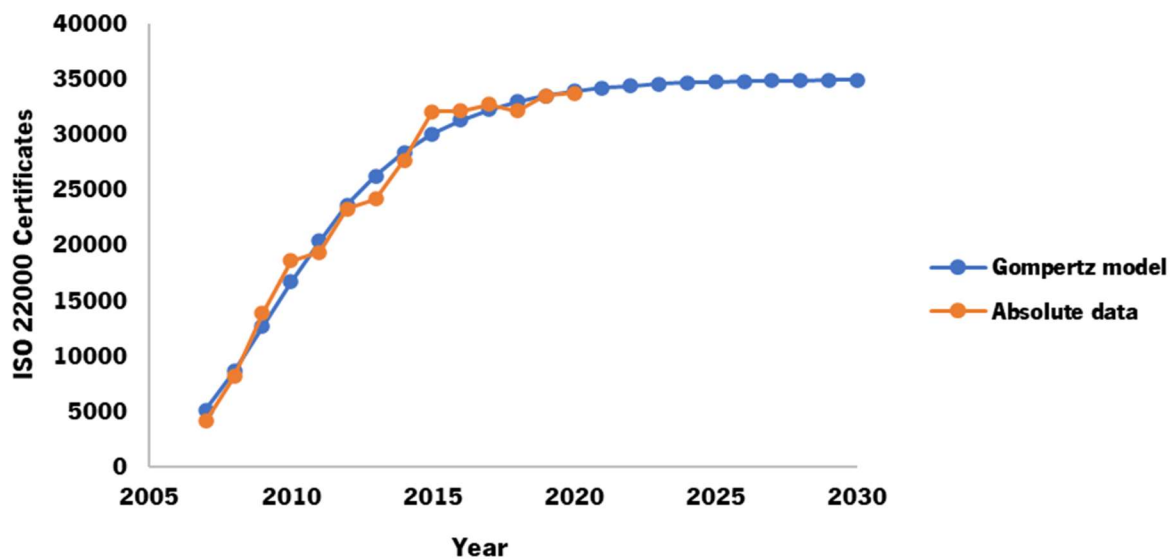


Figure 9. Forecasting model of worldwide ISO 22000 diffusion based on available data (Source: author).

However, there is a possibility that these results have not yet been reached once the lack of provided data impact the good performance of the forecasting model (Meade and Islam, 2006). The current available data are not enough to evaluate clearly the diffusion process of ISO 22000 certification around the world and the forecasting model must be updated with new available data from the forthcoming years.

Considering this lack of data, Granja *et al.* (2021) constructed forecasting models of ISO 22000 diffusion in Europe based on the growth of renowned international standards, such as ISO 9001 and ISO 14001. Figure 10 shows the updated forecasting model established by the aforementioned authors with additional number of issued certificates from the years 2019 and 2020 among European countries. Both forecasting models evidence similar results and indicate that Europe is currently positioned in the stationary phase (Granja *et al.*, 2021).



Analyzing the updated ISO 22000 dynamic of diffusion, it is possible to state that the saturation level will be reached in 2040 through an amount of 10,565 issued certificates. The inflection point was already reached in 2008, representing an amount of 3884 certifications, approximately.

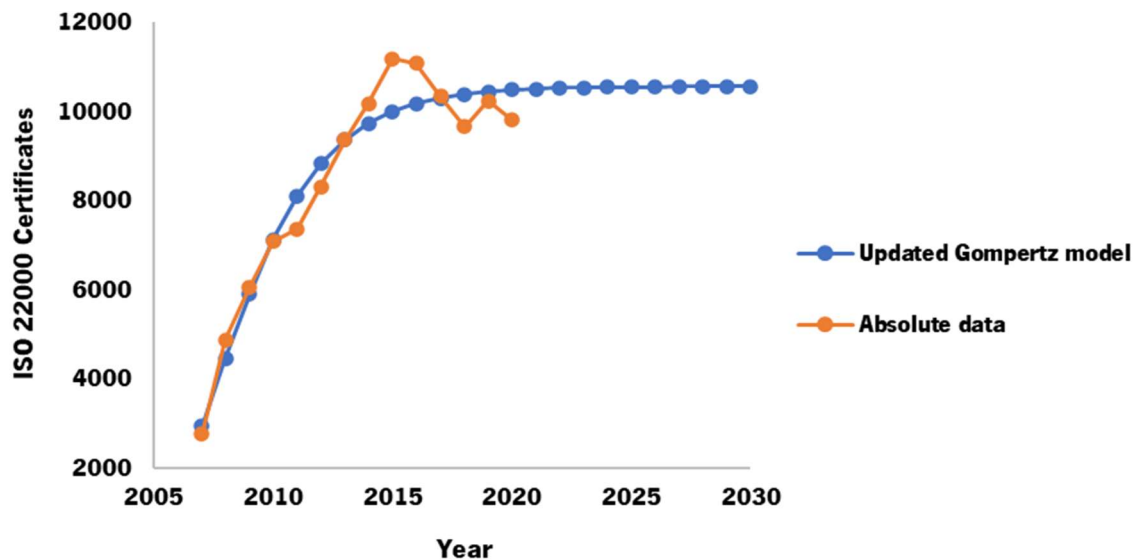


Figure 10. Forecasting model of European ISO 22000 diffusion based on available data (Source: author).

According to Franceschini *et al.*, 2006, the certification is devalued when the process of diffusion of a standard reaches the saturation effect. Furthermore, in analogy to the ISO 9001 standard, enhanced quality of products through ISO 22000 certification probably is not a good marketing tool among developed countries once they provide more business sophistication using different tools (Rodriguez-Arnaldo and Martínez-Lorente, 2020).

The popularity of ISO 22000 among Asian countries (Central and South Asia and East Asia and Pacific) also may be related to the findings of the aforementioned authors. Countries that do not have a good reputation use ISO 22000 certification as a worldwide recognized tool to maintain and attract new customers and so be able to be part of the international food trade.

According to Rodriguez-Arnaldo and Martínez-Lorente (2020), the country's high degree of development associated with better reputation is more appreciated than only hold a certificate. Concerning these countries, variables, such as innovation, business sophistication, and competitiveness are linked.

Based on both forecasting models developed, the intervals proposed by Granja *et al.* (2021) also were updated. As a result, Figure 11 empirically confirmed that the dynamic of ISO 22000 diffusion may be similar with the diffusion of ISO 22000 based on ISO 14001 growth.

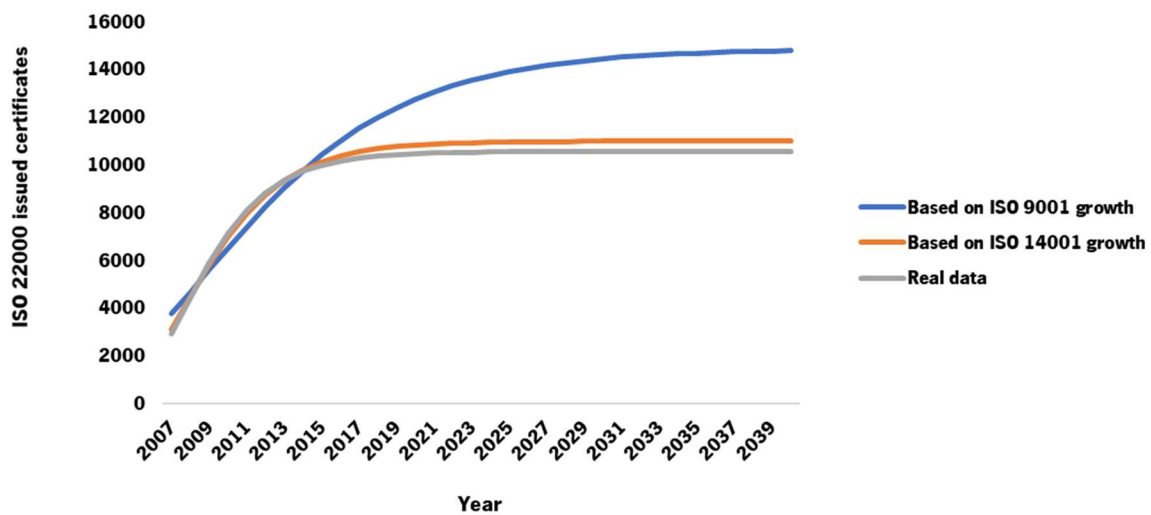


Figure 11. Suggested intervals based on both ISO 9001 and ISO 14001 to analyze ISO 22000 certification by Granja *et al.* (2021) updated with additional data from more recent years (Source: author)

This similar behaviour suggests that ISO 22000 diffusion may be related to not only geographic proximity, but also cultural similarity among European countries. According to Albuquerque *et al.* (2007), the role of cultural similarity appeared larger for ISO 14000 when compared with ISO 9000 certification. The authors concluded that the drivers, which lead the implementation of ISO 14000 are related to a broader set of stakeholders in harmony with communities and authorities resulting in a different trade flow of the ISO 9000 diffusion. Considering that global agriculture and food trade are strongly governed by several international standards and regulations (Herzfeld *et al.*, 2011), the similarities of diffusion processes between ISO 14000 and ISO 22000 may be suggested. However, it has to be taken into account that studies encompassing the diffusion of standards involve different variables that are highly correlated (Rodriguez-Arnaldo and Martínez-Lorente, 2020) and the uncertainty associated with these results will be minimized by updating new data from the forthcoming years.

4.4 IFS Food

Since IFS does not publicly disclose information on its certification, the analysis of IFS worldwide Food diffusion is a challenge to be overcome with limited data. However, the results based on data provided by IFS show a certification with particular behavior once only European countries comprise both IFS Food Top 10 countries and Top 10 countries *per capita*. This dominant behavior in Europe was already expected once Havinga (2013) evidenced that the majority of companies covered by IFS, BRC and GlobalG.A.P. is European. Considering the 47 selected countries based on established criteria, Spain leads the ranking reaching 0.0633 IFS Food issued certificates *per* 1000 inhabitants, followed by Italy (0.0614) and Belgium (0.0548) (Table 16).

**Table 16.** IFS Food Top Ten Countries by the current number of issued certificates *per capita*.

Nº	Macroregion	Country	IFS Foodpc
1	Europe	Spain	0.0633
2	Europe	Italy	0.0614
3	Europe	Belgium	0.0548
4	Europe	Hungary	0.0499
5	Europe	Netherlands	0.0466
6	Europe	Austria	0.0444
7	Europe	Croatia	0.0407
8	Europe	Greece	0.0404
9	Europe	Slovenia	0.0390
10	Europe	Czech Republic	0.0350

In comparison with the IFS Food Top 10, Spain and Italy continue leading the list with the highest number of IFS Food certifications. Croatia (0.0407), Slovenia (0.0390) and Czech Republic (0.0350) replaced France, Germany, and Poland, however these last countries comprise the IFS Foodpc Top 30 countries, holding the 11^o, 13^o and 15^o ranking positions, respectively.

Considering the year of analyzed data, the European country that reached the lowest number of IFS Food certificates *per capita* was the United Kingdom (0.0004), holding the 37^o ranking position in 2020. Interestingly, even considering all countries with the highest number of IFS Foodpc certification, Europe continues representing the majority of listed countries, reaching 93% of IFS Foodpc Top 30 countries (Appendix I). Only two countries from different macroregions were identified in the aforementioned list, as follows: Chile holding the 28^o ranking position with 0.0032 IFS Foodpc issued certificates followed by Tunisia (0.0025), representing Central and South America and Africa, respectively.

Regarding the dissemination of IFS Food among the defined macroregions, Middle East did not contribute to the expansion of these FSMS standard once among 4 countries only 5 certificates were issued and it did not allow them to be selected by the established criteria. Except Europe, the other macroregions presented very low levels of IFS Food certification ranging between 0.0001 (North America) and 0.0003 (Central and South America) IFS Food issued certificates *per capita*. Central and South Asia was not considered in this interval once the amount of 85 issued certificates distributed among the population of this aforementioned macroregion is not significant.

Currently, IFS Food certification covers an amount of 90 countries all over the world. Encompassing the absolute number of issued certificates, Europe, obviously, has the major contribution because of its 16,937 new certifications. This amount represents 94.8% of the worldwide IFS Food certification, followed by East Asia and Pacific (2.9%) that reached an amount of 519 issued certificates. Africa, both Central and South America and Asia, North America and Middle East represent together 2.3% of the total IFS Food certification in 2020, reaching an amount of 423 issued certificates. Figure 12 shows the distribution of these certification among the defined macroregions.

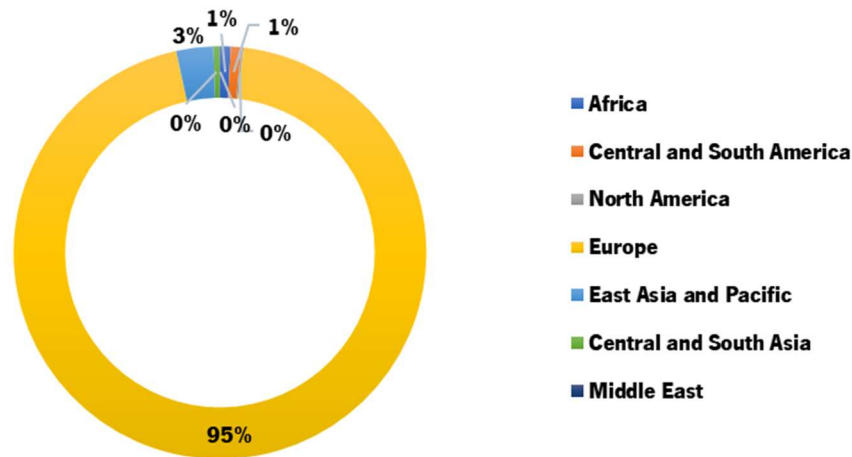


Figure 12. Dissemination of IFS Food certification among macroregions of the world (Source: author).

The evidenced behavior and the numbers attained by Top 3 of both IFS Food (1° Italy, 2° Spain and 3° Germany) and IFS Foodpc (1° Spain, 2° Italy and 3° Belgium) reinforces the powerful relationship among European retailers, especially and historically German, French and Italian retailers that comprise the begin of this initiative (Havinga, 2013). The author also stated that IFS Food as well as BRC are predominantly applied in European countries.

It is interesting to emphasize that the low popularity of IFS Food in North America may related to the SQF and PrimusGFS adoption, which both are American food safety standards recognized by GFSI. North America presented only 31 issued certificates in the EUA, representing 0.17% of the worldwide IFS Food certification. Canada and Mexico did not contribute to the dissemination of these FSMS standard once together only 4 certificates were issued in 2020 and it did not allow them to be selected by the established criteria.

Furthermore, American supermarkets did not join some standards owned by European retailers, instead, the acquirement of the Australian Safe Quality Food standard (SQF) was established by American Food Marketing in 2003 (Havinga, 2013). This fact supports not only the current behavior of FSMS in North American countries since these U.S.-based standards are dominant in this macroregion, but also reinforces that geographical proximity brings positive effects encompassing diffusion processes of standards (Mohammed and Zheng, 2017).

Even though the significant results of IFS Food certification, this standard evidenced negative growth rate among all defined macroregions. Middle East presented the lowest rate (-54.55%) followed by North America (-35.42%) and Central and South America (-28.50%). Europe and East Asia and Pacific represent the major contribution to IFS Food certification with growth rates attaining -0.76% and -0.29%, respectively.



Considering the country-level, the United Kingdom and Ukraine presented the lowest growth rates, evidencing a reduction of -52.94% and -39.39% of their IFS Food certification, respectively.

On the other hand, Finland presents the highest positive growth rate, attaining +160%, followed by Bosnia and Herzegovine (+21.62%), Sweden (+16.67%) and Serbia (+12.77%). Despite presenting low growth rates, countries, such as Italy (+1.40%), Spain (+1.19%), Poland (+3.62%) and Portugal (+9.13%) had a significant contribution to the absolute number of issued certificates reaching, respectively, 51, 35, 32 and 23 news certifications.

It must be highlighted that IFS Food provided data present uncertainties over the studied years (from 2017 to 2020), thus there is a possibility of these results do not show the real scenario of the worldwide dissemination of IFS Food certification.

Data encompassing audit results by country also were provided by IFS and Figure 13 shows the average audit results among the defined macroregions.

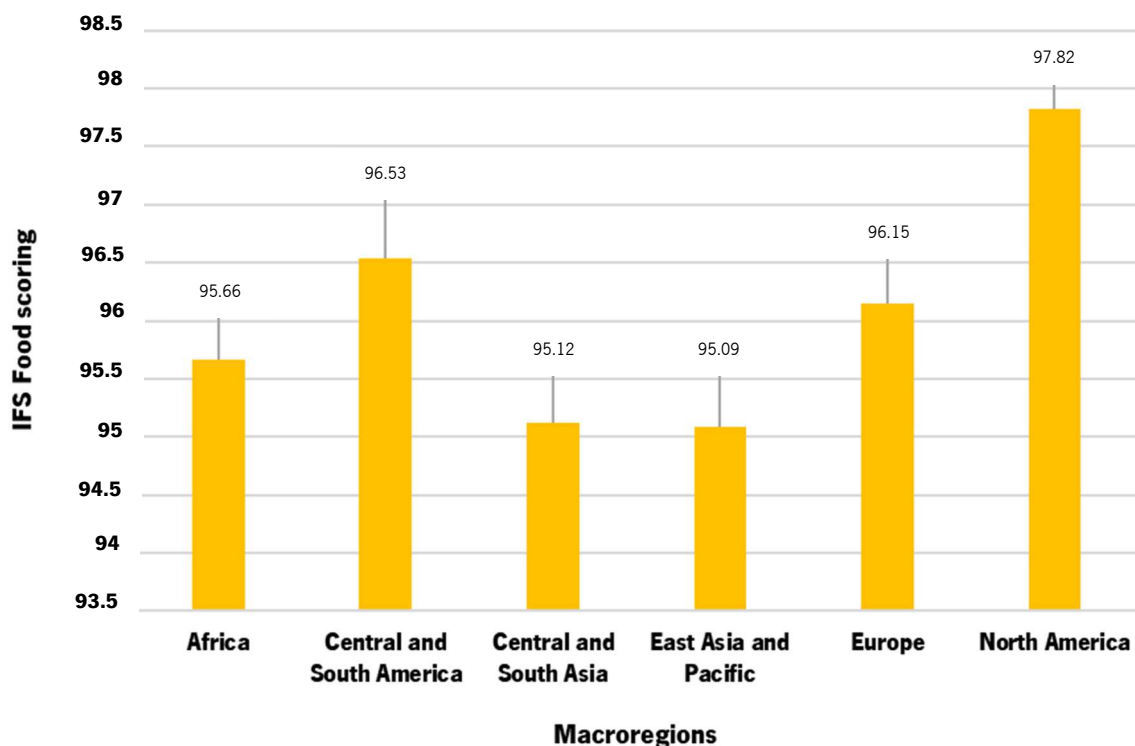


Figure 13. Average IFS Food audit results among the defined macroregions (Source: author).

Considering the period from 2017 to 2020, the average of IFS audit results among macroregions ranges between 95.09 (East Asia and Pacific) and 97.82 (North America). It is possible to state that the highest averages are related to higher income economy levels.



It is important to emphasize that the third position of Europe is directly affected by the number of covered countries, an amount of 32 European countries, while Central and South America is only represented by Brazil, Chile, Colombia, Ecuador, and Peru. However, these selected Latin American countries are considered upper-middle-income countries, except Chile, which has high-income economy (World Bank, 2021b). These results corroborate the findings of Mohammed and Zheng (2017) once the authors stated that *per capita* GDP positively influences the adoption process of certification in a country.

These authors also considered that the certified site numbers are completely different among developing and developed countries. To evidence this, the huge African continent is represented by only 3 countries, as follows: Morocco, South Africa and Tunisia. Together, they reached an amount of 149 IFS Food certificates.

Analyzing the average of audit results from 2017 to 2020, Table 17 shows the Top 10 countries by the audit results considering the IFS Food scoring.

Table 17. IFS Food Top Ten Countries by the average audit results considering the IFS Food scoring (2017 to 2020).

Nº	Macroregion	Country	IFS Food scoring	SD
1	Europe	United Kingdom	97.86	0.24
2	North America	United States	97.82	0.64
3	Europe	Luxembourg	97.70	0.51
4	Central and South America	Brazil	97.66	0.46
5	Europe	Italy	97.45	0.13
6	Europe	France	97.40	0.05
7	Africa	Morocco	97.32	0.17
8	Europe	Greece	97.16	0.11
	Central and South America	Peru	97.16	0.45
9	Europe	Poland	97.06	0.03
	Europe	Belgium	97.06	0.19
10	Europe	Lithuania	96.91	0.20

When considering the country-level, different perspectives can be evidenced since Africa is represented in the above list by Morocco, attaining an average audit result of 97.32 and 0.17 as standard deviation. It is interesting to emphasize that Morocco is a lower-middle-income country, thus it is possible to state that the degree of economic development of countries can affect worldwide diffusion process (Albuquerque *et al.*, 2007; Blackman, 2008; and To and Lee 2014).

However, it is not a limiting factor. Other aspects support the behavior of standard certifications around the world.

Aiming at clarifying the evolution of audit results among the defined macroregions, Table 18 shows the related growth rates from 2018 to 2020:

**Table 18.** Evolution of IFS Food audit results from 2018 to 2020 among the defined macroregions.

Macroregion	Year		
	2018	2019	2020
Africa	-2.45%	+2.33%	+0.48%
Central and South America	-0.58%	+0.55%	+0.94%
Central and South Asia	-1.40%	+0.12%	+0.30%
East Asia and Pacific	+0.16%	-0.16%	+0.16%
Europe	-0.65%	+0.42%	+0.25%
North America	+1.56%	-0.11%	+0.13%

In 2020, all macroregions evidenced a positive growth rate, ranging between +0.13% (North America) and +0.94% (Central and South America). Furthermore, analyzing the recent years, two macroregions presented an increase in their growth rates, as follows: Central and South America and Central and South Asia.

Although the lack of data explained in the limitations of this present study, it is possible to assume that the trend is enhanced worldwide audit results in the future. However, the uncertainty associated with the current results will be minimized by updating new data from forthcoming years.

4.5 Analysis of current benefits and obstacles of FSMS implementation

Aiming at clarifying the current behavior of FSMS diffusion, an online survey was conducted among 263 Portuguese companies related to the food chain. Properly completed survey forms were collected from 23 organisations reaching an amount of 8.74% of responses. The low response rate is due to the short period of research (November 23 to December 6).

Regarding the English version of the questionnaire that was shared to a largest professional network, only 5 responses were collected. However, these answered forms cover different regions (i.e., Africa and South America) and the individual responses were reported in this present study once the author considered an important contribution from countries with completely different social-geographical realities.

4.5.1 Social-demographical characteristics of the sample

Since enterprises can be classified among different business size categories, the measured number of employees as criterion is the most common. Based on OECD (2021), Table 19 presents the business size classification.

Table 19. Enterprises by business size based on OECD (2021).

Category	Number of employees
Micro enterprise	Fewer than 10
Small enterprise	10 to 49
Medium-sized enterprise	50 to 249
Large enterprise	250 or more



Presenting 48% of the responses, the majority of companies can be classified as medium-sized enterprises (Figure 14). Once large enterprises only represent 17% of the total amount, the importance of the companies considered small and medium-sized is evidenced within standards diffusion. Together, they represent a percentage of 83%.

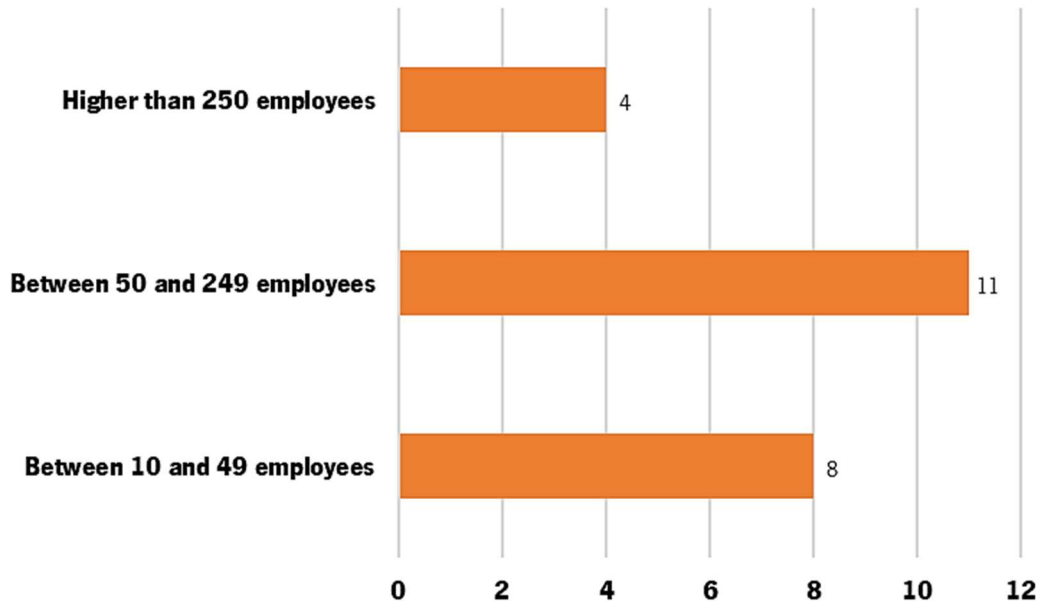


Figure 14. Business size of the surveyed companies (Source: author).

Other relevant considered aspect was the FSMS maturity (Figure 15). A system can be considered mature when operates higher than 4 years (Zimon and Domingues, 2020). It can be stated that 96% of the surveyed companies have a mature FSMS because of its implementation over the established period.

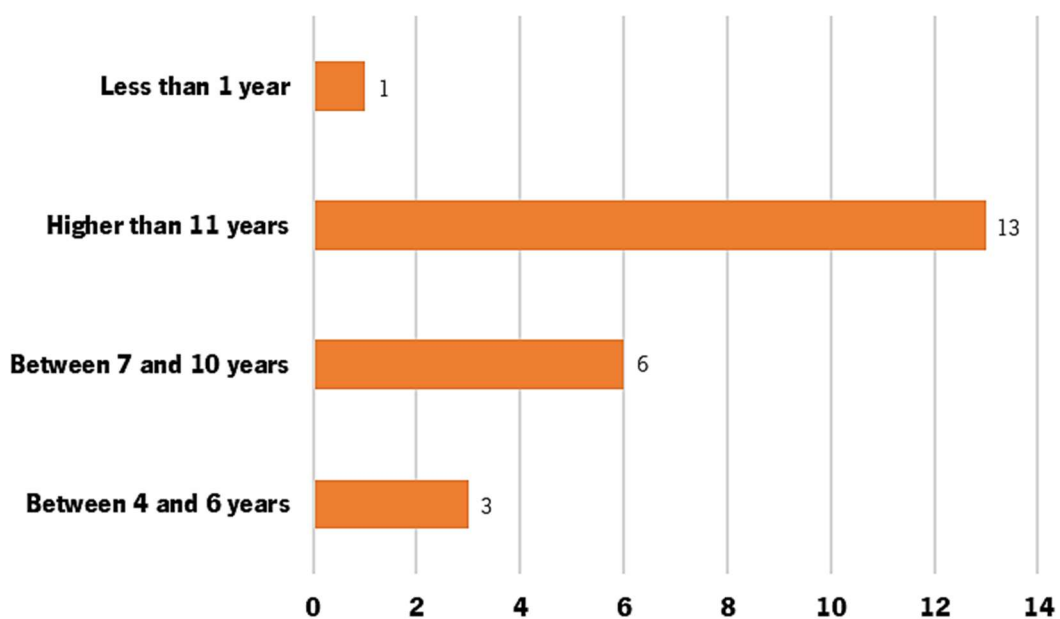


Figure 15. Maturity of the FSMS based on its implementation over the years (Source: author).



Furthermore, the major contribution was presented by companies with implemented FSMS over 11 years (57%). Considering the European origin of these companies, these results were already expected once countries from Europe as well as North America adopted standards much earlier when compared with other parts of the world (To and Lee, 2014).

Regarding the economic activity, the classification was based on CAE (2007). Positively, the sample encompasses not only all options listed in the questionnaire, but also the participants included in the survey three new categories: food packaging, transport of food products and food sensorial analysis. Figure 16 evidences that 65% of the Portuguese companies are related to Food and beverage industries category, followed by Production of food packaging and packaging materials (13%).

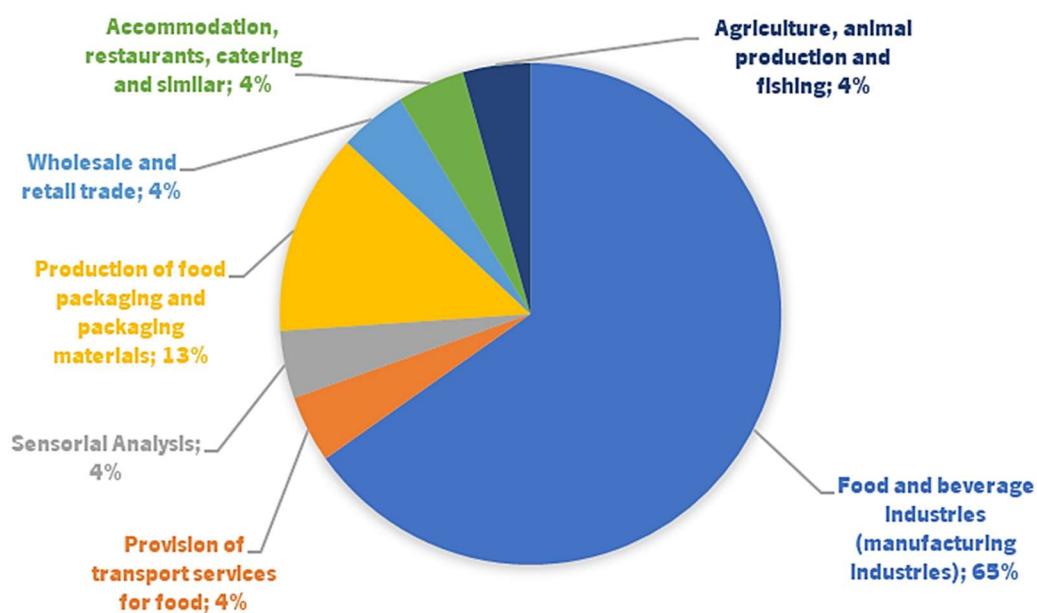


Figure 16. Economic activities of the surveyed companies based on CAE (2007) (Source: author).

As mentioned in the literature review of this dissertation, companies involved in all categories of the food chain seek a FSMS certification, and to evidence this, one surveyed company is related to a specific scope: production of cork discs used in the manufacture of stoppers for sparkling wine. This company also reported the main motivations to adopt an FSMS certification, which responses corroborate the stated by Bello-Pintado and Merino-Díaz-de-Cerio, 2013, such as compliance with food trade requirements and enhanced both competitiveness and trust of consumers.

Interestingly, in comparison with the qualification results of FSSC 22000 certification among food chain categories reported in the section 4.2 of this dissertation, similar information was provided once



Processing food products reached the highest contributions within FSMS certification, followed by Production of food packaging and packaging materials.

The vast majority of surveyed companies holds FSMS certification (Figure 17). In agreement with the results discussed in this present study, the major contributions are presented by ISO 22000 (61%) and IFS Food (26%), despite the limitations of the survey's sample.

Furthermore, it is necessary to emphasize that the sum of percentages exceeds 100% since a company can have more than one implemented FSMS. The graph below shows the number of times that each certification was reported by the surveyed companies.

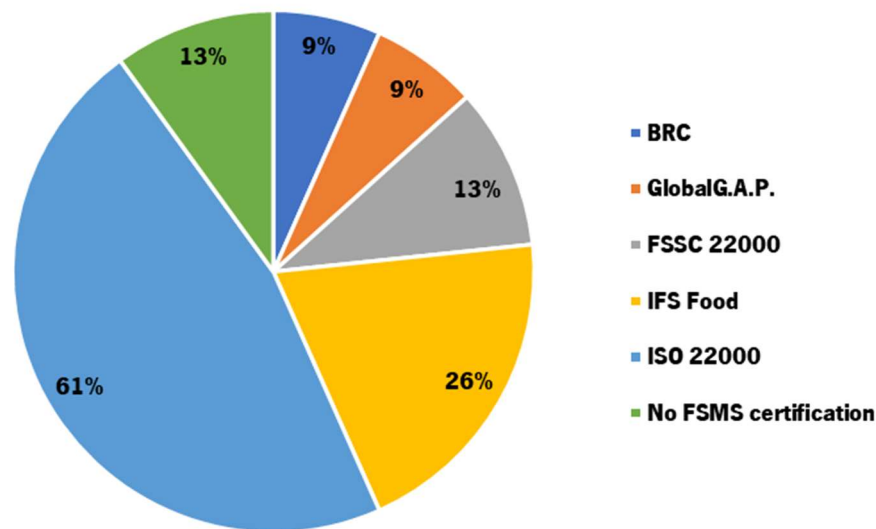


Figure 17. FSMS certification among surveyed companies (Source: author).

Although some companies declare not to have FSMS certification (13%), 2 of 3 companies also declare to work in compliance with the Codex Alimentarius and the HACCP guidelines. Considering that both companies hold a FSMS implemented over 11 years, a reason for non-certification may be related to the costs of the certification process as reported by one of the surveyed companies. Other aspect that must be clarified and related to the non-certification is the size of the aforementioned companies once they are classified as small and medium-sized enterprises.

When analyzed the existence of integrated management systems, 52% of the 23 surveyed companies declare to integrate the FSMS with other standards, such as ISO 9001.

Among 12 companies with IMS, 11 reported ISO 9001 certification as part of the integrated quality management system, attaining 92% of the responses. Other standards also were reported encompassing different scopes, such as: environmental management, competence of laboratories, occupational health and safety management systems (Figure 18).

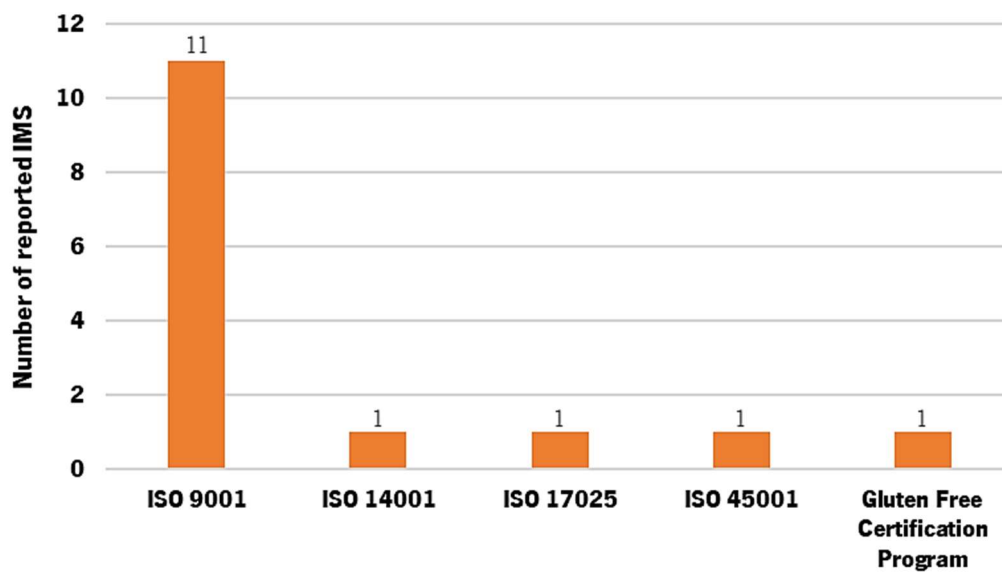


Figure 18. Integrated management systems among surveyed companies (Source: author).

4.5.2 Presentation and analysis of the results of the online survey

The purpose of the first question was to determine the main motivations among companies that seek a FSMS certification (Figure 19).

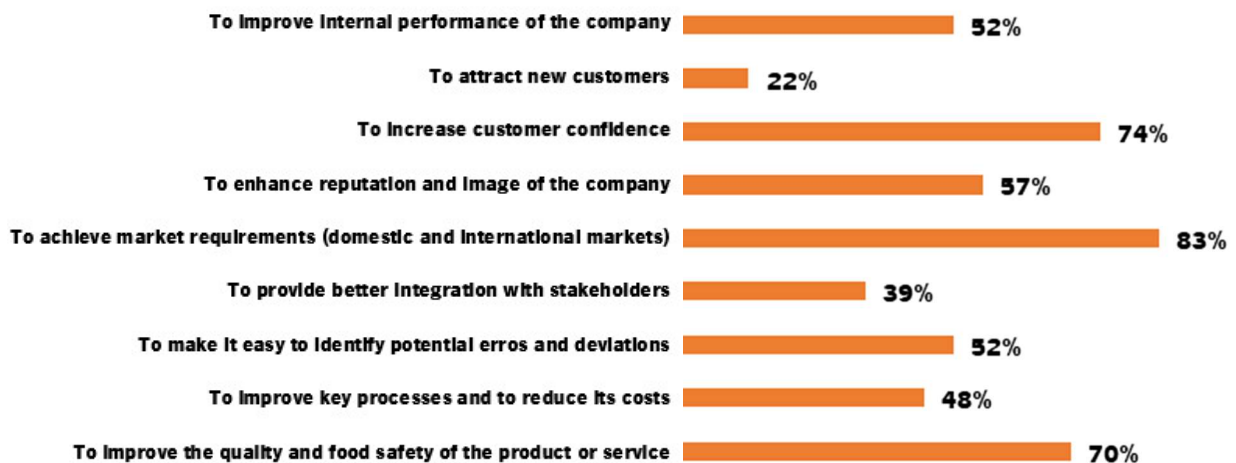


Figure 19. Main motivations that lead a standard adoption (Source: author).

Analysis of the distribution of the responses presented above evidences that the main motivation to adopt a FSMS standard is to achieve market requirements regarding both domestic and international food trade (83%). Aiming at increasing customer confidence and improving the quality and food safety of offered product or service also have the highest response rates, reaching 74% and 70% of the total responses, respectively.



The mentioned results corroborate the results by Teixeira and Sampaio (2013) once internal nature was identified as strong motivation among Portuguese certified companies within FSMS standards. The authors also evidenced both requirement and confidence of the customers as the main motivations for ISO 22000 certification.

To enhance reputation and image of the company was also appointed as important reason for companies that implement FSMS with score of 57% as well as to improve internal performance of the company and to make it easy to identify potential errors and deviations both representing 52% of the responses. Mercan and Bucak (2013) emphasized the importance of continuous improvement along the FSMS, otherwise the system can not address the needs and ever-changing expectations of the customers.

Despite the internal aspects identified among Portuguese companies, all FSMS standards implemented in a food industry located in the macroregion Central and South Asia were adopted due to the external pressures, such as commercial pressure and regulatory requirements. Thus, external factors forced the company from Maldives to implement some FSMS standards to attain further business opportunities in the international food trade (Muhammed Rafeeqe and Mini Sekharan, 2018). An analysis of factors that impact the implementation of standards in Pakistan also identified external factors, such as necessity to entry into markets as one of the main reasons for the FSMS certification (Masakure *et al.*, 2009)

However, it is possible to state that holding an FSMS certification happens for different reasons, which are directly related to the expected benefits of the company and its geographic origin probably is not a significant issue. Regarding surveyed companies from Africa and South America, the responses indicate internal aspects as main motivations to seek the FSMS certification, such as to improve the quality and food safety of offered products/services and to improve internal performance of the company.

On the other hand, Henson and Holt (2000) evidenced that the most motivations to implement the HACCP system in the UK dairy sector were compliance with legislation and to address the requirements of major customers, both considered external factors. Also encompassing UK companies, Mensah and Julien (2011) showed that external aspects, such as both statutory and private regulations were strong incentives among companies, which seek FSMS certifications.

Encompassing the achieved benefits within implementation and certification of FSMS, the majority of the surveyed companies considered that quality, safety, and traceability of the offered products/services were improved as well as increased confidence customer related to the enhanced reputation and image of the company, reaching a score of 78% and 65%, respectively.

Figure 20 presented the main achieved benefits due to the FSMS certification among the Portuguese companies. The findings of the presented analysis corroborate the results evidenced by Teixeira and



Sampaio (2013) once the authors stated that the improvement of food safety methodologies and practices was the most important benefit representing 50% of the responses.

As it was verified for the results of this study, both main benefits among Portuguese companies are considered as internal nature.



Figure 20. Main benefits achieved by companies due to the FSMS certification (Source: author).

Analyzing current determinants influencing diffusion of ISO 9001 by countries, Rodriguez-Arnaldo and Martinez-Lorente (2020) concluded that competitiveness, innovation and business sophistication are positively related to less developed countries. In agreement with that, responses from African and South American companies considered facilitated compliance with food safety legislation, enhanced use of time and resources and improved internal integration as main benefits of certification. The majority of aforementioned companies also considered provided business sophistication as main benefit. On the other hand, only 13% of the surveyed Portuguese companies considered this benefit as a main achieved one. Thus, still regarding ISO 9001 standard, determinants related to reputation are better linked to countries with high degree of development and because of that the necessity to hold a certification is reduced. However, when compared with countries that have low reputation, companies become certified by worldwide recognized quality certificate aiming at compensating the poor brand (Rodriguez-Arnaldo and Martinez-Lorente (2020).

Concerning performance and key processes, Zimon and Domingues (2020) concluded that the ISO 22000 implementation impacted on improving both efficiency and effectiveness in production and control process. Toufaili and Halawi (2019) also stated that ISO 22000 certification has a positive effect when a properly implementation involves all related employees. Surveyed companies emphasize this issue when stated that to maintain a good quality system it requires every person in company taking part of the process.



With the above mentioned in mind, through an analysis of factors and their impact on the effective implementation of the HACCP system, Fotopoulos *et al.* (2009) verified that human resource attributes, such as employee commitment, significantly affect the effectiveness of the food system. These authors considered management commitment as a critical attribute that impact significantly the HACCP implementation.

Obstacles related to employee resistance to change reached significant results among Portuguese countries reaching an amount of 22% of the survey's responses. Similar result was identified by Teixeira and Sampaio (2013) once 38.7% of surveyed companies considered internal resistance to change as the most difficulty for certification ISO 22000. Regarding the surveyed African and South American companies, this obstacle also had a significant impact and was considered the second highest one once the costs of the certification process ranked first.

Considering the quality movement in Brazil, Kubo and Farina (2013) showed a remarkable consideration within manager and employee relationship. Attaining a scores of 68,5% and 58%, stimulation of the interaction between managers and employees and sharing information across the company, respectively, were considered as main benefits of quality programmes in Brazilian industries.

Figure 21 presents the main obstacles that Portuguese companies need to overcome in order to properly implement and certify a food safety management system.



Figure 21. Main obstacles within FSMS certification that need to be overcome by surveyed companies (Source: author).

Both higher cost of the certification process and volume of required documentation were considered as main obstacles presenting scores of 35% and 30% respectively. Related to that, other studies identified and summarized the main obstacles, two of which are also financial constraints (Herath and Henson, 2006) and certification costs (Masakure *et al.*, 2009). All these difficulties impact the decision to



implement and certify an ISO 22000 FSMS due to the necessity to invest money, time and organization (Escanciano and Santos-Vijande, 2014).

Furthermore, the findings related above are in agreement with Schulze *et al.* (2008) since the authors evidenced that the implementation and certification processes are perceived as a costly and enforced requirement among medium-sized companies within IFS certification. Larger companies, in contrast, have enough financial resources to overcome obstacles and it includes hiring and delegating responsible employees concerning quality assurance tasks. Encompassing the most cited difficulties among medium-sized Portuguese companies, the findings presented by Teixeira and Sampaio (2013) meet the conclusion presented above once FSMS costs was considered the second of main difficulties within food safety management system implementation, with a score of 33.8%.

Several researchers (i.e., Escanciano and Santos-Vijande, 2014; Cantanhede *et al.*, 2018; Zimon and Domingues, 2020; and Rodriguez-Arnaldo and Martínez-Lorente, 2020) have focused on investigating what has led organizations in countries to adopt or not a certification but little is known about the decertification process. Considering the diffusion process of a standard, when the number of issued certificates reach the saturation point, hold this certificate becomes less attractive and the certification levels tend to decrease (Franceschini *et al.*, 2006). Related to this, Mastrogiacomo *et al.* (2020) also suggest a new diffusion phase titled post-decline due to the stabilized number of certifications at a lower level. However, issues encompassing the new phase are novelty, thus future researches are necessary to update the existing literature.

Aiming at contributing to reduce the aforementioned research gap, 2 companies (9%) of the sample already opted for the decertification process. The decertified standards were ISO 9001, ISO 22000 (Company A) and FSSC 22000 (Company B).

The decertification in Company A initially encompassed ISO 9001 once that company no longer recognizes the relevance of this standard in the food trade and decided to reduce the related costs. After that, to satisfy the business requirements and commercial pressure ISO 22000 certification was replaced by IFS Food certification. Currently, the Company A intends to hold also BRC certification based on the same external aspects. Concerning the Company B, FSSC 22000 certification was replaced by ISO 22000 also to meet the market requirements.

4.6 Current socio-economic importance of worldwide FSMS certification

Since food safety management system diffusion is directly related to socio-economic issues, the behavior simultaneous of studied standards was analyzed aiming at evidencing patterns of certification. Table 20



presents the Top 10 Countries that have, simultaneously, current data encompassing the certification of both FSSC 22000, ISO 22000 and IFS Food.

Table 20. Top Ten Countries by simultaneous FSSC 22000, ISO 22000 and IFS Food certification

N°	FSSC 22000pc			ISO 22000pc			IFS Foodpc		
	Macroregion	Country	2021	Macroregion	Country	2020	Macroregion	Country	2020
1	Europe	Netherlands*	0.0538	Europe	Greece	0.1934	Europe	Spain	0.0633
2	Europe	Switzerland	0.0467	Europe	Cyprus	0.1567	Europe	Italy	0.0614
3	Europe	Finland	0.0376	Europe	Macedonia	0.0524	Europe	Belgium	0.0548
4	Europe	Greece	0.0039	Europe	Bulgaria	0.0420	Europe	Hungary	0.0499
5	Europe	Sweden	0.0282	Europe	Netherlands	0.0310	Europe	Netherlands	0.0466
6	Europe	Serbia	0.0270	Europe	Romania	0.0299	Europe	Austria	0.0444
7	Europe	Cyprus	0.0258	Europe	Serbia	0.0271	Europe	Croatia	0.0407
8	Europe	Bulgaria	0.0257	Central and South Asia	Sri Lanka	0.0254	Europe	Greece	0.0404
9	Europe	Denmark	0.0253	Europe	Latvia	0.0200	Europe	Slovenia	0.0390
10	Europe	Lithuania	0.0204	Europe	Lithuania	0.0168	Europe	Czech Republic	0.0350

*Countries in bold also are presented in global Top 10 Countries by the number of issued certificates *per capita*.

This is evident by observing many countries, such as the Netherlands and Greece, that appear in the top 10 lists for multiple standards. Besides an amount of 45 countries have been selected, only 22 countries are presented even in the 3 aforementioned Top 10 countries by simultaneous FSSC 22000, ISO 22000 and IFS Food certification. The majority of selected countries represent Europe, with a score of 95%.

In comparison with global Top 10 Countries by the number of issued certificates *per capita*, the majority of European countries continues presented and they also hold better ranking positions. Interestingly, Top 10 countries encompassing IFS Food certification remain exactly the same. According to Mohammed and Zheng (2017), the behavior of FSMS certification focused on a specific standard in countries that have been faced with limited number of certified sites. Countries such as Algeria, Kuwait, and Zimbabwe evidenced this pattern.

Regarding FSSC 22000, representative countries from East Asia and Pacific and Central and South Asia, such as New Zealand and Costa Rica, respectively, were replaced by the European countries, Denmark and Lithuania. However, Norway also was removed once the number of IFS Food certificates did not meet the established criteria.

Moreover, similar results were found when analyzed ISO 22000 standard. Suriname (Central and South America), Maldives (Central and South Asia), Singapore, Taiwan and, Macao (both East Asia and Pacific) were replaced by European countries, such as Latvia, Lithuania, Romania, and Serbia. However, considering all three Top 10 by simultaneous FSSC 22000, ISO 22000 and IFS Food certification, Sri Lanka (Central and South Asia) is the only representative non-European country presented.



It should be pointed out that 96% of the presented countries have economies classified as high or upper-middle income (World Bank, 2021b). Figure 22 shows the distribution of selected countries among economic levels.

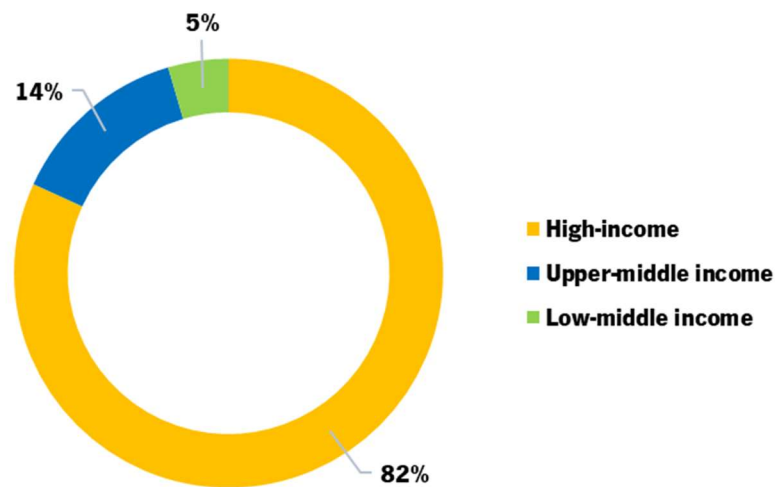


Figure 22. Economic levels of selected countries by simultaneous FSSC 22000, ISO 22000 and IFS Food certification (Source: author).

These results corroborate the Albuquerque *et al.*, (2007) and To and Lee (2014) findings once it possible to conclude that economic development of countries affects directly the expansion and diversification of standard diffusion processes around the world.

It should be emphasized that a successful implementation of FSMS standards is related to the company's ability to meet all the requirements and this is not always possible when less developed countries and small-medium-sized enterprises are involved. In order to minimize this context, Havinga (2013) stated that increased technical and financial assistance integrated to support programs help companies to achieve not only food safety and quality approval, but also business opportunities. To evidence that, Muhammed Raqueefe and Mini Sekharan (2018) presented a studied company that received financial support from United Nations Industrial Development Organization through the Government of Maldives to achieve ISO 22000 certification.

Regarding the geography of countries, less developed countries must overcome logistic issues for adopting the studied FSMS standards, which are all based in Europe. Mohammed and Zheng (2017) stated that by sharing a border with a standard holder, the adoption of this standard is increased. Thus, the number of domestic certification bodies in a country is also related to FSMS adoption. The authors suggested that providing better access to certifiers may alleviate the geographic disadvantages.

Currently, besides several researches addressing the adoption of food safety management system and its main drivers have been published, there is a research gap encompassing social-economic issues



(Colen *et al.*, 2012). These authors analyzed how FSMS certification affects employment and poverty in food industries related to agriculture and concluded that GlobalG.A.P. certification contributed positively to restructure the food supply chain as well as to respect national labour laws.

Once certified companies should maintain both integration and motivation of their employees in order to facilitate the good performance of the implemented FSMS, employee training supports the achievement of main benefits from the certification. As reported by a surveyed company in the section 4.5 of this dissertation, a quality management system enables, among other issues, investment in internal training. Findings reported by Colen *et al.* (2012) also identified improved employment conditions since several certified companies invested in infrastructure and training of workers aiming at being in compliance with GlobalG.A.P. requirements.

Moreover, sustainability aspects in the supply chain are a current concern among companies and customers. Not limited to environmental protection, the consumption of sustainable agricultural products has been increased as well as the welfare concern of both farmers and consumers (Mohamed *et al.*, 2016). Related to that, Taghikhah *et al.* (2019) evidenced that these consumers can motivate producers and suppliers to improve operations and processes. On the other hand, methods of production also may influence consumer's decisions (Del Giudice *et al.*, 2016) toward green consumption since the population is enhancing a new health-conscious.

To conclude this topic, it is necessary to emphasize that FSMS implementation and also its certification currently support the improvement of the agricultural system, which led huge quantity of food loss on farms and food waste at retail and consumption levels (Food Action Alliance, 2021). Thus, aiming at strengthening food security, a fortified food industry is a necessary food supplier to the population (FAO, 1998).

Encompassing the role of food safety management system around the world, FSMS standards, such as ISO has a social, economic and environmental commitment to support the United Nations Sustainable Development Goals (SDGs) directly addressed by ISO standards. Regarding both Goals 2 and 12, Zero Hunger and Responsible Consumption and Production, respectively, ISO 22000 help to meet these goals not only through ensuring quality and traceability, but also by identifying and controlling food safety hazards focused on the food sector (ISO 22000, 2021).



5. CONCLUSIONS

5.1 Retrospective and soundest conclusions

The overall goal of this dissertation was to present the current clear picture on how are the worldwide diffusion of FSSC 22000, ISO 22000 and IFS Food standards. Therefore, it is intended that this study be able to identify some behaviors related to the processes of certification encompassing current motivations, benefits and constraints.

Currently, the majority of defined macroregions is covered by two studied standards, FSSC 22000 and ISO 22000. The Americas and Africa are mainly covered by FSSC 22000 certification, while ISO 22000 certification is the major adoption by Asia, the Pacific and the Middle East. The only exception is Europe that has IFS Food as the main adopted standard.

During the last decade, the majority of countries with highest number of issued certificates of FSMS standards remains the same. This group represents an average of 24% of the total of countries covered by each studied standard and holds an average of 89% of the total amount of worldwide issued certificates. Based on the established criteria, East Asia and Europe have significant expressions in the Top 10 Countries encompassing the absolute numbers of each FSMS certification. China, Italy, Spain, Japan, Germany and India lead the worldwide diffusion within FSSC 22000, ISO 22000 and IFS Food certification.

On the other hand, the worldwide diffusion of FSSC 22000, ISO 22000 and IFS Food standards present different behavior when applied the relative basis *per capita*. Europe leads the spread of worldwide FSMS certification with scores of 81.8%, 50%, and 100% encompassing FSSC 22000, ISO 22000 and IFS Food, respectively. European countries, such as Cyprus, Italy, Greece, Netherlands, Spain and Switzerland, presented significative contribution. Moreover, it must be emphasized that countries, such as China, India and USA that are present in the Top 10 Countries by FSSC 22000 absolute number of issued certificates do not have ranking positions in the FSSC 22000pc Top 30 Countries. Similar results were found when analyzed ISO 22000pc.

Encompassing each standard, East Asia and Pacific had the highest growth rates with the exception of FSSC 22000, which was surpassed by Central and South Asia. Countries, such as Australia, Finlandia, Hong Kong, India, Indonesia, and Singapore had significative growth rates among the studied FSMS certifications. The contribution of East Asia and Pacific to ISO 22000 diffusion may be related to the international private retailers, which usually drive the adoption of certification in different macroregions around the world.



The current diffusion of FSMS standards may be considered unequal because of its wide dissemination among different countries and macroregions. However, despite FSSC 22000 and ISO 22000 certifications cross borders and hold a high international adoption, the results of this study demonstrate that geographic pattern is directly related to the origin of the standards since all FSMS studied standard are Europe-based. The behavior of worldwide FSMS also is positively affected by food export activities to developed countries in North America and Europe.

Some similarities between North America and Central and South America were evidenced by this study. The geographic proximity and cultural similarity may be related to the trade flows and diffusion processes of certifications in these countries. However, it is possible to state that the popularity of an FSMS standard is also related to the coexistence of other specific and required standards used by different and specific areas in the food chain. Furthermore, the non-recognition by GFSI probably negatively impacts the diffusion process of a food safety management system standard.

Other similarities also were found by analyzing the forecasting models based on Gompertz model to predict the behavior of ISO 22000 certification around the world and, particularly, among European countries. Aiming at reducing the research gap within diffusion of food safety management system standards, this present study confirmed similar behavior between ISO 14001 and ISO 22000 standard diffusion processes. The complex international food trade integrated with several regulations, international standards and powerful food retailers tend to create cultural similarities within standard diffusion. Besides this important finding, Europe probably is also in the stationary phase of the diffusion process once the number of certifications tend to stabilize in the next years. The respective inflection point was reached in 2008 encompassing an amount of 3884 issued certificates and attaining a maximum number of issued certificates of 10,565.

The relative unpopularity of ISO 22000 in European countries may be related to development level since these developed countries have already good reputation and do not use that certification as a marketing tool to enhance business activities. In opposite of less developed countries, which need to convince customers and stakeholders about products and services quality.

Concerning the worldwide ISO 22000 diffusion analysis through forecasting model also based on Gompertz model, it was predicted that the ISO 22000 diffusion around the world also reached the inflection point, evidencing an amount of 12,852 issued certificates. To achieve the saturation level of the process, the certification of ISO 22000 will issue an amount of 34,958 certificates, approximately. Nevertheless, there is a possibility that these results have not yet been reached since the lack of available data.



Regarding the main determinants of implementing a FSMS standard, companies presented not only different reasons but also expected benefits that define the process of adoption of a FSMS. Deal with external pressures, such as market requirements was the main motivation among the surveyed companies, followed by to increase customer confidence. Encompassing the achieved benefits within implementation and certification of FSMS, the positive achievements among the Portuguese companies were considered as internal nature. The majority of the surveyed companies considered that quality, safety, and traceability of the offered products/services were improved as well as increased confidence customer related to the enhanced reputation and image of the company.

On the other hand, obstacles related to employee resistance to change reached significant results among Portuguese countries represent the most difficulty for FSMS certification. Certification costs also was considered as main difficulty that impacts the decision to certify a company within food safety management system standards.

Aiming at contributing to reduce the research gap encompassing the decertification of a standard, the main reasons that led this process were analyzed from an experience reported by a surveyed company. Issues related to loss of relevance of the certification, business requirements, and commercial pressures were identified as main drivers of decertification process.

Besides the importance of implement and certify a food safety management system encompassing the production and processing of safer food, other current issues related to socio-economic aspects also need to be addressed. Through an analysis concerning the economic levels of selected countries by simultaneous FSSC 22000, ISO 22000 and IFS Food certification, it possible to conclude that economic development of countries affects directly the expansion and diversification of standard diffusion processes around the world.

In addition to exploring the reasons that have led companies to adopt FSMS certification, it is interesting to approach the positive contribution of these certifications encompassing the improvement of the food supply chain within employment conditions. Furthermore, once certified companies should maintain both integration and motivation of their employees in order to facilitate the good performance of the implemented FSMS, employee training supports the achievement of main benefits from the certification. To conclude this topic, it is necessary to emphasize that FSMS implementation and also its certification currently support the improvement of the agricultural system, which deals with a huge quantity of food loss and waste on farms, retail and consumption levels. Thus, aiming at strengthening food security, fortified international food trade is a current necessity to achieve food chains more sustainable that meet



both increased welfare concern among farmers and consumers and the new health-conscious of the population around the world.

5.2 Limitations and opportunities for further studies

Official data related to FSMS standards and their dissemination are scarce and relatively recent, since the first edition of ISO 22000 was published in 2005 and the recognition of the IFS Food and FSSC 22000 standards by GSFI occurred in 2003 and 2010, respectively. These facts do not allow a consistent analysis of the studied FSMS behavior through the years and it must be emphasized the necessity of comparison with other widely implemented quality management standards, such as ISO 9001 and ISO 14001. It also be highlighted that the uncertainties associated with those empirical results will be minimized by updating new data from forthcoming years.

Additionally, it has to be taken into account that diffusion processes of standards involve a large number of variables, which are highly correlated. Therefore, future researches encompassing current aspects that impact both expansion and diversification of food safety management system standards must be established.

Furthermore, several researchers have focused on investigating what has led organizations to certify or not their structures but little is known about the novelty decertification process of FSMS standards. In this way, the importance of conducting new studies related to this topic is noticeable. Moreover, although the explained limitations, the uncertainty associated with the current results will be minimized by updating new data from forthcoming years.



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APPENDIXES



Appendix I – FSSC 22000, ISO 22000 and IFS Food Top 30 Countries

FSSC 22000pc			ISO 22000pc			IFS Foodpc		
No.	Country	Certificates per capita	No.	Country	Certificates per capita	No.	Country	Certificates per capita
1	Netherlands	0.0538	1	Greece	0.1934	1	Spain	0.0633
2	Switzerland	0.0467	2	Cyprus	0.1567	2	Italy	0.0614
3	Finland	0.0376	3	Maldives	0.0560	3	Belgium	0.0548
4	Greece	0.0339	4	Singapore	0.0526	4	Hungary	0.0499
5	Sweden	0.0282	5	Macedonia	0.0524	5	Netherlands	0.0466
6	Norway	0.0275	6	Bulgaria	0.0420	6	Austria	0.0444
7	Serbia	0.0270	7	Suriname	0.0417	7	Croatia	0.0407
8	Cyprus	0.0258	8	Macao	0.0328	8	Greece	0.0404
9	Bulgaria	0.0257	9	Taiwan	0.0323	9	Slovenia	0.0390
	New Zealand		10	Netherlands	0.0310	10	Czech Republic	0.0350
10	Costa Rica	0.0254	11	Iceland	0.0305	11	France	0.0286
11	Denmark	0.0253	12	Romania	0.0299	12	Bulgaria	0.0283
12	Japan	0.0227	13	United Arab Emirates	0.0290	13	Germany	0.0281
13	Korea, Republic of	0.0209	14	Serbia	0.0271	14	Portugal	0.0267
14	Lithuania	0.0204	15	Sri Lanka	0.0254	15	Poland	0.0241
15	Israel	0.0201	16	Bahrain	0.0244	16	Serbia	0.0230
16	Belgium	0.0194	17	Lebanon	0.0228	17	Slovakia	0.0222
17	Estonia	0.0192	18	Latvia	0.0200	18	Denmark	0.0178
18	Singapore	0.0179	19	Estonia	0.0185	19	Cyprus	0.0175
19	South Africa	0.0154	20	Qatar	0.0179	20	Switzerland	0.0171
20	Taiwan	0.0149	21	Bhutan	0.0175	21	Luxembourg	0.0167
21	Latvia	0.0147	22	Lithuania	0.0168	22	Romania	0.0138
22	Czech Republic	0.0139	23	Switzerland	0.0163	23	Bosnia and Herzegovine	0.0136
23	Swaziland	0.0136	24	Portugal	0.0161	24	Lithuania	0.0118
24	Romania	0.0117	25	Hong Kong	0.0160	25	Macedonia	0.0095
25	Ireland	0.0116	26	Italy	0.0154	26	Latvia	0.0058
26	United Arab Emirates	0.0109	27	Malaysia	0.0144	27	Albania	0.0034
	Canada		28	Jordan	0.0139	28	Chile	0.0032
27	Malaysia	0.0108	29	Finland	0.0136	29	Tunisia	0.0025
28	Hungary	0.0104		Slovakia		30	Finland	0.0024
	Portugal							
29	Australia	0.0102	30	Ireland	0.0135			
30	Italy	0.0100						



Appendix II – Selected countries* simultaneously based on FSSC 22000, ISO 22000 and IFS Food certification

No.	Macroregion	Country
1	Europe	Austria
2	Europe	Belgium
3	Europe	Bosnia and Herzegovine
4	Central and South America	Brazil
5	Europe	Bulgaria
6	Central and South America	Chile
7	East Asia and Pacific	China
8	Central and South America	Colombia
9	Europe	Croatia
10	Europe	Cyprus
11	Europe	Czech Republic
12	Europe	Denmark
13	Central and South America	Ecuador
14	Europe	Finland
15	Europe	France
16	Europe	Germany
17	Europe	Greece
18	Europe	Hungary
19	Central and South Asia	India
20	Europe	Italy
21	Europe	Latvia
22	Europe	Lithuania
23	Europe	Macedonia
24	Africa	Morocco
25	Europe	Netherlands
26	Central and South Asia	Pakistan
27	Central and South America	Peru
28	Europe	Poland
29	Europe	Portugal
30	Europe	Romania
31	Europe	Serbia
32	Europe	Slovakia
33	Europe	Slovenia
34	Africa	South Africa
35	Europe	Spain
36	Central and South Asia	Sri Lanka
37	Europe	Sweden
38	Europe	Switzerland
39	East Asia and Pacific	Thailand
40	Africa	Tunisia
41	Europe	Turkey
42	Europe	Ukraine
43	Europe	United Kingdom
44	North America	United States
45	East Asia and Pacific	Viet Nam

*Alphabetical order