

Review

Determining Food Stability to Achieve Food Security

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Abstract: Food security, as part as public health protection, constitutes one of the main objectives for countries aiming to ensure the health of all their citizens. However, food security is compromised worldwide by conflict, political instability, or economic crises, both in developed and developing countries. Conversely, because of the importance of agriculture to the economies of rural areas both in developed and developing countries, this sector can contribute to improving food stability, as well as to furthering food security. Thus, livestock and traditional meat products represent a key factor in ensuring food availability. Overall, biosecurity measures improve animal welfare by decreasing the occurrence of diseases that compromise the stability by causing fluctuations in the availability of meat and animal-derived food products such as milk, eggs, or traditional fermented products. As a consequence, an absence of biosecurity measures affects food security (in its quantitative definition, as described above) as well as the productive, sanitary, and environmental sustainability of the rural environment. Products of animal origin support local trade and the regional economy, while contributing to the availability of foods without great external dependence. The manufacture of foods of animal origin aims to create products that are durable and that maintain food availability for long periods of time, even during seasons with scarce resources. Thus, dry-cured or fermented meat products play an important role in food availability. Food security also refers to food access under healthy economic conditions; therefore, knowledge of the main tools that guarantee the safety of these kinds of food products is essential to achieving food stability and further food security.

Keywords: food safety; food security; livestock; biosecurity; food stability; fermented products



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1. Introduction

Food security, as a part of public health protection, constitutes one of the main objectives countries aiming to ensure the health of all citizens. Thus, to achieve this objective, specific policies related to several aspects of food production, such as the hygienic conditions of food processing, packaging, shelf-life, or food labelling information is mandatory in every country worldwide [1]. In developed countries, consumers themselves demand the safety of the foods that they consume, which is associated with the social impact caused by recent food scandals, such as the horse meat scandal, the presence of melamine in milk, or the bovine spongiform encephalopathy [2,3]. Additionally, consumer concerns regarding chemical hazards in food have arisen in the last few years [4].

To address the issue of food security, it is necessary to define the concept, which is complex. The term “food security” has different connotations depending on whether it is referring to rural or urban areas, as well as to developed or developing countries [5]. Thus, food security has a quantitative dimension, which concerns the availability of enough safe and nutritious food, and a qualitative dimension, which concerns the sanitary conditions of food production and processing. Consequently, several concepts arise, such as food security, food safety, food defense, or food nutritional quality. Although these terms have inter-linked aspects, they describe different situations [6].

Food safety refers to handling, preparing, and storing food in a way that best reduces the risk of individuals becoming sick from foodborne diseases [7]. The concept of food security can be defined as the ability to obtain and/or to store basic food products to guarantee that food is available for consumption, saving fluctuations and prices [5]. Food defense refers to the protection of food products against intentional adulteration by biological, chemical, physical, or radioactive agents [8].

Another alternative definition of food safety has been proposed based on the quantification of its effects through the ultimate manifestation of food insecurity, which is malnutrition. Thus, the concept of food and nutritional safety can be defined as the guarantee that individuals, families, and the community as a whole have access at all times to sufficient safe and nutritious food, mainly produced in-country under conditions that are competitive, sustainable, and equitable, so that the consumption and biological use of the foods provides the public with optimal nutrition that supports a healthy and socially productive life, while respecting cultural diversity and consumer preferences [9].

The current review adopted the definition of food security that was established in the Plan of Action of the World Food Summit, which was signed in Rome in 1996 [10]. Food security is achieved when people always have physical and economic access to safe and nutritious food that satisfies the nutritional needs and preferences which are necessary for leading an active life.

According to the concepts provided by the Food and Agriculture Organization (FAO) [11], the term “food security” encompasses four basic pillars: (i) *food availability*: the existence of enough quantities of food of adequate quality, supplied through domestic production or imports (including food aid); (ii) *food access*: people’s access to adequate resources to acquire appropriate food and a nutritious diet; (iii) *utilization*: biological use of food through adequate nutrition, drinking water, sanitation, and medical care, to achieve a state of nutritional well-being in which all physiological needs are satisfied, a concept that highlights the importance of non-food inputs in food security; and (iv) *food stability*: a population, a household, or a person must always have access to adequate food in order to have food security. People should not be subjected to the impossibility of being able to acquire foodstuffs due to sudden problems, such as economic crisis, climate crisis, or cyclical events, such as seasonal food inaccessibility. In this way, the concept of stability refers to both the availability and access of people to secure sources of food [12].

It should be noted that access and availability of foodstuffs is not, as a rule, a problem in developed countries. In these societies, the concept of food security would be focused on food safety and relationship between food and health, keeping in mind the growing expectations regarding nutritional quality and the new functional properties of foods. However, the food security concept in developing countries mainly refers to the food supply as mentioned above.

To guarantee the access and availability of foods, the FAO adopts the “two-component approach” to combat hunger, combining agriculture and sustainable rural development throughout specific programs [13]. The objectives of these programs are aimed at increasing direct access to foods (food security) to the most sectors to guarantee a stable supply (food stability). Based on the theoretical framework of the two-component approach, seven principles are the basis of the FAO’s overall strategy [14]:

1. *Attention to food security:* ensure that objectives related to food security are incorporated into national strategies to reduce poverty, while considering each strategy's impact at the country-, sub-national-, household-, and community-level;
2. *Promotion of sustainable and broad-based agricultural and rural growth:* foster environmentally and socially sustainable development as a cornerstone of economic growth;
3. *Attend to the entire rural area:* consider, in addition to agricultural production, other opportunities to enhance the economy and income apart from farming;
4. *Attention to the main causes of food insecurity:* improve productivity together with accessibility to the land and human resources;
5. *Attention to the urban dimensions of food insecurity:* address the factors responsible for urban poverty and increase food security in terms of food availability and access, food marketing, management of natural resources, and accessibility to basic services;
6. *Attention to political issues:* take into account national and international policies and issues that impact the implementation and potential results of food security programs, including aspects such as public politics, peace, security, trade, and macroeconomic reforms;
7. *Encouragement of all stakeholders:* engage all in food security-related dialogue that leads to the development of national strategies and ensures broad agreements on common food issues, objectives and solutions.

2. What Measures Can We Apply to Improve Food Stability?

After years of increasing global food security, hunger in the world is rising again. This rise is mainly concentrated in countries affected by conflict and fragility where violent conflict destroys crops and assets, and displaces people. However, the recent economic crisis caused by COVID-19 may lead to a scenario of food insecurity related to a decrease in the economic income of families derived from the increase in unemployment [15]. Conversely, through the importance of agriculture in the economies of rural areas in both developed and developing countries, this sector can contribute to an enabling environment for increased stability. In particular, promoting the resilience of (rural) food systems can serve to increase the food security of households and communities in the face of instability [16]. One measure to ensure food stability is the availability of enough food for local population. Most rural areas have both agricultural and livestock potential, but sometimes the problem of ensuring adequate food availability is associated with a lack of basic infrastructure, human resources and lack of training and education. Additionally, the development of peri-urban landscapes has increased in recent years, contributing not only to aesthetic and environmental sustainability, but also to increasing the networks between rural farms and cities, improving the local economy, and enhancing the value of local (including traditional) products. These strategies also ensure food stability in urban areas [17].

To achieve a better life and sustainable future for everyone, the United Nations, by the resolution adopted in the General Assembly on 25 September 2015, stated 17 sustainable development goals (SDGs), with 169 measurable targets to be achieved by 2030 [18].

In the 2030 agenda, food is one of the most important topics discussed, highlighting the importance of the food sustainability concept. Although concepts such as food security, food availability, or food stability have been described above, the FAO document refers food sustainability in a multidimensional way in which elements such as productive practices, malnutrition or food habits are discussed as a transversal phenomenon related to human health [19].

Food is mentioned, directly or indirectly, in most of the 17 SDGs and their associated specific goals. Thus, SDGs "End of poverty" and SDG 2 "Zero hunger" are those that describe the food sector focused on problems derived from malnutrition and food insecurity. The SDGs do not provide a specific definition of food sustainability; therefore, a lack of guidelines about the implementation of sustainable food policies may hinder food stability.

Previous research has referred to food stability as a set of socio-political aspects (for example, regional conflicts), but specific aspects of animal and/or agricultural production applicable in any production system worldwide have not been defined. Thus, in this paper, two aspects to guarantee the food stability at rural areas will be discussed: livestock production in small farms, and techniques to guarantee food safety in products of animal origin.

2.1. Food Stability at Livestock Production to Achieve the Food Security

Livestock produce a wide range of nutritious, protein-rich foodstuffs such as eggs, meat, milk and cheese, thus diversifying the diets of families. Many animals can be used for weed control and are a vital source of traction power, maximizing the amount of land that can be cultivated and transporting goods to market. In all these different ways, livestock contributes to family health and are part of the family farming business [20].

In developed countries, livestock production is highly technical to obtain high meat or dairy yields. However, this type of production is economically unviable in other regions, due to various factors such as geography, animal adaptation to the environment, technical means or human resources [21]. Although the idea of food stability is associated with developing areas, it is also increasingly important in rural areas of developed countries where small-sized and family farms represents the main work and local economic activity. In addition, increasing green consumerism by consumers implies the implementation of programs to preserve this type of production and guarantee the availability of local foods (i.e., ethnic food) and greater food stability [22].

Thereby, to guarantee food availability, it is necessary to apply the know-how of modern livestock production. However, this knowledge must be adapted to small-sized livestock farms, usually based on extensive management (most of them are familiar farms), both in rural areas of developed and developing countries. The main question is: how do we guarantee the food stability? In order to guarantee livestock in a homogeneous way over time and in a specific geographical region, the application of biosecurity measures is essential to guarantee food stability [23].

Biosecurity can be defined as a set of measures aimed at preventing the entry of a disease into farm [24], as well as preventing the spread of a disease outside a farm in the case of an outbreak. Thus, the concept “biocontainment” (or internal biosafety) or infection control is also related to the concept of biosecurity, and it is defined as a set of measures aimed at preventing the spread of an infectious agent that arises at the farm [25].

Why are biosecurity measures important to guarantee food stability? Biosecurity in animal production represents an important concept because livestock diseases translate into great economic losses. The implementation of biosecurity measures optimizes production costs because it improves animal welfare, reduces the risk of zoonoses, and controls livestock diseases [26]. In general, biosecurity measures improve animal welfare by decreasing the occurrence of diseases that compromise stability by fluctuations in the availability of meat and animal-derived products such as milk or eggs. Consequently, the absence of biosecurity measures affects food security (in its quantitative definition as described above) as well as the productive, sanitary (i.e., health status) and environmental sustainability of the rural environment [27]. Moreover, the lack of biosecurity measures regarding zoonotic diseases may affect farmers’ health, compromising the workforce in a geographical area that may lead to a decrease in animal production and a greater lack of food stability [28]. Additionally, it has been suggested that zoonoses display a greater negative impact on livestock than crops [29].

Biosecurity plans should be considered as a preventive strategy and should be referred to as an investment and not as an expense [30]. Additionally, they should be implemented as part of the daily work and management of the farm. It is important to highlight that food safety is highly dependent on animal health, because certain zoonoses, such as salmonellosis or listeriosis, can be transmitted to humans through food.

The implementation of biosecurity plans in large farms has some advantages due to the existence of specific equipment and facilities that enable keeping specific infectious disease under control easily, as well as the existence of human resources. In contrast, its application in small-sized farms may be conditioned not only by a scarcity of equipment, human resources or facilities, but also by the type of production (extensive management) and the environment.

The implementation of biosecurity measures aims to obtain economic income with lower morbidity (fewer veterinary treatments), less mortality (economic losses due to casualties) and higher meat and/or dairy yield based on correct welfare measures [31]. Biosecurity plans must be specific for each farm; however, some generic measures should be applied in all livestock farms, as described below. Additionally, we discuss how each measure influences food stability.

Farm limits: this control aims to avoid contact with other animals [32]. This measure is easy to implement in intensive farms but almost impossible to apply in extensive livestock management. On those farms that have isolated and fenced pastures near stables, limited contact with other animals can be achieved. However, on small farms whose premises are within villages, this measure is impractical because livestock share paths and roads to move from premises to communal pasture areas. Moreover, sharing males for reproduction in developing countries, where there is scarce veterinary control of reproductive disorders such as brucellosis or Q fever (i.e., Coxiellosis), remains a common practice. Although implementation of the “farm limit” biosecurity measure is impossible in some types of specific livestock management (e. g. extensive management), the implementation of some measures such as avoiding lending males or the geographic distribution of livestock in a village in separate areas to minimize their interactions may contribute to the control of infectious and zoonotic diseases (and the health of farmers), ensuring food stability.

Facilities and equipment—design and hygiene: livestock facilities must be designed according to the species, management (extensive or semi-extensive), production (meat or dairy) and size of the farm. Farm premises must be built with resistant, durable materials that are easy to clean and disinfect to ensure animal welfare. Correct bedding material and maintaining the proper hygiene of premises avoids an excess of insects inside, reducing the risk of disease transmission, decreasing the immunity of animals, and preventing foot problems. Poor hygiene conditions make animals more susceptible to infectious processes with great economic losses. In those geographic areas where extensive management predominates, livestock are reared in communal pastures during the temperate season (spring and summer) and return to the farm in the cold season (autumn and winter). In this type of management, proper premises (including watering points) are located in the communal areas according to the species, livestock population, access paths or climatic characteristics. The objective of communal premises is to provide and guarantee the necessary welfare conditions to the livestock, such as protection from cold or rain and providing drinking water. Therefore, the implementation of maintenance programs of livestock premises located in communal pasture areas is essential. It is important to remark that the previous biosecurity measure “farm limits” is not applicable here, although this management technique may improve the sustainability of silvopastoral communities [33] and food stability in a specific area.

Control of animal movement: the objective here is to prevent the entry of diseases into farms. In countries with measures such as livestock disease surveillance programs, the existence of traceability systems and veterinary controls, among others, reduces the chance of infectious diseases entering the farm. However, in developing countries in which there is an absence of livestock identification as well as an absence of veterinary controls, and other criteria such as in-breeding, the purchase of livestock with good body conditions, an absence of clinical signs, or the purchase of livestock from the surrounding area, among others, must be considered. Even in the absence of control measures, good livestock practices such as prophylactic treatments (e.g., deworming) or quarantine periods of purchased livestock are always recommended. Livestock movements are essential to

guarantee trade [34], but in the case of disease outbreaks, it impacts not only the local economy, but also food stability related to a lack of supply due to the compulsory slaughter of livestock in some cases. Thus, farmers are responsible for the livestock they buy, even in those countries where surveillance programs are implemented (because they only control for specific diseases).

Feed and water: these must be adapted to each animal species and provide enough quantity and quality. Thus, feed shortage seasons such as winter should be considered to avoid an instability of foods of animal origin. Feed can affect the health of the livestock; therefore, it must be stored appropriately. Based on the objective of guaranteeing food stability, farmers must program possible shortages associated with climate changes, price increases, or outbreaks of plant diseases, for example. Thus, new sources of feed such as insects, food waste or plant by-products may be utilized to address the challenge of food security and the health and welfare of livestock while maintaining environmental sustainability [35–37].

Control of external vectors: this represents a potential source of diseases for farm animals and its control is a real challenge. Total control is almost impossible; therefore, the application of some measures contributes to reducing the risk of disease transmission. External vectors are classified as domestic or wild. Domestic vectors include all animals that enter the farm voluntarily, such as dogs, cats, horses or chickens. Wild vectors include all animals that enter the farm involuntarily, such as insects, birds, rodents or wildlife. The presence of only one species in a farm is recommended, although in almost all family farms, the presence of dogs, cats, chickens, rabbits, horses or donkeys is also frequent. What does this mean for avoiding sanitary problems? All species must be subjected to an appropriate veterinary management regimen. Insects represent a source of contamination and disease transmission. Although total control is almost impossible, the application of some measures such as correct manure elimination, installation of mosquito nets on windows, or the application of insecticides can reduce the incidence of insects. Rodent control is also essential on farm, not only to avoid disease transmission, but also due to the contamination of feed and/or water by urine and/or feces [38]. Rodenticide application, as well proper feed storage, can reduce the negative effect on animal health and farm management. As described for rodents, birds can act as vectors of disease transmission through contact with their feet, feathers and/or contamination of food and/or water through feces. Control here involves the correct maintenance of premises and other farm facilities. As previously described, the proper health management of livestock is essential to guarantee food stability [39].

2.2. Food Stability of Products of Animal Origin to Achieve Food Security

Once the importance of the proper management of livestock has been discussed to guarantee the food supply and therefore its stability, the manufacture of products of animal origin maintains local trade and economically supports the region, as well as contributes to the availability of food without great external dependence [40]. Thus, food security can be guaranteed through food stability.

Local and traditional products are increasingly appreciated in developed countries as consumers seek more natural and less processed products. Furthermore, in developing countries, these types of products are part of the daily diet habits [41]. Livestock represent the main source of fresh meat, and other derived products such as eggs, milk or meat-based products are also important in maintaining food availability and play an important role in the nutritional support of the local population.

Regarding the 2030 agenda, food safety aspects are related to SDG 3 “good health and well-being”, SDG 6 “clean water and sanitation”, and are also related with SDG 2 “zero hunger”, because the unlimited access to enough and nutritionally appropriate food to provide the energy and nutrients needed to maintain an active and healthy life must be through the distribution of safe food. In fact, food safety and food security must be considered together [42].

It is important to remark that basic supplies such as electricity or water are not always available in some areas of the world. Thus, the need for food conservation processes with scarce technical resources (e.g., an absence of freezers or fridges) to avoid a lack of food availability must be associated with food processing aiming to extend the shelf-life. Therefore, cured or fermented meat products play an important role in the availability of food.

Meat fermentation is a low-energy, biological acidulation, preservation method, which results in unique and distinctive meat properties, such as flavor and palatability, color, microbiological safety, tenderness, and many other desirable attributes of these products. Changes from raw meat to a fermented product are caused by “cultured” or “wild” microorganisms, which lower the pH [43]. Dry-cured meat products were traditionally produced by the chance contamination of sausages with local microorganisms. Moreover, the manufacture of dry-cured meat products can be achieved even with few technical resources. However, food safety (with its hygienic definition), must be ensured to avoid foodborne outbreaks. Thus, we discuss the different processes and/or techniques commonly used in the manufacture of dry-cured meat products to guarantee safety.

These types of products originated several thousand years ago, in different parts of the world, when microorganisms were introduced incidentally into local foods. It is believed that more than 10 millennia ago, in the Middle East, fermented foods were discovered by keeping milk in animal skins, which produced pleasant, fermented milk drinks and yoghurts [44]. Traditionally, fermented meat processes have been one of the most utilized food conservation methods. The drying of foodstuffs was probably the first development prior to meat fermentation [45]; smoking and salting were also found to be effective. The early manufacture of these products most certainly occurred accidentally [46]. Records showed that Greeks and Romans used this technique thousands of years ago [46,47]. Initially, fermented meat products were produced empirically [45], but it was not until the 1950s that industrialization and developments in the field of microbiology revealed the process which occurs [47]. Initially, fermented meat products were homemade. Nowadays, most fermented meat products are produced industrially, although there are still areas where these products are processed traditionally and represent a significant economic benefit for rural areas [48].

Dry-cured meat products consist of a mixture of comminuted meat and fat, salt, nitrates/nitrites, sugar and spices that are stuffed into casings, subjected to fermentation, and dried; this contributes to its firmness and flavor [43]. Each ingredient has a special role in the fermentation process. Salt solubilizes muscle proteins, increases osmotic pressure in such a way that spoilage bacteria are suppressed, and enhances the flavor. Sodium nitrite promotes the typical color of preserved meats by forming nitric oxide compounds by reactions with the heme group of myoglobin. In addition, it contributes to flavor as well as inhibiting the development of pathogens such as *Clostridium botulinum*. Seasoning with herbs and spices was developed to serve as flavoring agents and also for their antimicrobial properties [49]. Most traditional homemade fermented meat products, both in developed and developing countries, are made without use of technological additives such as nitrate and/or nitrites (NO_x^-). Although the role of NO_x^- has mainly been associated with improving safety against *C. botulinum*, as previously described, other contemporary health concerns such as nitrosamines has emerged in recent years due to their potential carcinogenic effects [50]. Based on the increasing consumption of natural, additive-free products, new research about other natural nitrate-like additives has been studied [51].

Briefly, the manufacture of dry-cured meat products is as follows: comminuted meat and fat, mixed with salt, nitrate/nitrite and spices is stuffed into a casing. Then, the stuffed sausages are held under appropriate conditions to promote the curing process. The sausages are subjected to a drying process, during which, several changes occur regarding the physical, chemical and microbiological composition, which leads to acquiring the final organoleptic characteristics of the product [52].

Dry-cured meat products are considered as safe products due to the development of unfavorable conditions that inhibit the growth of spoilage or pathogenic microorganisms. The low values of pH and water activity (a_w), presence of salt, spices and other ingredients, called hurdle technology, are responsible for the inhibition of pathogenic and spoilage microorganisms [53].

Although fermented meat products are usually safe, these hurdles, in some cases, are not enough and food-borne pathogens can survive, causing outbreaks [54]. There are three hypotheses for the presence or foodborne pathogens in dry-cured meat products: (1) pathogenic microorganisms are present on raw meat and/or ingredients and survive along the fermentation and drying process; (2) pathogenic microorganisms are already present in the production environment and survive the manufacture; and/or (3) the contamination of meat products by improper handling. It highlights the importance of training programs about food safety and good manufacture practices with special relevance in developing countries [55].

2.2.1. Safety of Dry-Cured Meat Products

As stated above, the safety of dry-cured meat products is not only achieved through low pH and a_w values, but also through the role of other ingredients. The most important step in dry-cured meat product manufacture is to decrease the pH of fresh meat (which averages about 5.6 to 5.8 post-rigor) to reduce the growth of spoilage microorganisms. The final pH of fermented sausages typically ranges from 4.8 to 5.2, depending on tanginess, firmness, and other desirable product characteristics [56]. Lactic acid bacteria, which produce lactic acid through glycolysis, can be introduced into meat either by natural fermentation (with relevance in homemade meat products) or by inoculating a starter culture, and their growth and metabolism inhibit the normal spoilage flora of the food material and any bacterial pathogens that it may contain [57].

The production of acid by fermentation plays a significant part in the preservation of foods. In the case of dry-cured meat products, the reduction in pH, and not the production of lactic acid, is mainly responsible for the preservative action [58].

The last hurdle in the stabilization of the dry-cured meat products is the reduction in the a_w . For most meat spoilage microorganisms, a_w values above 0.98 are optimal for growth. Consequently, the inhibition of microbial growth by a_w reduction needs to be engineered either by drying and/or by the addition of solutes such as salt or sugar [43]. The reduction in a_w (from 0.96 to 0.86) during drying also stabilizes the product, by controlling undesirable bacteria. Dry-cured meat products have a_w values below 0.85, inhibiting the most important foodborne pathogens. In general, common spoilage bacteria are inhibited at a_w values of about 0.97 [59].

Smoking represents an ancient technique related to food conservation, consisting of a process that generates some chemical substances with preservative properties that are deposited on the surface of the product. The smoking process reduces the microbiological population due to the heat and the deposits of chemicals which have bacteriostatic action. Many smoke compounds also have bacteriostatic or bactericidal properties; formaldehyde and phenolic compounds are thought to provide much of this effect [60]. The shelf-life of smoked meats depends on the heating time and temperature during the process, on the decrease in a_w , and on the antibacterial and antioxidant activity of smoke components. Moreover, the temperatures used during smoking or smoke concentration may influence the antimicrobial effects [61]. Smoking treatment decreases the number of viable microorganisms in the products by one to two log cycles, although the antimicrobial effect increases with increasing the time and temperature of the smoking process [62].

Herbs and spices in fermented meat products are largely utilized as ingredients to confer specific organoleptic characteristics. They represent a cheap source of substances with antioxidant activity protecting from oxidative deterioration [63], antimicrobial activity [64], or inhibitory effects of biogenic amine contents [65]. Essential oils (EOs) are volatile, natural liquids extracted from plant material that have gained a huge importance

in the manufacture of traditional products due to their conservation properties. EOs are extracted from plant material as leaves, roots, bark, seed, or the entire plant. In developing countries, the use of EO may be limited due to a lack of local suppliers or by the need of specific equipment to obtain it. However, in developed countries (in which EO can be purchased from food additive suppliers), the antimicrobial and antioxidant properties of EOs represent an interesting source of natural compounds for food preservation, and thus increasing the shelf-life of foodstuff [66].

The action mechanism of spices and EO is still not totally clear. Its action mechanism is related to alterations in the cell membrane causing permeability and a loss of intracellular material [67]. Additionally, antimicrobial effects could be associated with interactions with membrane proteins and enzymes [68]. Thus, the presence of an outer membrane in Gram-positive bacteria may explain the reduced antimicrobial effect of EOs. The antioxidant effect has been associated with the high reactivity with peroxy radicals [69]. Thus, both antimicrobial and antioxidant properties may improve the shelf-life of these type of products by the control of foodborne and spoilage bacteria and decreasing unwanted chemical reactions (e.g., rancidity by fat oxidation) that result in organoleptic alterations [70]. Use of local spices may also represent an alternative approach to improve the food safety of food of animal origin in developing countries in which good hygienic practices, food safety knowledge, manufacture and/or storage equipment are not always achievable or available.

As described above, the use of nitrates in the manufacture of dry-cured meat products to improve the organoleptic characteristics and inhibiting *C. botulinum* is a common practice in developed countries. However, its availability from local suppliers in developing countries is not always possible. Thus, the use of spices [71], EO [72] or other vegetables [73] as nitrate replacements, in addition to the antimicrobial and antioxidant effect, has also been suggested.

2.2.2. Contribution of Dry-Cured Meat Products to Food Stability

Regarding food stability, dry-cured meat products represent a source of proteins, vitamins and minerals that are relatively easy to manufacture and allow their preservation without major requirements due to their physical–chemical stability. The shelf-life of these types of products are very importance in geographical areas with fewer resources (such as a reliable electric supply) [40]. Additionally, they contribute to improving the nutritional requirements and protecting against malnutrition in those geographical areas in which access to other types of highly nutritious products is limited or scarce [74]. Fermented meat products can be manufactured from different livestock species [75]; therefore, it may contribute to ecological variety and land sustainability.

In the context of food sustainability, the use of vegetable ingredients such as pulses, cereals, tubers or fruit have been proposed as meat extenders mainly aimed to decrease the meat content and further decrease the impact of livestock on the environment [76]. Although the objective of decreasing livestock production is associated with developed countries in which intensive livestock farming represent an important economic activity, it can also be important to increase the yield of meat products in periods of shortage, contributing to enhancing food stability. In addition, the use of vegetable ingredients may imply greater crop diversity (i.e., not only crops for feed production) which would increase ecological variety due to the potential use of underutilized crops, sustainability improving the land use.

3. Conclusions

Food stability can be defined as the availability of food over time. This concept is linked to another concept, food security, because the latter is considered a measure of access to food population. Thus, to achieve the food security, technical and human resources are necessary to guarantee the food stability.

Food availability is often associated with developing countries, where political conflicts or weak economies lead to food fluctuations. However, recent economic crises may

lead to a scenario of food insecurity related to a decrease in the economic income of families derived from increases in unemployment. Conversely, through the importance of agriculture in the economies of rural areas both in developed and developing countries, this sector can contribute to an enabling environment for increased food stability. The promotion of resilience of (rural) food systems can serve to increase household and community food security in the face of instability.

In rural areas, livestock represents not only economic income but also a source of foods and labor. Thus, to guarantee the performance of livestock (and food availability), it is necessary to implement management programs that maintain proper welfare, hygiene, and sanitary conditions. The implementation of biosecurity measures is essential to achieve this objective. Although some measures are difficult to put into practice in small and family farms, their adaptation together with good livestock practices allows farmers achieve healthy and productive animals.

In addition, the manufacture of foods of animal origin aims to obtain more durable products which enables us to guarantee the availability of food over time, even in seasons with scarce resources. Thus, dry-cured meat products play an important role in food availability. Food security refers to food access in healthy conditions; therefore, knowledge of the main tools that guarantee the food safety of these types of products is essential.

As described above, guaranteeing food stability depends on the joint implementation of livestock production and use of their products (either fresh or processed products) in developing countries. This allows a continuous supply of a variety foods that provide adequate nutritional intake which enables the healthy development of populations (food security).

In addition, this productive system implies the use of land to obtain other products, thus contributing to environmental sustainability. It is important to highlight that proper training and education programs regarding livestock and food safety for populations are necessary. In developed countries, in which the concept of food stability as a food supply does not exist, consumers are increasingly concerned about the type of both livestock and agricultural production. Thus, sustainable production must be extensively adapted to satisfy increased consumer demand. Furthermore, the link between livestock and agricultural farming adapted to a specific geographical area may optimize land use, favoring sustainability. Understanding food security, such as the guarantee of access to food by the population and the food availability of products of animal origin (food stability), must adhere to proper livestock management practices (both animal health and welfare) as well as the use of fresh and processed products of animal origin according the technical and geographical conditions of the specific area.

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