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A decade of Food Safety Management System based on ISO 22000: A GLOBAL overview.

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Abstract: The worldwide implementation and certification of food safety management systems (FSMS) have significantly increased during the last decade, reflecting the importance of assuming these standards in activity sectors involved in the food chain. Companies of all types and sizes worldwide have made several efforts for implementing a FSMS based on International Organization for Standardization (ISO) 22000. Certification system and quality management tools development in international context, are analyzed in food processing and food service sectors. Studies of food safety, performance of ISO 22000 implemented in food companies and hurdles of context characteristics wherein operate were reviewed. To summarize, improved product quality and safety has been identified as the major benefit of implementing ISO 22000. Other benefits highlighted include enhanced employee skills, improved company image, increased product sales, increased market share and access to new markets.

Keywords: Food safety, ISO 22000, HACCP, food processing, food services.

Resumen: Una década del Sistema de gestión de la seguridad alimentaria basado en ISO 22000: VISIÓN GENERAL.

La implementación y certificación mundial de los sistemas de gestión de la seguridad alimentaria (SGSA) se han incrementado significativamente durante la última década, lo que refleja la importancia de asumir estos estándares en los sectores de actividad involucrados en la cadena alimentaria. Empresas de todos los tipos y tamaños han realizado esfuerzos para implementar un SGSA basado en la Organización Internacional de Normalización (ISO) 22000. El sistema de certificación y el desarrollo de herramientas de gestión de calidad en el contexto internacional se analizan en los sectores de procesamiento de alimentos y servicios de alimentos. Se revisaron los estudios de inocuidad de los alimentos, el desarrollo de ISO 22000 implementado en las empresas de alimentos y los problemas según las características del contexto en donde opera. En resumen, la mejora en la calidad y seguridad del producto ha sido identificada como el principal beneficio de implementar ISO 22000. Otros beneficios destacados incluyen mejoras en las habilidades de los empleados, en la imagen de la compañía, mayores ventas de productos, mayor participación de mercado y acceso a nuevos mercados.

Palabras clave: Seguridad alimentaria, ISO 22000, HACCP, procesamiento de alimentos, servicios de alimentos.

Introduction

In the last ten years, the quality of food products, especially regarding safety, has become one of the most important aspects to influence food industry, food market, governments and non-governmental organizations (NGOs), as well as consumers, national and international business and economical patterns. Globalization of food production and procurement makes food chains longer and more complex, in addition to increasing the risk of food safety incidents. Certainly, food products are sourced from all over the world, transported over long distances, produced under different cultivation practices and climatic conditions, and are manufactured using several processing techniques, extending the probability of a higher risk of incidences in food safety hazards.

Millions of people around the globe are hospitalized and even die

every year from foodborne diseases and illnesses caused by the consumption of contaminated food. Hygiene in the food sector is of capital importance in food services, especially in health facilities. In fact, microorganisms can proliferate and reach dangerous levels in kitchens where growing conditions are optimal. Due to their condition, patients are more sensible to foodborne illnesses than other people. Therefore, foods prepared in unhygienic conditions may infect or intoxicate people. In less developed countries, the underreporting of foodborne illnesses and diseases aggravates the situation. In the absence of any published studies assessing consumer's food safety preferences, along with relevant awareness campaigns, it is expected a minimum consumer's knowledge and attentiveness of proper food handling practices. This is in turn linked to an increase in the risk of contracting foodborne illnesses (Abouda et al., 2014).

Worldwide economic globalization processes and the development of international trade have needed rapid quality standardization processes, as they are crucial in defining the quality of a product and the trustworthiness of a company. These processes mean that more countries are into keeping with unified standards and technical regulations, quality and environmental management systems (EMS), quality satisfaction evaluation and certification procedures. The attempt of regulation reveals that food safety remains to be one of the major public health issues worldwide. The use of these rules and recommendations along the food chain will allow not only to be assured the quality of goods and services on an international scale, but also their implementation will lead to the elimination of technical trade barriers which are becoming increasingly pervasive. There are great variations between regions and countries in how these technical rules are applied in manufacturing and agriculture. In order to guarantee the production of pure and healthy food products, many countries have come up with especially strict and restrictive rules. Given the existing complicated and non-uniform rules, their systematization is hardly achievable (Kussaga et al., 2014).

In 2005, the international standard from the International Organization for Standardization (ISO) 22000 was published in order to fill the managerial gap in the FSMS hazard analysis and critical control points (HACCP). ISO 22000 is an international standard that specifies requirements for a guaranteed food security system with the incorporation of good manufacturing practices and HACCP with an adequate organization system, that enables a company to demonstrate that the products supplied meet the requirements of customers as well as those of application related to the food safety. The standard is based on the Codex Alimentarius HACCP principles and it was developed by lining up with the ISO 9001 standard in order to improve the compatibility and integration with the quality management standard. It is designed to cover all processes by food safety systems (easy to understand, implement and audit), along the supply chain that affect directly or indirectly the food products. In the ISO 22000, the hazards that require control are managed at the critical control points (CCPs) but also through prerequisite programs (PRPs). The purpose of the food safety system ISO 22000 is to provide a practical approach to ensure the elimination and reduction of food safety risks to protect consumers (Fernandez-Segovia et al., 2014).

As ISO 22000 is a generic food safety management standard, it can be used by any organization directly or indirectly involved in the food chain including farms, fisheries, dairies, meat processors, manufacturers of soups, snacks, bread, cereal, beverages, canned and frozen food, etc. together with food service providers such as restaurants, fast food chains, hospitals and hotels. It is the only

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standard that encompasses both consumer and market needs (Wang et al., 2011). Since the publication of ISO 22000 in different countries, efforts were made to integrate these regulations. In that sense, there are several studies about rigorous assessments of the costs and benefits associated with the implementation of FSMSs in various industries. The results reflect the particular characteristics of different industrial sectors and provide some indication of the incentives, costs and benefits of HACCP implementation by food processing enterprises in general (Bilalis et al., 2009).

Up to the end of December 2014, at least 30 500 ISO 22000:2005 certificates, a growth of 13,6 %, had been issued in 152 countries and economies, ten more than the previous year. The top three countries for the total number of certificates and proportional growth in number of certificates in 2014 were China, India and Greece. Even its expansion has decreased compared to 20% and 15% increases in previous years, ISO's food management standard nevertheless clocks in a respectable 14% (or 30500 certificates issued) as pointed out previously – its dented progress offset by it breaking the 30000 certificate threshold for the first time this year. In particular, North America experienced a spectacular growth rate of 70%, remarkably in the USA, where a new certification body joined the survey and a major existing contributor reported more certificates than usual. On European shores, Greece – one of the countries boasting the largest number of certificates – plummeted this year due to an important certification body not participating in the survey. Conversely, Australia's remarkable progression can be linked to a significant contributor reporting more certificates than usual (ISO survey, 2014).

Overall, worldwide implementation and certification of food safety management systems (FSMS) have increased significantly during the last decade, reflecting the importance of assuming these standards in different activity sectors. The aim of this review is to contextualize and assess the understanding of the implementation advances and the level of satisfaction reached by consumers and producers based on the literature found on the ISO 22000 standard, including surveys, interviews and reported cases (Escanciano & Santos-Vijande, 2014).

Method

A systematic literature search was made including clinical trials and reviews related to ISO 22000 standard, using databases such as Web of Science and Pubmed with the following search criteria:

Timespan: 2005-2016.

Research domains: Science technology

Document type: article

Search word: "ISO 22000": 56 articles.

Finally, 30 articles were chosen to be reviewed, selecting those that were original articles assessing ISO 22000 standard implementation in any company or sector involved in the food chain.

ISO 22000 in European food processing companies

In European countries ISO 22000 regional share is 34,9%, with 10654 certificates in 47 economies in 2014 (ISO survey, 2014). In table 1 there is a summary of the studies conducted in this geographical area in the last ten years.

Some countries as Denmark started to regulate using the standard DS 3027 E: 2002. It was published by the Danish Standard Institute indicating the requirements for a management system in order to standardize control of food safety. Those requirements were imbedded in ISO 22000: 2005 in aim to simplify the data interpretation, especially for small businesses, and facilitate the food safety system implementation (Sheps, 2007).

Other countries, as Lithuania, revealed problems at the implementation of FSMSs. The Lithuanian certification system involves products, organizations and employees conformity assessment. Apart from "traditional" quality (ISO 9001) and

Table 1. Studies of ISO 22000 in European food processing companies.

European countries	Food Processing	Activities	Reference	Journal
Denmark	Danish Standard Institute	Requirements	Sheps, 2007	J Environ Protec Ecol
Greek	Organic Industry	Surveys	Bilalis et al, 2009	Food Agric Environ
Lithuania	Lithuanian enterprises	Certification systems	Ruzevicius, 2008	Engi Economics
UK	120 firms	Surveys	Mensah & Julien 2011	Food Control
Poland	4 Enterprises	Interviews	Kafel P et al., 2013	Zywnosc-Nauka Technologia Jakosc
Portugal	Companies	Surveys	Teixeira & Sampaio, 2013	Total Quality Mana&Busi Excel
Spain	198 firms	Surveys	Escanciano & Santos-Vijande, 2014a, b.	Food Control
Cyprus	50 small food businesses	Interviews	Charalambo us et al., 2015	Food Control

environment (ISO 14001) management systems, Lithuanian companies use other systems as ISO 22000. It must be highlighted that Lithuania should improve all certification system and introduce the providences of quality management science development (Ruzevicius, 2008).

Also, evaluations of the differences between two FSMSs, HACCP and ISO 22000 which are used in the Greek organic food industry, are herein reviewed. The results of the survey indicated that food enterprises/industries are influenced by various factors concerning certification. Surprisingly, the survey showed that businesses face this matter superficially. Moreover, a high percentage within human resources cannot understand the functional principles underlying these systems. However, it should be mentioned that systems cannot guarantee absolute food safety and quality of the end product for itself; food enterprises must take additional measures towards improvement and responsibility and compromise of the board is crucial to maintain the standards required. It was concluded that certification with a FSMS could exert pressure on farmers to provide more quality raw materials, although they may face problems in implementing the processes needed to support the system (Bilalis et al., 2009).

In UK, Mensah & Julien (2011) examined the response of food manufacturing enterprises to food safety regulation, and used statistical techniques to investigate the effects of enterprise size on the drivers for, benefits of, and challenges to compliance. The survey was answered by 120 food manufacturing enterprises, representing approximately 26% of the final sample (463). The majority (97.5%) of enterprises that responded to the survey had an integrated food safety management system (FSMS) in place. Three enterprises (2.5%) did not have any FSMS; nonetheless, these enterprises had one of the ISO 9000 series implemented. Approximately 81% of companies claimed that their motivations for compliance were driven by the prospects of product safety improvement, 76% were driven by customer requirements and 60% were driven by regulatory requirements. The survey also revealed that 59% of enterprises were driven by the expected marketing advantage that could be derived from implementing the standard, others, 54% saw the potential for improved corporate image and 38% claimed that their certification was motivated by the fact that their competitors were certified. Only 35% of enterprises complied because of potential liability claim. 30%

were driven by the prospect of operational cost reductions. Approximately 18% of the enterprises claimed that they complied to avoid potential export barriers from overseas customers, and because it was an insurance requirement. Regarding benefits of compliance, 85% of the respondents enjoyed the benefit of increased customer satisfaction. 83% of respondents claimed improved internal procedures and 82% of the respondents also claimed improvements in product quality. Finally, the study identified five topmost challenges: lack of technical knowledge and skill of employees (58%), employee resistance to change (58%), lack of awareness of the requirement (40%), high cost of development and implementation (26%) and inappropriate infrastructural capabilities for validating and verifying FSMS (30%).

There are study attempts to fill the gap in the literature on FSMS by providing quantitative empirical evidence about the reasons for implementing a FSMS based on ISO 22000, as well as by analyzing the main constraints that may prevent the adoption of the standard in the food industry. On this topic, a survey based on a sample of 189 Spanish firms with ISO 22000 certification distributed at all levels of the food chain, matched our criteria. The profile of the ISO 22000 certified company in Spain is an SME food producer with presence in foreign markets, and with two or more management systems implemented. While external pressures that lead companies to adopt a FSMS based on ISO 22000 exist, the most determinant reasons in their decision to implant it are internal in nature, specifically the desire to improve efficiency, productivity and quality. Results also identify major constraints limiting the dissemination and use of ISO 22000: it is not a well-known standard and many food companies are unaware of its potential (Escanciano & Santos-Vijande, 2014a; Escanciano & Santos-Vijande, 2014b).

Concerning the main motivations of ISO 22000, it was observed that Portuguese companies became ISO 22000 certified mainly to improve consumer confidence and because this kind of registration is a requirement for satisfying other interested parties. Regarding the benefits achieved, the surveyed companies had reported an improvement in food safety methodologies and practices. As verified for the ISO 22000 certification motivations, the most important benefit stated by the respondent companies was of internal nature. Regarding the implementation barriers, two main difficulties were reported: internal resistance to change and FSMS implementation costs (Teixeira & Sampaio, 2013).

Integrating management systems in food sector enterprises in Poland was examined. A planning phase as described in the Publicly Available Specifications (PAS) with 99 specifications was studied as one of the elements of the joint systems constituting an integrated management system. Four organizations were selected for the study, where at least two standardized management systems were introduced and certified. It was assumed that the investigated organizations should have an implemented HACCP system. The research study was a case study. In every organization, the employees responsible for the operation of management systems in the enterprise were interviewed. The study was performed in the form of in-depth interviews based on a pre-developed scheme according to the PAS 99 guidelines. Based on the research results, it was found that all the organizations surveyed were aware of the fact that in the case of emergency situations, risk management was a must. In three enterprises, the risk management procedures were implemented and in operation; in the fourth organization, the employees worked at implementing those procedures. In all the organizations, there was one person responsible for all the implemented management systems. The objectives linked with food safety constituted a minority compared to all other objectives adopted in the organization within the scope of management systems in operation therein. In addition, it was proved that the implementation of the system and the ISO 22000 certification did not cause any significant changes in the map of processes or in the type of actions taken by the organizations surveyed. Impediments to the integration of systems (including the planning element) were mainly associated with the fact that those organizations operated within international groups where some rules

were established top-down with no possibility of change (Kafel P., 2013).

An assessment of FSMS implementation in a sample of 50 small food businesses in Cyprus demonstrated an improvement in premises hygiene, with the most significant improvements occurring after the implementation of PRP's and a bespoke HACCP plan. Increasing the system complexity by imposing the Cyprus standard (CYS 244) or ISO 22000 resulted in hygiene deterioration as measured by the audit and some sampling results. However, the final standard was generally higher than at the start of the study, suggesting the premises usually had better hygiene after the study period. This may have been due to the improved hygiene knowledge demonstrated by the food handling staff. The attitude of the Food Business Operators was generally in favor of FSMSs at the start of the study, but became less positive after the imposition of the CYS 244 and ISO 22000 standards. Because of the difficulties faced by Food Business Operators in trying to implement these more complex systems, 90% wished to stop using them, and by 2014, 75% of them were no longer using even a formal HACCP system. A further 10% had closed. All the Food Business Operators reported substantial costs related to the implementation of the systems (Charalambous M, 2015).

To summarize, the major problem to solve in Europe in order to implement satisfactorily ISO 22000 or other FSMS in companies is the employees' commitment with the daily standard monitoring and its usefulness.

ISO 22000 in African food-processing companies

In African countries ISO 22000 regional shares is 3,7%, with 1130 certificates in 32 economies in 2014. In table 2, there are three studies found about ISO 22000 in this geographical area in the last ten years.

Table 2. *Studies of ISO 22000 in African food processing companies.*

African countries	Food processing	Activities	Reference	Journal
African countries	Companies	40 Reported cases	Kussaga et al., 2009	J Sci Agric
Togo	4 small and medium food businesses	Authors' research	Lamboni & Azouma, 2013	Environ Ris Sante
Zimbabwe	Companies	Surveys	Macheka L et al 2013	Food Control

The first study was performed to provide insight into current deficiencies in FSMS in African food-processing companies and to identify possible strategies for improvement so as to contribute to African countries' efforts to deliver safe food to both local and international markets. As a result, it was found that most African food products had high microbiological and chemical contamination levels exceeding the set (legal) limits. Relative to industrialized countries, the study identified various deficiencies at government, sector/branch, retail and company levels, which affected performance of FSMS in Africa (Kussaga et al., 2014) .

Very few companies, except exporting and large ones, had implemented HACCP and ISO 22000:2005. Various measures were proposed to be suggested to the different governments, for instance, the construction of risk-based legislative frameworks, strengthening of food safety authorities, using ISO 22000:2005 and consumers' food safety training. For each branch/sector it were recommended sector-specific guidelines and third-party certification and for retail, developing stringent certification standards and imposing product specifications. At company levels it was suggested improving hygiene, strict raw material control, production process efficacy, and enhancing monitoring systems, assurance activities and supportive administrative structures. The conclusion was that by working on those four levels, FSMS of African food-processing companies could improve and be better designed and tailored towards their production processes and specific needs to ensure food safety (Kussaga et al.,

2014).

An approach that integrates the FSMS and the West African Economic and Monetary Union (WAEMU) directives to small and medium food businesses (SMFBs) design has been proposed. The quality of food produced by SMFBs and their practices in relation to environment protection and consumer health often do not meet ISO norms, although these are an important factor for competitiveness on the national and particularly the international market. Many existing SMFBs fail to meet these norms and will require new or redesigned plants to do so. These solutions involve significant investments that delay or discourage SMFBs from obtaining certification, in view of their limited financial capacity. In an attempt to enable ISO certification, it is examined how FSMSs could be integrated into new SMFB designs. Firstly, it is conducted a diagnostic investigation of four SMFBs in the maritime region of Togo. Consequently, the authors found various extents of failure to conform the FSMS requirements of the ISO 22000:2005 as environment relative to the plant site: 33 to 67%; buildings: 29 to 86%; equipment and workspace: 0 to 67%; air, water, and energy supply systems: 75 to 81%; waste disposal: 22 to 100%; suitable equipment: 14 to 86%; prevention of cross-contamination (forward planning): 33 to 100%; and finally, pest control: 67%. Dissemination of information and up-to-date clear training materials for the food industries and their workers remain insufficient. To these challenges must be added the fact that SMFBs do not receive adequate technical assistance (Lamboni & Azouma, 2013).

In a similar way, small-scale companies dominate the food-manufacturing sector in Zimbabwe and most of these companies do not have FSMSs. The barriers and motivation factors towards the implementation of FSMS such as HACCP and ISO 22000 in the food-manufacturing sector in Zimbabwe have not yet been explored, so a survey was realized in order to determine factors that influence the implementation of FSMS by food manufacturing companies in Zimbabwe. For that purpose, fifty-five questionnaires were distributed to different food companies in Harare Province in Zimbabwe: thirty of which were fully completed and returned. The questionnaires elicited information on the barriers hindering implementation of FSMS and factors that motivate food-manufacturing companies to implement an FSMS. The survey revealed that the main barriers for the implementation of an FSMS included lack of financial resources, size of organization, inadequate infrastructure and facilities, and lack of top management commitment. Improved product quality and safety was identified as the major benefit of implementing an FSMS. Other benefits highlighted included increased employees' skills, improved company image, increased product sales, increased market share and access to new markets (Macheka L et al. 2013).

To sum up this section, African countries need governmental economical and technical support to implement ISO 22000 or any other FSMS in SMEs and increase their competitive potential. On the other hand, consumers must acquire better food safety education to fully appreciate the standard implementation.

ISO 22000 implementation in agricultural sector

Agricultural practices are a consumers' concern, for instance plaguicide contamination, whereas for producers product quality but also quantity are major worries. Table 3 shows four reports about ISO 22000 standard use in the agricultural branch in the last ten years.

With the intention of approaching quality, control and management, ISO 22000 deployment in a grain storage unit, one of the largest cooperatives in the region of Parana state, Midwest of Brazil, was revised. Technological advances in agricultural production methods, new food preparation techniques, packaging of the products, the growing concern for the environment and sustainable development are aspects enclosed in the discussions on the issue of quality and food safety for the consumer. As it was demonstrated, it is important

Table 3. Studies of ISO 22000 in the agricultural sector.

Country	Product	Action	Authors	Journal
Brazil	Grain	Study	Furlan & Morozini, 2013	Custos e Agronegocio on line
Iran	Pistachios	Aflatoxins	Fallah et al 2013	Journal of Food Safety
Tunisia	Flour	Study	Gaaloul et al 2011	Food Control
South Africa	Sugar	Management survey	Ramphal & Simelane, 2010	International Sugar Journal

to be acknowledged along the whole food chain, with its main links, which serve as control points that facilitates the current monitoring and the identification of problems, their location and possible cause. The installation and operation of these mechanisms necessarily imply increased transaction costs for the system as a whole. However, given the importance of food and its impact on health and environment, it is assumed that such costs are lower than those that would result if these mechanisms would not operate (Furlan & Morozini, 2013).

Iran is the largest producer and exporter of pistachios in the world (FAO Consultant 2009). Because of the importance and usage of pistachios, it is necessary to improve their agricultural situation by establishing good processing equipment and packaging units near pistachio farms. It is possible to supply a large quantity of high quality products for foreign and domestic markets but one major problem in this field is the production of aflatoxin, which is one *Aspergillus* metabolite produced in adequate humidity and temperature conditions. A study employing FSMS based on ISO 22000:2005 model to prepare safe pistachios with less aflatoxin content has been performed. The results obtained in this study indicate that the stages immersing pool, wet sorting and dry sorting had significant effect on aflatoxin B1 reduction while washing of pistachio nuts did not have a significant effect on decrement of aflatoxin B1. The stages temporary sorting and drying even increased the concentration of aflatoxin B1 in the product. Adverse effect of these stages could be attributed to biological activity of molds and reducing moisture content of the product, respectively. Overall, it is concluded that operational PRPs (OPRPs) and CCPs have no important differences regarding to hazard control but they are dissimilar from a type of control measure aspect. For the effective implementing of FSMS, suitable PRP are necessary. It is not true to say that maximum hazard control is achieved with CCP, but CCP is the last point for hazard control and therefore must be concentrated upon for most monitoring actions (Fallah A et al., 2013).

In Tunisia, a corporation of various industries of flour, the *Société des Minoteries et des Industries Diverses* (SMID) launched the study of ISO 22000 implementation during wheat grinding process. Various methods and procedures have been developed to monitor cereal products safety issues at an early stage, including early detection, warning systems, vulnerability assessment and corrective actions. The PRPs implementation allowed them to control the likelihood of incidence of physical, chemical and microbiological hazards. The HACCP established plan enabled to monitor the real hazards which make up five CCPs: the survival of cereal insects during wheat storage operation, the presence of foreign bodies during cleaning, the contagion and proliferation of mushrooms during moistening, the proliferation of mushrooms and insects during transfer and storage of the finished products and, finally, the presence of foreign bodies during packaging (Gaaloul et al., 2011).

Another topic of investigation was the choice of standards attending to management preferences, consisting of comparative analyses of the standards, an empirical determination of management's preferred choices of standards or combinations of standards and the study of

the implementation of ISO 22000 at the Mhlume Sugar Factory in Swaziland (Royal Swazi Sugar Corporation, South Africa). The findings showed that an ISO 9001 certified organization can add some requirements and be equivalent to ISO 22000 depending on customer and market demands. It was also shown that management have the least preference for ISO 9001 only, and prefer both ISO 9001 and ISO 22000 certificates. The benefit of this contribution is to inform the management of the similarities and differences between quality, HACCP and food safety systems and the possibility of combining both (Ramphal & Simelane, 2010).

Finally, Varzakas et al. (2010) applied the Failure Mode and Effect Analysis (FMEA) model to the risk assessment of almond manufacturing. The main emphasis was put on the quantification of risk assessment by determining the Risk Priority Number (RPN) per identified processing hazard. Pasteurization, fumigation with propylene oxide, packaging, storage and distribution and hulling/shelling were the processes identified as the ones with the highest RPN (240, 225, 180, 144, respectively) and corrective actions were undertaken. Following the application of corrective actions, a second calculation of RPN values was carried out leading to considerably lower values (below the upper acceptable limit of 130). It is noteworthy that the application of Ishikawa (Cause and Effect or Tree diagram) led to converging results thus corroborating the validity of conclusions derived from risk assessment and FMEA. Therefore, the incorporation of FMEA analysis within the ISO 22000 system of an almond processing plant was considered imperative.

To conclude, agricultural sector companies are aware of the benefits of HACCP and ISO 22000 standard implementation and use during all the processes that commodities suffer.

ISO 22000 implementation in dairy products sector

Providing 'on-farm food safety' programs which address the daily management of the production unit with regard to animal health and well-being, public health and environmental health must be a top priority for agriculturalists and veterinarians. In table 4, are cited the five articles found about ISO 22000 standard in the dairy sector in the last ten years.

Table 4. ISO 22000 implementation in dairy products sector

Country	Product	Action	Authors	Journal
Greece	Yoghurt	Microbiological hazard	Chountalas P et al 2009	British Food J
Cuba	Ice cream	HAPPC analysis	González-González et al 2012	Ingeniería Industrial
Kenya	Dairy	Microbiological hazard	Opiyo BA et al 2013	Journal of Food Protection
Greece	74 dairy companies	Levels of the HACCP FSS effectiveness	Psomas et al 2015	Food control
Serbia	27 dairy companies	Survey	Tomašević et al 2016	Mljekarstvo

Several types of companies have made efforts to implement the ISO 22000 in Greece including the application of these requirements, as interpreted, to industrial yoghurt manufacture, considering all major varieties (set, stirred and strained) and types (with or without flavorings) (Chountalas P et al., 2009).

A research study was carried out in 74 Greek dairy companies using a structured questionnaire showing that the ISO 22000 certified ones significantly outperform the non-certified with regard to the HACCP Food Safety System (FSS) effectiveness. Thus, managers of dairy SMEs, taking advantage of the structured organization and the documented procedures provided by the ISO 22000 standard, can increase the level of the HACCP FSS achieved objectives, meaning

HACCP effectiveness. In doing so, dairy SMEs can set the foundations in order to optimize the conditions under which safe food is provided, minimize the possibility of food non-conformities and scandals, rise in market share and consequently withstand the current downturn (Psomas et al. 2015).

In Cuba a procedure was designed for the application of HACCP in the small Icy Lark factory in order to guarantee the innocuousness of the product. This work allowed to evaluate the sanitary state of the food areas related with the ice cream production. The results obtained implementing the procedure were satisfactory during the three years in which compliance was checked. The product was suitable for consumption, which gave confidence to management and customers, both tourism workers and consumers (González-González et al. 2012).

In Kenya, the effects of existing FSMS and size of the production facility on microbiological quality in the dairy industry were studied. A microbial assessment scheme was used to evaluate 14 dairies in Nairobi and its environs, and their performance was compared based on their size and on whether they were implementing HACCP systems and ISO 22000 recommendations. Environmental samples from critical sampling locations, i.e., workers' hands, food contact surfaces and from end products were analyzed for microbial quality, including hygiene indicators and pathogens. Microbial safety level profiles (MSLPs) were constructed from the microbiological data to obtain an overview of contamination. The maximum MSLP score for environmental samples was 18 (six microbiological parameters, each with a maximum MSLP score of 3) and for end products was 15 (five microbiological parameters). Three dairies (two large scale and one medium scale; 21% of total) achieved the maximum MSLP scores of 18 for environmental samples and 15 for the end product. *Escherichia coli* was detected on food contact surfaces in three dairies, all of which were small scale dairies, and the microorganism was also present in end product samples from two of these dairies, an indication of cross-contamination. To summarize, microbial quality was poorest in small-scale dairies in Nairobi. Most operations in these dairies were manual, with minimal system documentation. Non-compliance with hygienic practices such as hand washing, cleaning and disinfection procedures, which is common in small dairies, directly affects the microbial quality of the end products. Dairies implementing HACCP systems or ISO 22000 recommendations achieved maximum MSLP scores and hence produced safer products (Opiyo BA et al., 2013).

Recently, a Serbian dairy industry survey about food safety management systems implementation was published (Tomašević et al., 2016). It involved 27 food business operators with the national milk and dairy market share of 65 %. Indeed, in most of the cases, the investigated dairy producers (70.4 %) indicated that they had an entirely operational and certified HACCP system in place, while 29.6 % implemented HACCP, but had no third party certification. ISO 22000 was implemented and certified in 29.6 % of the companies, while only 11.1 % had IFS standard. The initial set-up of food safety management system was the cost of product investigation/analysis and hiring external consultants. Important conclusions extracted from this survey are the identification of the attitudes and the motivation of the food production staff as the most important barrier for the development and implementation of HACCP. The most important recognized benefit was increased safety of dairy products. Moreover, the increased customer confidence and working discipline of staff employed in food processing were also found as essential benefits of implementing/operating HACCP.

In conclusion, this section reveals similar findings than the first results section. Workers must be involved in ISO 22000 or other FSMS standard implementation in order to feel responsible of consumers' health during their daily work.

ISO 22000 in fish sector

Consumers and regulatory officials are aware of the human health risk of the presence of microorganisms and/or chemicals in fish. Studies from three countries have been found discussing ISO 22000 and are cited in table 5.

Table 5. ISO 22000 implementation in fish products sector.

Country	Product	Action	Authors	Journal
Greece	Salmon	Risk Assessment	Arvanitoyannis & Varzakas, 2008	Rev Food Sci Nut
Greece	Trout	Risk Assessment	Arvanitoyannis et al, 2009	Critical Rev Food Sci Nut
Greece	Octopus	Risk Assessment	Arvanitoyannis & Varzakas, 2009	Inter J Food Sci Technol
Portugal & Spain	5 Seafood processing	Study	Weyandt et al, 2011	Procedia Food Sci

A comparison of ISO 22000 with HACCP was carried out over salmon processing and packaging in Greece. However, the main emphasis was put on the quantification of risk assessment by determining the risk priority. Fish receiving, casing/marketing, blood removal, evisceration, filet-making cooling/freezing, and distribution were the processes identified as the ones with the highest risk and corrective actions were undertaken. After the application of these actions, a second calculation of risk was carried out resulting in substantially lower result comparing to the first one. Therefore, the incorporation of failure mode and effect analysis (FMEA) within the ISO 22000 system of a salmon processing industry is anticipated to prove advantageous to industrialists, state food inspectors, and consumers (Arvanitoyannis & Varzakas, 2008).

Furthermore, the FMEA was applied to the smoked trout manufacturing process in an attempt to calculate quantitatively the Risk Priority Number (RPN) and to find out whether it can be effectively correlated to ISO 22000 and/or HACCP. RPN was found to be in close agreement with HACCP, thereby indicating that corrective actions will have to be undertaken (Arvanitoyannis et al., 2009).

In the next study, comparison of ISO 22000 analysis with HACCP was carried out over octopus processing and packaging. CCPs were identified in the risk assessment of octopus (*Octopus vulgaris*) processing and implemented in the HACCP plan. In the hazard analysis worksheet the different hazards were identified at each processing stage, whereas in the HACCP plan each CCP was identified and accompanied with the relevant significant hazard, critical limit, monitoring of the CCP and corrective actions. ISO 22000 Analysis Worksheet was employed for determination of some PRPs. Comparison between the two systems was carried out using the hazard analysis worksheet with the result that the PRPs were the main difference between the two systems. In conclusion, the incorporation of PRPs in the ISO 22000 made the system more flexible as a smaller number of CCPs were introduced (Arvanitoyannis & Varzakas, 2009).

In another study, five seafood processing plants located in Portugal and Spain were chosen for their prominence in the fishing industry, their certifications, and their reputation for remarkable performance with integrated management systems (IMS) already implanted. The results showed that all of the five analyzed plants have set quality and FSMSs; however only three of them have IMS. These companies showed good practices aimed at the preservation of the environment as opposed to the plants that did not have IMS as well as it was observed a greater gain in time with simultaneous implementation. As benefits of the adoption of the IMS, the plants identified an increase in sales and satisfaction on the part of their employees. Regarding the critical factors, the analyzed plants pointed to:

interpretation of the standards, the empowerment and valuing of people and industry sensitivity towards the implantation of the IMS. Considering the importance of standards ISO 14001 and ISO 22000 and the results observed, it can be concluded that the integrated implementation of these standards allied to the measures for overcoming the critical factors, presents great potential for the increase of competitiveness of fish processing plants (Weyandt et al., 2011).

To summarize this section, in fish sector industries implementation of ISO 22000 or at least a FSMS is highly recommended. After implementation, benefits have been found in all cases reported.

ISO 22000 in meat products sector

Quality and safety are key for the meat industries. Quality assurance of the whole process is significant for the consumer acceptability, while safety assurance is obligatory for protection of public health. The studies that address this issue are compiled in table 6.

Table 5. ISO 22000 implementation in meat products sector.

Country	Product	Action	Authors	Journal
UK	Poultry	Risk assessment	Manning et al. 2006	British Food Journal
Australia	Meat (13 firms)	Study	Khatri & Collins, 2007	British Food Journal
Greece	Snails	Study	Arvanitoyannis & Varzakas, 2009	Critical Rev Food Sci Nut
Turkish	Poultry (18 producers)	Survey	Kök, 2009	Journal of Food Protection
France	Pate	Microbiological hazard	Poumeyrol G et al, 2010	Food Control
Cyprus	Meat delicatessen	Risk assessment	Zorpas et al, 2010	Open Food Science J
Serbia	Meat (9 industries)	Survey	Tomasevic et al, 2013	Food Control

In the UK, Manning et al. (2006) analyzed how a PRP and key performance indicators for food safety can be developed in the poultry meat supply chain. They reviewed the legislative and market externalities and the key food safety hazards associated with the broiler growing stage of production. Among the results, they included the requirement to reduce the level of *Campylobacter spp.* contamination, and the use of antimicrobial products in the food industry.

One of the first studies found evaluating food safety management in meat industry was performed in Australia. It might be possible that the unwillingness of small firms to participate in the research had repercussions on the outcome, because the 13 participant firms (out of a total of 42 possible) own the 80% of Australian meat processing throughput. Nevertheless, results show that the benefits of food safety systems incorporating HACCP within the meat industry in Australia have been widespread and significant. In particular, Australian firms reported a reduction in rejects/rework/out of specification products, reduction in customer complaints, improved product hygiene, improved morale and an increase in overseas markets. However, this has been at the cost of refurbishment for small businesses, training and the exiting of firms that have not complied/been able to comply with the HACCP requirements. Most of the costs involved with HACCP could not be recouped in the short-term (Khatri & Collins, 2007).

A bacterial hazard analysis methodology, based on the ISO 22000 standard, which could be adopted by small food manufacturers, was provided for meat pate prepared by pork butchers in France. The

results of the hazard analysis showed that many bacterial hazards, particularly *Listeria monocytogenes*, *Salmonella* and *Staphylococcus aureus* could be effectively controlled by good hygiene practices. For the three microbial hazards *Bacillus cereus*, *Clostridium botulinum* and *Clostridium perfringens*, specific control measures must be implemented. Hazard analysis provided the necessary basis for a rational choice of these specific control measures (Poumeyrol G et al., 2010).

FMEA has been applied for the risk assessment of snails manufacturing. An approach of FMEA application to the snails industry was attempted in conjunction with ISO 22000. Preliminary Hazard Analysis was used to study and predict the occurring failure modes in a food chain system (snails processing plant), based on the functions, characteristics, and/or interactions of the ingredients or the processes, upon which the system depends. CCPs have been identified and implemented in the cause and effect diagram (also known as Ishikawa, tree diagram, and fishbone diagram). The processes identified as the ones with the highest RPN were sterilization of tins, bioaccumulation of heavy metals, packaging of shells and poisonous mushrooms. Following the application of corrective actions, a second calculation of RPN values was carried out leading to considerably lower values. It is noteworthy that the application of Ishikawa (Cause and Effect or Tree diagram) led to converging results thus corroborating the validity of conclusions derived from risk assessment and FMEA. Therefore, the incorporation of FMEA analysis within the ISO 22000 system of a snails processing industry is considered imperative (Arvanitoyannis & Varzakas, 2009).

In Cyprus, a risk profiling work has been carried out according to the standard ISO 22000:2005 in a meat delicatessen industry. The verification activities in food industries encompass sampling for monitoring CCPs and determination of microbiological variables, review of records, flow diagrams and HACCP plan. However, regarding the implementation of such a safety assurance system and hygiene, programs are also required. The detailed analysis of the safety and hygiene factors affecting the quality and safety in the whole processing of the examined meat delicatessen products (bacon, lountza, hiromeri, ham, sausages), evidenced that the control of CCPs relative to raw materials' specifications or temperatures in retaining or thermal processing steps, as well as the PRPs relative to the hygienic conditions during production, should be satisfied (Zorpas et al., 2010).

A survey was performed in the Serbian meat industry, involving 77 producers out of which 93.5% claimed that they had a fully operational and certified HACCP system in place, while 6.5% implemented HACCP, but without third party certification. ISO 22000 was implemented and certified in 9.1% of the companies, while only 1.3% had implemented and certified IFS standard. The most important incentive for implementing FSMSs for Serbian meat producers was to increase and improve safety and quality of meat products. Investment in the new equipment, civil work in the plant including redesign of production facilities were the costs related to the initial set-up with the greatest importance. The results indicated that the major difficulty encountered during HACCP implementation and operation was associated with the finance, namely the fact that companies were not able to recoup costs related to the implementation/operation of HACCP system. The most important identified benefit was increased safety of food products with mean rank scores 6.45. The increased quality of food products and working discipline of staff employed in food processing, were also found as important benefits of implementing/operating HACCP in Serbian meat industry (Tomasevic et al. 2013).

Another survey was conducted to determine the extent of FSMSs (ISO 22000/HACCP) implementation in the Turkish poultry industry, with 25 major poultry meat producers, which meant close to 90% of national production. Then a comparison was made between

the procedures of small-to-medium enterprises (SMEs) and large firms (LFs). The survey revealed that there is a high level of application of ISO 22000 (72%), which is seen to aid the export market. It was shown to adopt more stringent schemes and make better use of governmental support services for SMEs and be also more aware of, and able to deal with, risks from a greater range of contaminants (Kök, 2009).

In this section the financial issue has been brought out, although the benefits of FSMS implementation are the same than in other sectors.

ISO 22000 in Food Supplement Industry

A methodology is proposed to carry out hazard and control measures assessments to properly establish OPRPs and an HACCP plan in the food supplement industry according to the ISO 22000 standard. This study focused on the manufacture of propolis, royal jelly and vitamin C ampoules, sold as energy boosters. Seven of the 13 hazards identified in this study were significant: two hazards were in the reception step (residues of pesticides, antibiotics and/or heavy metals and contamination by pathogens), two in the ingredients weighing step (cross-contamination by metabisulphite and contamination by pathogens, one in the mixture preparation step (contamination by pathogens and/or proliferation of microorganisms) and two in the ampoule-filling and -sealing step (cross-contamination by metabisulphite and contamination by pathogens). After assessing the control measures, CCPs were determined in the hazards with codes 2, 9 and 12, which could be managed by an HACCP plan. The remaining hazards were managed by establishing OPRPs.

It can be concluded, that implementation of the ISO 22000 standard in the food supplement industry guarantees food safety and helps to improve their competitiveness in the global market. In this study, the company in Spain achieved the ISO 22000 certification, thus guaranteeing food safety, which may contribute to increase its share market and to enter new markets (Fernández-Segovia et al., 2014).

ISO 22000 in Food Service providers

In several articles ISO 22000 was assessed after implemented in bars and restaurants (Brazil), catering services (Poland), hotels (Taiwan) and in hospitals (Tunisia & Turkey).

Food environmental service and FSMSs according to two checklists, based on Brazilian Technical Standards Association ISO 22000 and 14001, were assessed. This exploratory and descriptive study investigated food services of the Federal District in Brazil. A total of 37 food services were selected from the list of the Brazilian Association of Bars and Restaurants by simple random sampling. Only five food services employed dietitians to supervise meal production. These establishments achieved the highest ISO compliance, even though no establishment had more than 50% ISO 14001 or 22000 compliance. Restaurants showed little concern for the environment and disobeyed waste disposal laws by not separating recyclables from non-recyclables. Moreover, these food services did not have safe meal production systems, evidenced by non-conformity with the reference standards. In conclusion, food services supervised by dietitians are better prepared to produce safe foods, but the implantation and consciousness of employees on the system is still a great challenge in this sector (Santos et al., 2012).

It is clearly noticed that prestige and trustworthiness are the benefits that may motivate hoteliers to obtain the accreditation of quality. A firm could lose its competitive position in the international market as well as the domestic one by failing to pay attention to food safety management issues. A survey investigation of three types of stakeholders in 29 hotels across Taiwan was performed. The officials and team leaders of hotel inspection and supervision center from government tourism bureau, the hotel front and back of the top hotel managers and first line managers plus employees, participated in the study. It was concluded that successful ISO 22000 implementation requires changes within a structural organization with clearly defined

responsibilities and authorities, besides well-defined training goals and measurable objectives to overcome the obstacle. These findings of the study suggested that ISO 22000 can be an effective strategy to improve managerial efficiencies and maintain competitiveness (Wang et al., 2011).

The goal of the study, was to analyze the effectiveness of training provided to employees in a catering company in Poland with implemented FSMS pursuant to ISO standard of 22000 series and to determine the risk of making mistakes by those employees, when fulfilling their on-the-job duties owing to insufficient assimilation of the knowledge introduced during the training. The study allowed the verification of the level of employees' knowledge in the company prior to and after the training. The acceptable risk of errors made by the employees in the catering company with the implemented FSMS pursuant to the ISO standard of 22000 series, was proved exclusively referring to the employees hired as cooks. The statistical analysis using a chi-square test, confirmed the statistically significant relation that exists between the increase in knowledge and the job position in the company. The applied risk assessment proved to be a useful method to analyze the results of staff training effectiveness, leading to enhance conclusions by means of statistical methods. It was confirmed that staff trainings played a significant role in the upskilling of the catering employees and in minimizing the risk of making mistakes (Trafialek J and Pawlowska J, 2013).

Abouda el al. (2014) studied the bacteriological quality of food served to patients in the Sousse Hospital (Tunisia) and they recommended the application of good hygiene practices to work towards the implementation of the food safety preventive system (ISO 22000) based on the principles of HACCP.

Patients' satisfaction before and after HACCP/ISO 22000 implementation was studied at hospital food service in the Ankara University Hospital (Turkey). The subjects were 466 patients consisting in 191 males and 275 females from different clinics in one university hospital. The questionnaire of food and food service satisfaction of patients were filled by an intern dietician. The results showed that the satisfaction of patients was increased after HACCP and ISO 22000 implementation not only for food quality but also related to organoleptic quality, menu and service specifications (Uyar et al., 2012).

ISO 22000 related with consumers' attitudes

In the region of South-East Poland it was found that, when choosing food, the consumers checked, in the first place, the expiration date (93.7 % of the responses), next price (63.6 %), and at last composition of food product (62.2 %). The level of consumer interest in information on whether or not the product was produced in accordance with the principles of HACCP/ISO 22000 (11.9%) was very low. Women were interested in the composition of food more often than men: 69% of all women participating in the survey. The graduates of universities (51.1%) paid attention to that particular element shown on the food label more often than other respondents. The composition of food was more important for the city residents surveyed than for the rural residents. The composition of a food product was particularly important for the persons living in the households with a monthly income of more than net 1,600zł per person. The respondents from the households with incomes not exceeding 800zł regarded this element on the food label as the least important for them. For those consumers, the most important factor that affected their food purchase was the price in the first place. The women surveyed (76.5 %) paid more attention to the information on whether the product was produced in accordance with the principles of HACCP/ISO 22000. The respondents aged above 40 (38.2%) reported this information to be important for them (Niewczas M, 2013).

Consumers' attitudes, knowledge and practices governing food safety in the Middle East and North Africa (MENA) are understudied. There

are no studies investigating the food marketing implications of these factors in the context of eating out or ordering delivery. In this study, a choice experiment (CE) was conducted to study consumers' preferences and purchasing behavior governing shawarma sandwiches, a high risk Lebanese fast food, purchased from quality management (ISO 9001) and safety (ISO 22000 and ServSafe) certified food shops in Beirut, Lebanon. Moreover, the study looked at the effectiveness of information provision on each type of certificate in influencing consumers' purchasing decisions. Estimation of data revealed a strong overall preference for all types of certified shawarma sandwiches and a strong heterogeneity in the degree of this preference in the Beirut population. These results also suggested that once informed about the role of each certificate, preference for each food certificates increased significantly, but more and in a much more variegated manner for the food safety certificates, ISO 22000 and ServSafe than for ISO 9001. The determinants of preference shift (mostly increase) that are affected by information provision, are herein studied. Results suggested consumers' mental conception of food safety revealed by their knowledge, perceptions, attitudes, preventive behavior and purchasing habits, are more important respect to objectively measured sociodemographic characteristics. This poses a challenge for food safety marketing research, not to mention the difficulty of collecting this type of data (Chalak A and Abiad M, 2012).

Conclusions

In conclusion, the ISO 22000 in the last decade has demonstrated to be a useful tool for food safety management and specifies the system requirements needed for monitoring and mastering hazards to ensure food suitability for human and animal consumption as proved by its application growth around the world. In addition, ISO 22000 implementation is an effective strategy to improve managerial efficiencies and maintain competitiveness at food services as catering, hotels, restaurants, bars and hospitals.

On one hand, attending to developing countries, Public Administration should make an economical effort to implement this standard in SMEs, in order to improve consumers' health and international market competitiveness. On the other hand, food safety knowledge should be included in children and adults education.

Improved product quality and safety have been identified as the major benefits of implementing ISO 22000. Other benefits highlighted include enhanced employee skills, improved company image, increased product sales, increased market share and access to new markets. As a result, consumers' attitudes and preferences tend towards preferring food from companies that have implemented ISO 22000 as they gain a higher position in the trust of their clients.

ISO 22000 is a standard which its main characteristic is that is specifically focused on food safety and not quality, giving the highest priority to consumers' health. This relatively new sight on the whole food chain industry is becoming more and more the greater concern for public administrations, as the globalization has brought new issues on food safety which will be increasing in the following years, due to the internalization of the market and the high variability on countries legislation.

In all likelihood, during the 21st century, ISO 22000 will continue taking a leading international role ensuring consumers' health and food economies' benefits.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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