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Food safety and quality are the primary concerns of consumers and are the priorities of European policy through Agenda 2000 and the White Paper on Food Safety (2000). The recurring food poisoning cases and the dispute on GMO derived food have undermined public confidence on intensive or industrial food producing systems. Consumers are turning to “traditional” products. Traditional and/or organic agro-food production systems, besides responding to the requirements of a sustainable agriculture, can be important means to secure a sufficient income for people working in rural areas not suited for intensive agriculture.

Small producers experience technical and financial difficulties in complying with official food safety regulations (Directive 93/43 EEC, repealed by the Regulation EC 852/2004). In particular, hygiene standards generally defined for large processing plants are not always compatible with such small production units. This difficulty has created acute problems, particularly in the countries of southern Europe. It is crucial, therefore, to give traditional producers the means to produce safe products, as it is the only way to insure the survival of local economies with positive effects on employment and environmental protection.

In this context, the project Tradisausage aimed to evaluate and improve safety of traditional dry sausages from the producers to the consumers while preserving their typical quality. The objective has been pursued according to the following plan.

1. Characterisation of the traditional production of sausages in southern and eastern Europe

A total of 315 traditional processing units from 6 European countries (France, Italy, Portugal, Spain, Greece and Slovakia) covering 7 large regions and all Greece were surveyed for the socio economic aspects, the raw materials and the processes, the characteristics and the marketing of the sausages. The processing units with less than 7.5 tons/week failed into the category of “very small enterprises” (50% have 2 or 3 employees; 93% have less than 10 employees). Farm processing units were numerous in mountainous regions such as Massif Central in France, Trás-os-Montes in Portugal and Abruzzo in Italy. Whereas in Spain, Slovakia, and Greece butchers generally manufactured the traditional dry sausages. Regarding pig breeds, 21% were regional and the others were industrial (mainly porkers are used as raw material). More than 50% of the producers used natural dryers for maturation of the sausages, lasting between few days (small sausages, Greece) to 36 weeks (Italy). A large diversity in the shape and in the weight from 15 g to 2 kg of the dry sausage was observed. These units and the sausages can be described by one word: diversity.

These small traditional processing units often found in lagged regions have an important economic impact in these areas since most of them have at least one employee. These traditional products that may be named “produit de terroir” result from local know-how, as well as from the specific, unique, microbial ecology of the workshops. However, few of these products are protected by an official sign of quality at the moment. Catalonia in Spain has “Llonganissa de Vic” a product with a Protected Geographic Indication (PGI) and Portugal has PGI for traditional sausages.

2. Identification of the consumers of traditional products and characterisation of their habits of preservation and patterns of consumption.

The survey about socio-economic data, purchases, preservation and consumption habits of traditional sausages involved the same countries and regions mentioned above. It concerned 963 consumers of traditional sausages in the Southern Europe and Slovakia.

Three groups of consumers can be distinguished according to socio-economics data. The first group concerned rural consumers, married, 31-50 years old, with 2 to 3 children. The second one gathered urban consumers, 31-50 years old and the third gathered young consumers, single, without child.

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If we considered the behaviour of purchase, preservation and consumption of traditional dry sausages, again 3 groups of consumers can be considered. The *traditional style* concerned consumers that bought sausages at the processing unit, stored them without packaging in the kitchen or in the cellar for more than one week and are used to eat them as starter course. This style of consumption characterised mainly French and Italian consumers. The *modern style* concerned consumers that bought sausages at the market, stored them vacuum packed or wrapped with aluminium and ate sausages as aperitif. It characterised mainly from Portuguese and Spanish consumers. The *new style* concerned consumers that bought sausages for preparing snack; they stored them in plastic in the fridge and kept them 3 to 7 days. It concerned mainly from Greek or Slovak consumers.

3. Assessment of safety from producer to consumer

The hazards associated with traditional sausages and the critical points of the entire chain, consumption included, have been identified to ensure safety and quality of traditional sausages from production to consumption. Hazards considered are microbiological (*Staphylococcus aureus*, *Salmonella*, *Listeria monocytogenes*, enterohemorrhagic *Escherichia coli*) and chemical with biogenic amines of microbial origin (tyramine, histamine, putrescine and cadaverine).

The safety was evaluated at the producer's level first by studying the manufacturing environments. Thus 54 processing units were surveyed for hygienic level using a questionnaire addressing criteria related to pre-requirements needed for a self-control system based on HACCP, to critical points of the process and to the efficiency of the hygienic program implemented on the equipments. 89% of the workshops had the adequate infrastructures for the implementation of an auto control system. 80% of the workshops had an efficient hygienic program on the equipments. The occurrence of pathogens in 314 environmental samples (machines, cutting tables, knives.....) of the 54 processing units was studied. *Salmonella* was absent in all the processing units except in Greece in which it was detected in 3 ones. *L. monocytogenes* was found in 2.2% of samples. *S. aureus* was numerated in 6.1% of samples. The level of spoilage bacteria (*Enterobacteria*, *Pseudomonas*) varied from processing unit to processing unit and also from sample to sample from a very low level to level of 3 to 4 log CFU/100 cm².

Pathogenic bacteria were found in few cases in the 54 final products. *L. monocytogenes* was numerated in only one product at a level superior to the tolerate one (2.0 log CFU/g). *S. aureus* was detected in four samples with a level superior to the tolerate one (2.7 log CFU/g). By contrast, *Salmonella* was present in 3 products, which would not fit the microbiological criteria for fermented sausages. Enterohemorrhagic *Escherichia coli* were not detected. The level of spoilage bacteria varied greatly from very low to high level (5 to 6 log CFU/g for both bacteria). The level of biogenic amines was low in initial products (batter) and increased during ripening, generally with the dominance of tyramine. The level of biogenic amines in traditional fermented sausages does not represent a sanitary risk for the general population.

The safety was evaluated at the consumer's level by studying the microbial stability of the sausages. Considering the main consumers habits of storage of south and east European consumers and the characteristics of the sausages, 3 groups can be considered:

1-French, Spanish and Italian sausages contained black pepper and are ripened for minimum 3 weeks. They were shortly stored for 7-10 days under refrigeration or at room temperature. Little changes occurred irrespective of the storage conditions.

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2- Portuguese sausages were smoked *chouriço*-like products, containing red pepper, ripened for only 1 week. The products were stored under refrigeration up to 7 days. During this period neither any significant modification was observed nor was any decrease in safety detected.

3- Sausages from Greece and Slovakia were stored sliced. Little changes occurred in the technological parameters, but both spoilage microorganisms and biogenic amines increased in some cases, most probably due to the contamination during the slicing process.

Summarising the data from consumers, a brochure was designed to explain to consumers that European traditional fermented sausages (*tradisausage*) can be considered safe products, irrespective of the typology of the product manufactured and the consumer's habits of handling. As an overall recommendation, *tradisausage* should be better placed in a cold and dry place for their storage at home.

Quantitative microbial risk assessment was based on data for prevalence and concentration of pathogens, in combination with data on pH, a_w , and time/temperature combinations of raw materials and products at different stages of manufacturing process and storage (distribution) until consumption. Validated pathogen growth and survival models were used to assess the probability of exposure to *L. monocytogenes* at the time of consumption, whereas a well established dose-response model was employed to assess the risk of listeriosis due to consumption of heavily or low contaminated products. Exposure assessment revealed that if initial pathogen contamination is high ($>10^2$ CFU/g), then no significant reduction is expected, mainly because the observed variability of pH varying from 4.6 to 6.3 with the majority of the final products having a pH higher than 5.0. However, *L. monocytogenes* is not able to grow more than 2 logs in any product, regardless of workshop and country, due to the low a_w of traditional sausages, which seems to be the most crucial hurdle for the safety of these products. This observation suggests that traditional sausages may be considered safe if the initial pathogen contamination is low, and specifically below 10^2 CFU/g as it usually occurs.

4. Improvement of safety

The safety of products and the hygiene of processing units could be improved and assured by directed microbial ecology which is based on (i) the introduction of targeting disinfecting procedures towards spoilage and pathogenic bacteria, while preserving technological bacteria; (ii) the development of starter cultures that prevent the growth of pathogenic and spoilage bacteria in products.

To select targeting disinfectant we considered mainly essential oils of *Satureja thymbra* plant and components of essential oils (*thymol*, *eugenol*) as they can inhibit certain bacteria. The efficiency of these components was tested on bacteria grown in biofilm. The essential oil of *Satureja thymbra* was the most efficient disinfectant against spoilage bacteria with a reduction of 5 logs of *Pseudomonas* and *E. coli*. The reduction was about 2 logs for pathogenic bacteria (*L. monocytogenes*, *S. aureus*, *Salmonella enterica* serovar Enteritidis) while technological bacteria (lactic acid bacteria and staphylococci) were weakly affected. In parallel, the inhibitory activities of bacteriocins (enterocins) produced by *Enterococcus faecium* strains were shown against spoilage (*E. coli*, *Pseudomonas*) and pathogenic bacteria (*S. aureus*).

To select starter culture we have first identified the technological bacteria (Lactic Acid Bacteria, and staphylococci). Tools were developed, such as “*Staph. Array*” that allowed the identification of 36 species of staphylococci, fluorescence spectroscopy and real time PCR methods to identify LAB. In the final products, *S. equorum* or *S. xylosus* were often dominant and *S. saprophyticus*, *S. carnosus* and *S. warneri* were less frequently isolated. Considering

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the LAB, *L. sakei* was often the dominant species and variable levels of *L. curvatus*, *L. plantarum*, *L. fermentum*, *Leuconostoc*, *Weissella* and enterococi were identified. The selection was based on criteria such as: their safety (no production of biogenic amines, no resistance to antibiotics), their competitiveness (ability to colonise environment or to grow in sausage, to inhibit pathogenic or spoilage bacteria), their diversity (pulsed gel field electrophoresis, RAPD-PCR), or their technological properties (proteolytic and lipolytic activities).

Finally a process to improve sanitary quality of the products has been done according different strategies: addition of glucide, starter cultures or natural antimicrobial agent. The addition of glucide alone did not improve the sanitary quality of the products. Whereas the addition of selected starters with or without natural antimicrobial agent improved it, either by reducing the spoilage and or pathogenic bacteria, the biogenic amine content, the lipid and cholesterol oxidation. The sensorial qualities of the products manufactured in these conditions were often close to the naturally fermented control, thus the typicality of the traditional products was preserved.

A guide of good hygienic practice has been elaborated to help the small producers to control sanitary risks and thus to produce safe products. This guide focuses on traditional fermented sausages. It is written as recommendations sheets easy to understand and apply for the small producers. This guide will be distributed and explained directly to the producers by organising a specific workshop in each country.