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Quality Improvement of Traditional Dry Fermented Sausages Based on Innovative Technological Strategies

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Abstract

Dry fermented sausages are highly appreciated food specialties, mainly in Portugal and other southern European countries. Therefore, all research efforts aiming at improving the food quality and safety of traditional dry sausages are of interest, since they are likely to result in products with higher added value and quality standards most suited to the requirements and concerns of the modern consumers. Among those efforts, it may be highlighted the studies involving innovative processing parameters and technologies to overcome practical problems gathered in the meat industry, which are mostly associated with food quality and safety. Additionally, characterization of traditional dry sausages and rationalization of their processing are essential for further achievement of any official certification. Thus, this article attempts to point out some research lines of highest interest in meat science (and particularly to the broad variety of regional dry fermented sausages), towards to the valorisation of technological, nutritional and commercial features. In addition, it is here emphasized the importance for the continuous improvement of the quality and safety of meat products as a way to respond to the current concerns regarding its consumption and the general advices in reducing its daily intake.

Keywords: Dry Sausages; Food Safety and Quality; Meat Industry; Meat Science and Technology; Official Certification; Biogenic Amines; Polycyclic Aromatic Hydrocarbons; Sensory Characteristics; Micro Biota and Starter Cultures; Coagulase-Negative *Staphylococcus*; Lactic Acid Bacteria; *Yeasts*.

A sort number of dry fermented sausages (locally called “enchidos”) constitute typical gastronomic specialties in Portugal. These products – frequently from autochthonous pig breeds – are still enjoying increased popularity as part of the traditional Mediterranean diet, and also due to the increasing trend of the Portuguese people and tourists to consume light meals (locally called “petiscos”) outdoor – along with other food specialties such as regional cheeses, breads and wines – in moments of relaxation and socializing, as a complete meal or just as a way to explore the traditional gastronomy. For that reason, this trend anticipates a major opportunity for the market expansion of these and similar foods and the concomitant growth of gourmet and regional restaurants, snack-bars or taverns (locally called “tascas” or “tabernas”). In contrast and at the same time, the populations are being advised to reduce the daily intake of meat, as well as of dry sausages and similar meat products, often in an ambiguous and alarmist way and with obvious damaging

consequences for the meat industry and market.

There are several types of traditional Portuguese dry fermented sausages, e.g. *chouriço*, *chouriça*, *paio*, *catalão*, *salsichao*, *linguiça*, *palaio*, *salpicao*, *butelo*, *cacholeira*, *alheira*, *farinheira*, *morcela*, etc. Depending on the geographic region, dry sausages have different designations and variations in shape, formulations and manufacture and processing techniques employed. The manufacture of traditional dry fermented sausages follows ancient protocols – which are still in use at household level as a result of the empiric know-how passed among generations. Although variations might exist within different local producers and industrial manufacturers and across regions, the *modus operandi* is essentially the same. As already mentioned, traditional dry fermented sausages have different shapes and sizes. For instance “*paio*” has typically a cylindrical shape with a diameter range of 4–5 cm and a length range of 20–25 cm, whereas “*chourico*” and “*catalao*” has classically a horse shoe shape with an overall length ranging from 30 and 40 cm and a diameter ranging from 2.5 and 3 cm. In the preparation of dry sausages like “*paio*” and “*chourico*”, the meat is mechanically minced in small cubic portions. To prepare the meat batter, the previous meat cubes are mixed with pepper/capsicum (*Capsicum annum* L.) paste, garlic (*Allium sativum* L.) paste, refined salt (NaCl), fine ground black pepper (*Piper nigrum*), disodium diphosphate ($\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$), pentasodium triphosphate ($\text{Na}_5\text{P}_3\text{O}_{10}$), sodium nitrate (NaNO_3), potassium nitrate (KNO_3) and potassium nitrite (KNO_2). The resulting mixture is kept under controlled refrigeration (5°C) conditions and relative humidity (90%), for a maturation period of 72 h. After maturation, the mixture is stuffed in natural casings from pig large intestine of ca. 50–55 mm-

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diameter, for “*paio*”, and in small intestine, with *ca.* 36–38 mm-diameter, for “*chourico*”. Then, the sausages are placed on dryers with chambers under controlled temperature and relative humidity of 9°C and 80–85 %, respectively, during a period of 40 d, for “*paio*” and 25 d, for “*chourico*”. Regarding the dry sausage “*catalao*”, the cubes of minced meat are mixed with cubic portions of dorsal pork fat, water, salt, black pepper crops, fine ground white pepper (*Piper nigrum* dried ripe seeds), $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$, $\text{Na}_5\text{P}_3\text{O}_{10}$, NaNO_3 , KNO_3 and KNO_2 , and the resulting mass follows similar procedures to those described for “*chourico*”. Several changes in the manufacture may be observed between producers, chiefly in formulations (percentage and type of ingredients) and pig breeds used, fermentation time and type, ripening and drying time and temperature, use of an additional stage for stabilization after ripening, use or absence of smoking treatment and its type, manual *versus* mechanization degree of the production process and degree of automation, and type of packaging, among others.

Manufacture of these pork specialties play important roles based in the three pillars of sustainable development: the economic, environment and social standpoints. It holds a major economic and environmental importance because represents the full recovery of all parts of the animal for feeding purposes, thus with minimal losses and food wastes. Besides, this economically and environmentally sustainable approach contributes to obtain extra sources of income to the farmers. In fact, the livestock production of autochthonous species stands for a substantial part of the economic activity in the western part of the country (where the primary sector continues to play an important role to the gross domestic product, GDP) but, at some minor extent, all over the territory. The diversity of the meat market and its expansion also helps settling people in rural regions – thereby preventing the existing rural exodus towards urban areas –, and contributes to the promotion of local tourism (presently booming).

The food safety and quality is a major concern and policy priorities of the European Union (EU), as highlighted earlier in the White Paper on Food Safety, in Agenda 2000, as well as in the actual Horizon 2020 – the EU Framework Programme for Research and Innovation. Therefore, all scientifically-based characterization focused on these traditional products will contribute to the required knowledge towards the official certification via, for instance, a Protected Geographical Indication (PGI). It will also contribute to the food quality improvement and to more effectively rationalize health claims associated with its consumption – both of which will help to expand the market niches and, consequently, its economic value as food commodity.

Biogenic amines (BA), naturally present in meat products, are chemical compounds largely resulting from the microbial decarboxylation of amino-acids. In dry sausages, biogenic amines are associated with long ripening periods. These compounds are of great importance in food quality of meat products, since some of them in excessive amounts are closely related to various adverse effects (*e.g.* allergic reactions and circulatory problems, toxicity due to vascular and psychoactive properties) and symptoms in humans (*e.g.* severe headaches, nausea, blood pressure disorders) [1, 2]. Biogenic

amines are also linked with some diseases, including certain types of cancer; moreover, they also affect the organoleptic characteristics of food. A possible way to control the content of biogenic amines in dry sausages is through the use of selected starter cultures and the manufacture under innovative and better controlled processing conditions and formulations. Examples of biogenic amines present in dry sausages are tryptamine, phenyl ethylamine, putrescine, cadaverine, histamine, tiramine, spermidine and spermine. Nevertheless, dry sausages and other fermented meat products may contain a very large variety of other biogenic amines, with molecular weights ranging from *ca.* 61 to 202.

Polycyclic aromatic hydrocarbons (PAH) are organic compounds of two or more fused benzenic rings, formed by incomplete combustion of organic matter, namely fossil fuels or wood [3] and are often associated with industrial pollution. Also known as polynuclear or poly-aromatic hydrocarbons, they may be found at high levels in meat when cooked at high temperatures as well as in smoked meat. The polycyclic aromatic hydrocarbons result from pyrolysis of wood, which increases with the temperature. Its deposit in smoked sausages is greater the more extensive is the smoking period. The toxicity of some of those polycyclic aromatic hydrocarbons have been identified as carcinogenic, mutagenic, and teratogenic, thus the continuous consumption of smoked products is associated with the etiology of some cancers. Hence, all comprehensive surveys on the relationship among polycyclic aromatic hydrocarbons and smoking temperatures and times are crucial to ensure the consumer’s safety. A large diversity of molecular species of polycyclic aromatic hydrocarbons may be found in smoked meat products depending in the processing and technological parameters applied [4-6].

The use of starter cultures has been widely studied [7-8] as a result of the growing interest for its application in industrial environments. Its application at industrial scale encompasses several advantages, *viz.*: hygiene and food safety improvement; advances in monitoring and optimization of industrial processes – thus leading to the reduction of processing costs; and improvement of homogeneity between batches – thus increasing the product quality and consumer’s acceptability. It is also of first importance the use of starter cultures to improve technological characteristics, such as colour, acidity, and bacteriocinogenic and probiotic properties.

The traditional fermented dry sausages are characterized by its distinctive organoleptic characteristics. The sensory characteristics are related to the manufacture process and the microbiota in attendance. In these food products, spontaneous lactic acid bacteria (LAB), coagulase-negative *Staphylococcus* (CNS) and yeasts prevail [8-11]. The fermentation in meat products provides unique taste and flavours and contributes to extend its shelf-life. Several mechanisms are involved in pathogen and spoilage microbiota inhibition, namely the production of organic acids and other compounds with antagonistic action (*e.g.* bacteriocins, hydrogen peroxide and diacetyl) [12]. Bacteriocins (*i.e.* natural antimicrobial substances) have received particular attention due to their potential application in food industry as natural preservatives [13-15]. Lactic acid bacteria produce a large diversity of bacteriocins

generally active with respect to other microorganisms (thus contributing to its competitiveness), including other lactic acid bacteria strains and species but also food-borne pathogens such as *Listeria monocytogenes* [16-20]. When lactic acid bacteria are used as starter cultures they are typically employed in consortium with coagulase-negative *Staphylococcus* strains (such as *Staphylococcus xylosum*, *Staphylococcus carnosus* or *Staphylococcus equorum*). The main reason is due to nitrate reducing ability and catalase character of *Staphylococcus*, among other catabolic activities potentially useful for flavour development. Moreover, lactic acid bacteria – commonly found in the human gastrointestinal tract – might have also a positive effect on human health. *Lactobacillus plantarum* and *Lactobacillus sake* are versatile microorganisms encountered in different niches, including fermented meat products [21-23]. Therefore, introducing single or mixed starter cultures in dry fermented sausages is a promising natural choice to improve its quality and safety.

All research efforts to improve food quality and safety of traditional dry sausages and other foods are always worthy of being undertaken. Therefore, all the scientifically sound work on the characterization of traditional dry fermented sausages resulting from a large number of technological experiments (rigorously designed and developed to be applied in the meat industry), and in collaboration with a large number of meat regional producers and manufacturers is of first importance. Examples of relevant technological parameters to be evaluated throughout the manufacturing process (e.g. beginning of processing, during maturation/ripening, in the final product, and during various stages of storage) of these regional specialties are the use of distinct salt levels, use of different ingredients and raw materials, variation of gauge of sausages, smoking type and time, genotype (pig breed), ripening time and temperature, introduction of a stabilization temperature step at the end of the manufacturing/ripening process, presence of additional contents of natural preservatives (such as acetic or lactic acids), etc.

Furthermore, inclusion of technological trials aiming at development of distinct combinations of single and mixed starter cultures from autochthonous microorganisms (viz. lactic acid bacteria, coagulase-negative *Staphylococcus* and yeasts) are also very important to be commercialized in the meat industry, as a way to improve the food quality and achieve a constant quality of the wide variety of dry sausages from batch to batch. Appropriate indigenous microorganisms are obtained after isolation from local dry sausages, raw materials, utensils, surfaces and equipments, followed by a comprehensive genotype and phenotype characterization which enables the selection of strains with potential technological interest as starter cultures, which stand out for instance: regarding biogenic amines production, it is desirable the selection of strains without amino decarboxylase activity (in lysine, tyrosine, ornithine and histidine), in addition to strains with amine oxidase activity; and regarding proteolytic activity (hydrolysis of casein), it is desirable proteinases, peptidases and amino peptidases activity. Other phenotypic criteria might be: lipolytic and acidifying capacity; antimicrobial capacity under anaerobic conditions as well as bacteriocins production, activity and efficiency in controlling pathogenic bac-

teria resistance to antibiotics; limitation of transferring antibiotic resistance genes; tolerance to freezing and lyophilization; nitrate and nitrite reductase activity (which is a desirable activity in lactic acid bacteria but is more pronounced in coagulase-negative cocci); growth at different ranges of pH and temperature; tolerance or synergy with other microorganisms (in mixed cultures); probiotic properties (acid resistance; resistance to bile salts by the action of hydrolyses tolerance to acidic environments, adherence capacity and persistence in the gastrointestinal tract) and selection of strains with nutraceutical properties, e.g. production of vitamins (such as folic acid).

Based on the above considerations, biogenic amines and polycyclic aromatic hydrocarbons as well as microbiological, rheological and sensory evaluation, and shelf-life validation are important parameters to be determined and monitored in those technological products and to be correlated with technological variables – so as to ultimately ensure the desired quality, hygiene and food safety of the technological dry sausages. Comparative evaluation of process performance and economic viability must always be considered. Several examples of important correlations to be studied between technological factors and effects can be given. For instance, the correlation between the biogenic amines content and the final salt content, type and gauge (thick and thin) of sausages, presence or absence of natural preservatives, or the employment of mixed starter cultures. Other examples could be the relationship between the levels of polycyclic aromatic hydrocarbons and the exposure to different smoking times, and the relationship between the type of starter culture employed and the presence and activity of naturally occurring antimicrobials that prevent the growth of pathogens.

It is expected that this type of scientific efforts by the research community results in a significant improvement of the quality of dry fermented sausages and other meat products – and thus may contribute to expanding its market. This, in turn, will lead to numerous beneficial effects such as increasing the variety and quality of Mediterranean food specialties, the prevention of the population exodus from rural towards the urban areas, and the valorisation the whole economical sector – both upstream (stimulating the production of autochthonous pig breeds) and downstream (an incentive to the meat industry).

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