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CHEMICAL, MICROBIOLOGICAL AND SENSORY CHARACTERIZATION OF A TRADITIONAL *PRESUNTO* (SMOKED HAM) FROM PORTUGUESE AUTOCHTHONOUS *BÍSARO* PIGS - A COMPARISON WITH INDUSTRIAL *PRESUNTO*

[1]Carina Cruz, [1]Élia Fernandes, [1]Manuela Vilarinho, [1]Mário Barros, [1]Preciosa Pires, [1]Rita Ferreira, [1]Orlando Morais, [1]Luís Correia, [1]Carla Ramos; [1]Joana Santos, [1]Paulo Fernandes, [2]Peter Ho, [2]Manuela Vaz Velho

[1]Departamento de Ciências Básicas e da Computação
[2]Departamento de Ciências de Engenharia e Tecnologia
Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo. Avenida do Atlântico- Apartado 574.4901-908 Viana do Castelo, Portugal. www.estg.ipvc.pt

ABSTRACT

The This study on Portuguese smoked ham, aimed at comparing chemical, microbiological and sensory characteristics between industrially and traditionally smoked hams. Ten smoked hams (*presunto*s), which consisted of 5 individual industrially produced hams and 5 other individual *Bísaro* hams produced by traditional processes were analysed.

Results of the chemical analysis showed that traditional hams have higher contents of total fat of unsaturated fatty acids; of ash; of chlorides; N-free amino acids; total volatile nitrogen (TVN), non-protein nitrogen (NPN), ammonium nitrogen (N-NH3). On the other hand, industrial hams showed a high pH value and higher levels of total nitrogen, nitrites, nitrates, proteins and water. With respect to Polycyclic-Aromatic hydrocarbons (PAHs) there were no differences between the two types of ham. The two groups of hams were significantly different by analysing either the parameters all together (Hotteling T2) or individually (t test).

Microbiological analysis aimed to search for the selection and quantification of the following microorganisms: Total mesophiles, fungi, yeasts, Micrococcaceae, Lactic Acid Bacteria (LAB), Enterobacteriaceae and Clostridium spp.. No Clostridium spp. were found in both types of hams. Traditional hams showed lower cfu/g in all types of the analysed microorganisms compared to industrial hams: less than a log cycle difference in cfu/g for mesophiles, fungi and Micrococcaceae and higher than a log cycle for yeasts, LAB and *Enterobacteriacea.*

For sensory analysis, a laboratory consumer panel of 90 subjects, comprising of 56 women and 34 men, aged between 18 and 65 years was asked to rate each ham sample for overall acceptability or liking using a 9-point hedonic scale.

Plotted histograms (based on the frequency of hedonic scores for acceptability and stratified according to different criteria, such as sex, treatment, type and age) to visual examine if any differences in overall acceptability existed among panellists suggested that there was a slightly higher preference for the industrial hams among women in this study. On the other hand, it seemed that men had a slight preference for the traditionally processed hams. An examination of preferences based on gender for the 10 individual hams seem to reaffirm the previous observation that women generally preferred the industrial samples, however, men had no specific preferences.

Segmentation of the liking scores between industrially and traditionally processed hams, with regard to both age group and gender, indicated that women below 25 years had a higher preference for industrial hams. However, as they grow older, even though the overall liking of industrial hams remains unchanged, more women begin to appreciate traditionally processed hams.

However, an intrablock ANOVA analysis indicated that there were indeed no significant preferences between panellists for any particular ham.

INTRODUCTION

Bísaro is the common name for *Sus celticus* an autochthonous pig breed of the North of Portugal and Galiza. The evolution of animal production and changes on dietary concepts almost led *Bísaro* pig to extinction by crossbreeding with precocious growth animals. *Bísaro* breed takes 2-3 years to reach 120-250 kg carcass (Nogueira, 1900, cited by Alves, 2003) and it has a high level of intramuscular fat. Survival of this breed to agriculture evolution it was only possible in a few remote rural areas having agriculture of subsistence. It was only in 1994 that *Bísaro* breed was recognised and protected. In 1994, *Bísaro* breed was extinct in Galiza. A year later they imported some animals to Faculty of Veterinary of Lugo (Alves, 2003).

Reproductive adults in Portugal are, in 2003, about 770 females and 160 males (Alves, 2003). Most of the producers are located in the Northeast of Portugal, 75% of which are in Vinhais area.

Table I- Number of registered pigs, Bísaro breed, by producers and region

Region	Nº of producers
Trás-os-Montes e Alto Douro	100
Entre Douro e Minho	1
Douro Litoral	1
Beira Litoral	1
Total	103

(Source: Alves, 2003)

Bísaro pigs are usually reared in a semi-extensive production having always access to outside and being confined only in the period of birth and lactation. They fed on cereals (corn, wheat, rye, barley and), potatoes, pumpkin, beetroot, turnip, cabbage, apples, acorn and chestnuts.

Recent studies showed that it has a slow growth (550g/day) and a low feed efficiency (3.8kg/kg). The carcass yield is about 70%. It also shows an average subcutaneous fat of 20 mm. Its meat shows a very high sensory and technological quality for being processed (Programa para Preservação, Recuperação e Desenvolvimento do Porco *Bísaro*, 2003).

To fit diet concepts and to short the smoking/curing processes, in order to reduce costs, most of the industrial hams are lean and subject to smoke just for a short period or even smoke-flavoured with liquid smoke.

It was reported that the effect of pig rearing conditions in Iberian pigs (free-range system based on acorn and pasture versus confinement on a concentrated feed) are the main factors affecting sensory quality of hams due to the modification in intramuscular fat content and fatty acids profiles. Hams from free range pigs have a more intense aroma, flavour and after-taste from fatty acid composition that cannot be masked by a stronger salty taste as it is probably happen in hams from confined pigs (Cava et al.,2000).

Two traditional smoked sausages made of *Bísaro* meat -Salpicão and Linguiça de Vinhais- have achieved in 1999 a Protected Geographical Indication (PGI) certification. Other *Bísaro* smoked products, *presunto Bísaro* among them, have applied for PGI but they are not yet certified.

Bísaro presunto is made of pork ham (female or male animals these last being castrated) dry-salted for about 30 days with no other additives. Ham is then washed to eliminate the surplus salt and covered with a mixture of paprika, olive oil an/or pork fat. After is exposed to gradual smoke (from oak or chestnut tree), for about 1 to 3 months. Curing/maturation process takes one year in a cold and dry cellar. The *Bísaro* hams show a subcutaneous adipose tissue of 2-4 cm thick and its meat is also very marbled.

Despite of globalisation and standardization of food products, local resources represented by traditional products, although produced on a small scale, can have a great economic impact owing to the creation schemes to exploit diversities and complementarities and, consequently, contributing for a sustainable rural development.

This study is aimed to characterize chemically and microbiologically the *Bísaro presunto* and to ascertain its sensory acceptability compared to industrial hams (made from pig confined and fed on

concentrated feed) and somehow contributing for the recognition of the added value of traditional foods concerning to flavour, nutritional value and safety.

CHARACTERIZATION OF THE SMOKED HAMS

Bísaro smoked hams were brought from the Northeast of Portugal, from Vinhais (samples 1-4), from Bragança (sample 5) local producers. Industrial smoked hams were bought at five meat-processing factories located in Minho. All hams were stored at 10ºC temperature until sampling.

The major differences in processing conditions between the two types of ham are:

- Salting takes one month in *Bísaro* hams whereas in industrial hams salting takes about 10 days. The concept is about one day per kg of ham. However industrial hams weigh 5.5 to 8,5 kg (average weight of 7.1 Kg) whereas *Bísaro* hams weigh 12.76 to 14Kg (average weight 13.3kg).
- In *Bísaro* hams salting is only performed with sea salt
- In industrial hams nitrites, nitrates, sugars, ascorbic salts and polyphosphates are also added during the salting period.
- The length of exposure to smoke (1-3 months in *Bísaro* hams; 5-8 days in industrial hams)
- In traditional hams smoke is applied to the product before curing whereas in industrial hams smoke is applied after the curing/maturation period
- the curing period in *Bísaro* hams is one year whereas in industrial types is 6-8 months. Again the size of the hams will influence the maturation period.

In both hams smoking temperature do not exceed 40 ºC to avoid protein coagulation. Therefore this type of products can be considered ready-to-eat but raw products.

CHEMICAL ANALYSIS

Materials and Methods

Sampling

Sampling was done by collecting the ham meat from two opposite areas in parallel to femur bone. After removal of visible subcutaneous fat, samples were minced and stored overnight at 0ºC. The day after, samples were vacuum-packed and frozen to –20ºC. The 20 samples (10 per ham) were analysed in triplicate a week later.

Analytical methodology

All the parameters were analysed in triplicate. The analysed chemical parameters and respective analytical protocols are shown in Table I.

Table II. Analytical protocols for the analysed parameters

Parameter	Analytical protocols
pH	NP-3441/1990 (Potenciometry)
Moisture	NP-1614/1979 (Gravimetry)
Total fat	NP-1613/1979 (Soxhlet extraction, gravimetry)
Fatty acids	Hydrolysis (KOH/ethanol), gas chromatography
Ash	NP-1615/1979 (Gravimetry)
Polycyclic Aromatic Hydrocarbons (PAH)	AOAC 973.30 – 48.1.01(16th Edition) (HPLC)
Total Nitrogen (N-total)	NP-1612/1979 (Kjeldahl)
Proteins	NP-1612/1979 (Kjeldahl, conversion factor=6,25)
Ammonium Nitrogen (N-NH_3)	NP-3444/1990 (Titrimetry)
N-Free amino acids	NP-3443/1990 (Titrimetry)
Non-protein N	NP-3442/1990 (Kjeldahl)
Total Volatile Nitrogen (TVN)	Distillation followed by titrimetry, Lab. Veterinary Investigation, Agriculture Ministry, Alford-France
Nitrites (NO_2^-)	NP-1846/1987 (Colorimetry)
Nitrates (NO_3^-)	NP-1847/1987 (Colorimetry)
Chlorides Cl^-	NP-1845/1982 (Titrimetry)

Statistical analysis

T^2 of Hotteling and T tests were used for statistical analysis of these results.

Differences were considered significant for a confidence level of 95% (α=0.05).

Results and discussion

Results of the chemical analysis showed that traditional hams have higher contents of total fat; of ash; of chlorides; N-free amino acids; total volatile nitrogen (TVN), non-protein nitrogen (NPN), ammonium nitrogen (N-NH3). On the other hand, industrial hams showed a high pH value and higher levels of nitrites, nitrates, total nitrogen (TN) proteins and water (Table III). The results, per each parameter/each ham shown in Table III, are the average of six duplicates. (samples taken from 2 different parts of the ham, each one analysed in triplicate).

The two groups of hams were significantly different considering the chemical parameters all together (Hotteling T2). The obtained T2 for the individual parameters was 1086, corresponding to a F value of 73, much higher than the theoretical F value (F(0.05,12,47) = 1.965).

By analysing the chemical parameters individually (T test), differences between the two types of hams were also considered to be significant.

Table III. Chemical analysis results per 100g (B-samples means the medium value of the ten Bísaro ham samples analysed in triplicate and C-samples means the medium value of the ten industrial ham samples analysed in triplicate).

Chemical Parameter	*B-samples	*C-samples
pH	5.64 (0.081)	5.83 (0.088)
Water (g)	48.84 (2.46)	54.60 (3.67)
Total fat (g)	5.96 (1.69)	3.64 (0.56)
Ash (g)	10.52 (1.57)	8.7 (2.06)
N-total (g)	4.68 (0.39)	5.02 (0.35)
proteins (g)	29.8 (2.5)	32.0 (2.2)
$N\text{-}NH_3$ (mg)	78.89 (17.36)	59.68 (14.75)
amino-N (mg)	450 (75)	338 (60)
non-protein-N (mg)	0.979 (0.189)	0.684 (0.169)
ABVT (mg)	73.1 (20.8)	61.2 (11.0)
NO_2^-(mg $NaNO_2$)	0.012 (0.0060)	0.439 (0.420)
NO_3^-(mg KNO_3)	3,1 (2,1)	18,4 (6,2)
Cl^- (g NaCl)	8.49 (1.70)	6.71 (1.99)

*Values between brackets are the Standard Deviations

The higher levels of N-free amino acids; total volatile nitrogen (TVN), non-protein nitrogen (NPN), ammonium nitrogen (N-NH3) might be related to a post-mortem proteolysis that it was prevented in industrial hams due to the addition of nitrites. Bísaro hams are much heavier and thick than industrial types. The salt uptake takes longer in Bísaro hams and, meanwhile, endogenous and exogenous enzymes can lead to a certain degree of proteolysis. However, both type of hams showed higher values than the average values reported for the same parameters in industrial ham (Anonymous, 1984).

The higher levels of chlorides of Bísaro hams are typical of traditional smoking/curing processes where hams were produced in conditions to assure them a long shelf life by lowering the water activity. Nowadays, smoking is just to impart flavour to the product, the preservative effect being slight, and many smoked products need to be stored at refrigeration temperatures. As reported before, hams from free range pigs have a more intense aroma, flavour and after-taste from fatty acid composition that cannot be masked by a stronger salty taste as it is probably happen in hams from confined pigs (Cava et al.,2000).

Reported values for: moisture: 61.52; proteins: 27,53; salt: 5.86; total fat: 3.85 (g/100g) in Parma Ham, an Italian product with Protected Origin Denomination (PGI), are much closer to the industrial hams values than to Bísaro ones (Consorzio per ll'exportazione del Prosciutto – Parma Ham, Italy 2003, www.conexprosciutto.com). But of course, the PGI certification of Parma ham is related to its traditional curing process and not to a particular breed such as Bísaro.

Higher contents of total fat and of Fatty Acids (FA) (Table IV) were found in Bísaro hams. Bísaro hams also showed high levels of unsaturated fatty acids (UFA). The high fat content and high levels of UFA might be related with the quality of feeding. As reported by several authors, hams from pigs fed on acorn and pasture (Cava et al., 1999; 2000) or reared extensively (Coutron--Gambotti and Gandemer, 1999) revealed higher amount of total lipids and UFA compared to pigs fed on concentrated feed.

Table IV- Total of fatty acids (FA) and unsaturated fatty acids (UFA)

Type of Ham	Total FA (g/100g of ham)	UFA (+stearic) (mg/100g of ham)	% of UFA/Total FA
Bísaro	3.15 (1.08)	1.019 (0.279)	32.96 (2,48)
Industrial	1.25 (0.42)	0.309 (0.113)	24.78 (3.08)

*Values between brackets are the Standard Deviations

It was expected Bísaro hams, due to its longer exposure to smoke, having higher levels of PAH comparing to industrial hams. However, with respect to Poly-aromatic hydrocarbons (PAH) just fluorene was found in both types of hams and at identical levels (Figure 1). Control: fluorene pattern, Tr=2.961; anthracene pattern, Tr=3.456)

Another control analysis was performed in parallel - samples of both types of hams where fluorene and anthracene were previously added (fluorene pattern, rT=2.990; anthracene pattern, Tr=3568).

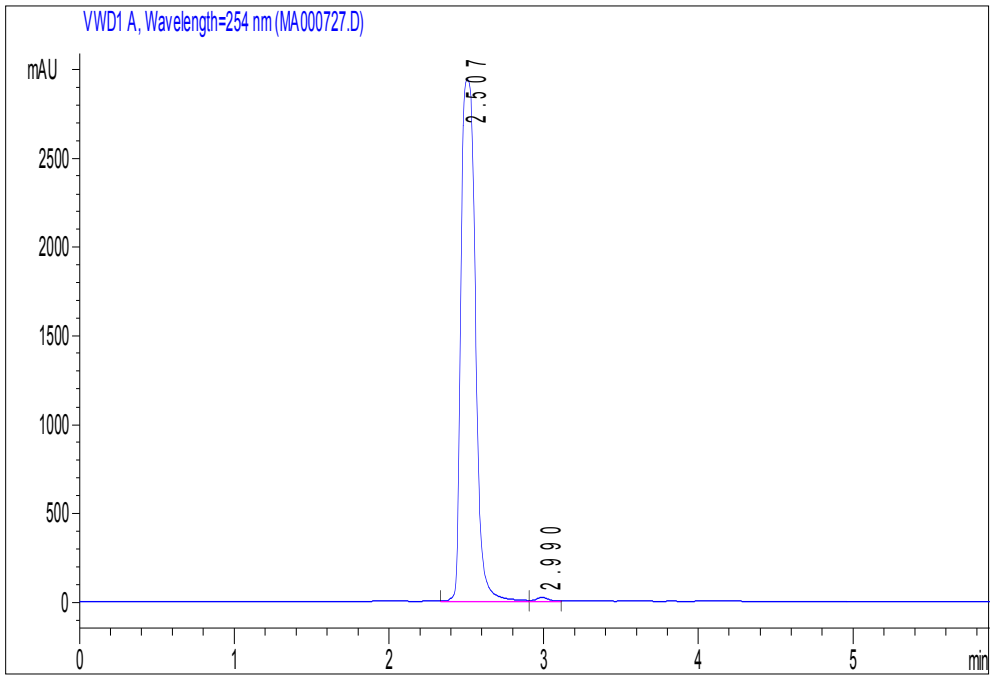

Figure 1- Chromatogram of fluorene in both types of hams (rT=2.990minutes). rT= retention Time

Thirteen PAH have been detected in smoked foods at least one benzo [a] pyrene is a known carcinogen. However the greatest levels appear to be related with charcoal meats, which are incidentally smoked, rather than those products normally described of as smoked. There are another group of chemicals of concern in smoke, the N-nitrosamines (NNAs), which are also considered potential carcinogens. The NNAs in smoked foods are primarily formed by the reaction of nitrogen oxides (generated from nitrites) of the wood smoke with, mainly, secondary amines present in flesh foods (Vaz Velho, 2003).

In this study levels of nitrites and nitrates were much higher in industrial hams because, in these last products, they are added during salting to impart the red colour and flavour to the ham. Despite of having anti-microbial properties, nitrites an additional risk factor as they may react with both secondary and tertiary amines of the ham flesh leading to the formation of NNAs (Vaz Velho, 2003).

MICROBIOLOGICAL ANALYSIS

Sampling

Sampling was done by collecting the ham meat from two opposite areas in parallel to femur bone. From each meat portion, two samples were taken. Ten grams of each sample were placed in 90g of sterilised peptone water and homogenised for 2 minutes in a Stomacher (maximum speed).

Quantification

Decimal dilutions of the mother suspension were made in sterilised peptone water and 0.1 ml of each suspension were spread plated in the correspondent solid media:

- For Total Mesophiles- 0.1 ml of 10^{-3} to 10^{-5} onto Plate Count Agar (PCA) and incubated at 30ºC for 48 hours.
- For Fungi and Yeasts- 0.1 ml of 10^{-2} to 10^{-4} onto Yeast Extract peptone dextrose Cloranphenicol Agar (YEPDC) and incubated for 5 days at 25ºC. After incubation differential counting was performed.
- For *Micrococaceae*- 0.1 ml of 10^{-1} to 10^{-3} onto Manitol salt agar (MSA) and incubated for 48 hours at 37ºC.
- For Lactic Acid Bacteria (LAB)- 0.1 ml of 10^{-1} to 10^{-3} onto Man Rogosa Sharpe Agar (MRS*)* and incubated for 48 hours at 37ºC.
- *For Enterobacteriaceae*- 0.1 ml of 10^{-2} to 10^{-5} onto Violet Red Bile Lactose Agar (VRBA) and incubated at 37ºC for 24 hours.
- For *Clostridium*- 0.1 ml of 10^{-1} to 10^{-2} onto Perfringens Agar (PA) and incubated at 37ºC for 24 hours (anaerobic conditions).

After incubation, counting of colonies from the different plate media was performed.

Identification

After the incubation period and counting of colonies from the different plate media, the most representative colonies were selected for identification and streaked onto Tryptone Soya Agar (TSA) and incubated in the same conditions. For *Clostridium* identification, the colonies isolated from PA were streaked onto TSA and aerobically incubated and also streaked onto Anaerobic agar (AnA) and anaerobically incubated. To identification, Gram-positive bacteria were placed into identification galleries ID System/GP (BBL) and Gram-negative were placed into the Enteric/Nonfermenter ID System/E/NF (BBL). Oxidase and Indol test were also, applied to Gram-negative bacteria. After inoculation of the galleries, those were incubated at the same temperature as previously.

Results and discussion

Quantification

Quantification of Total mesophiles, fungi, yeasts, *Micrococcaceae*, Lactic Acid Bacteria (LAB), *Enterobacteriaceae* and *Clostridium* spp. Found in 5 *Bísaro* hams and 5 industrial hams was performed. Results of this survey are presented in Figure 2. Each value is the average of 4 duplicates from each type of smoked ham. A log cycle difference in cfu/g between samples was considered to be significant.

No Clostridium spp. were found in both types of hams. Traditional hams showed lower cfu/g in all types of the analysed microorganisms compared to industrial hams: less than a log cycle difference in cfu/g for mesophiles, fungi and Micrococcaceae and higher than a log cycle for yeasts, LAB and *Enterobacteriacea.*

Even if the length of the smoking process for cold-smoked products (such as hams with smoke temperatures below 40ºC) is much higher then for the hot-smoked products, a pasteurisation temperature is not achieved in any stage of the process. Thus, temperatures and times used in processing hams are very favourable for the proliferation of food spoilage and food poisoning types of microorganisms. However, in industrial hams nitrites, known to have strong antimicrobial properties, did not apparently have any effect on microbial growth compared to Bísaro hams (where nitrites are not added). The lower number of micororganisms found in Bísaro hams might be related to its higher salt content and low moisture that acted as barrier to microbial growth. Clostridium spp. are very sensitive to nitrites but also very sensitive to salt (Huss, 94). Therefore its absence in both types of hams would be expected. No searching for Listeria was performed. Among the genus, Listeria monocytogenes is the pathogen of concern able to grow at temperatures as low as 1 ºC and levels of NaCl up to 10%. However due to the high salt content of both types of hams (Bísaro hams 8.49 g/100, industrial hams 6.71g/100, which is

equivalent to a water-phase salt content of 14.81 and 10.94 g/100, respectively), is unlikely Listeria presence can occur. Salt in the water-phase is the amount of salt compared with the total amount of water and salt in the product and is the parameter that largely determines the water activity (aw) (Vaz-Velho, 2001).

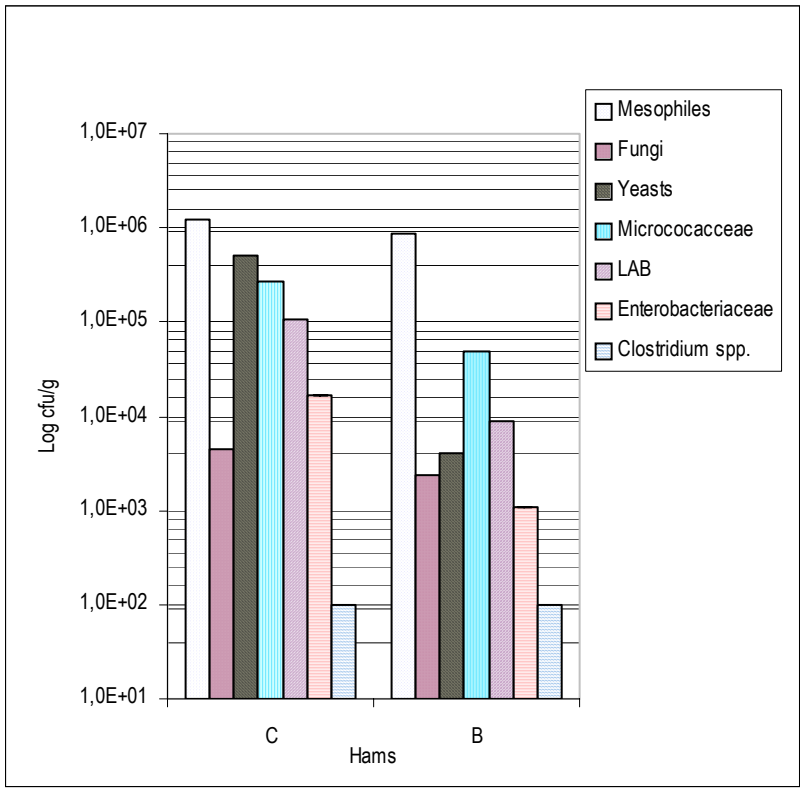

Figure 2- Quantification of microorganisms in Bísaro (B) and Industrial hams (C)

Identification

92% (23/25) of the colonies isolated from MRS for identification were identified as yeasts. It was not possible to identify the two last colonies as LAB.

From PA medium colonies growth in aerobic conditions was faster than in anaerobic atmosphere (TSA and AnA). Macroscopic analysis of these colonies revealed just 3 types of colonies whereas microscopic analysis (after Gram colouration) showed that all colonies were spherical Gram positive (cocos). Identification of 6 of those colonies (2 per each type) revealed the species Staphylococcus xylosus (4/6), Staphylococcus aureus (1/6) and Staphylococcus gallinarum (1/6).

From MSA, 10 colonies, whereas manitol positive (10%) or manitol negative (90%), were isolated for identification. All were Gram positive cocos. 4 colonies were identified as S. xylosus; 1 colony as S. aureus; 1 colony S. simulans; 2 colonies S. equorum and 2 colonies S. kloosi.

From VRBA medium all colonies showed the same macroscopic features and 10 were selected for identification at microscopic level. As they presented the same microscopic features and all were oxidase negative, only 5 were further identified to the species level. 4 colonies were of Serratia liquefaciens and 1 of Serratia marcescens.

Finally, from PCA, 25 colonies were selected for identification. After macroscopic and microscopic characterisation (Gram and oxidase tests), 15 colonies were chosen (11 Gram positive cocos, 2 Gram positive bacilos, 2 Gram negative colonies) and identified as S. xylosus (8/15), S. aureus (2/15) and Bacillus cereus (3/15) and the other two identified as S. liquefaciens (1/15) and Xantomonas maltophilia (1/15).

Overall, it can be concluded that 72.2% of the isolated and identified colonies belong to Micrococcaceae family, genus Staphylococcus, whereas just 19.5% were Gram negative colonies.

From the total of 26 identified Staphylococcus colonies, 22 were found in industrial hams and 4 in the Bísaro hams.

Smoking temperatures and salt content of these smoked products have no effect on S. aureus growth. Although, as the organism requires a minimum growth temperature of 7 ºC, but requires temperatures >15 ºC for toxin production therefore storage temperatures of these products maintained under 5 ºC it will prevent both growth and toxin production (Huss, 1994). It was said that recommended temperature storage of hams for optimal sensory characteristics is 10ºC, which will prevent toxin production.

SENSORY ANALYSIS

Introduction

As part of this larger study on Portuguese smoked ham, aimed at comparing chemical, microbiological and sensory characteristics between industrially and traditionally processed ham, a laboratory consumer panel was asked to examine a range of hams and evaluate a range of characteristics, including liking of appearance, liking of aroma, liking of flavour and overall acceptability. At the same time, they were also asked to rate the perceived intensity of those attributes. This study examines only the overall acceptability of the 10 smoked hams. Although, there were 10 smoked hams in total, it was decided that it was not possible for all 10 hams to be evaluated by each subject, as taste fatigue occurs and may produced biased response (Gacula and Singh 1984). It is generally recommended that under such situations a panellist receives not more than four items at any one particular time. A class of designs, known the balanced incomplete block designs (BIBD) are normally used. However, a disadvantage of these designs is that they do not account for the effect of sample position and carry-over effects, unlike crossover designs such as Williams Latin square designs (Williams 1949). Instead, an optimal incomplete crossover design (OICOD) (Pagès and Périnel 2002) was used in this study. For reasons of simplicity, an analysis of variance was carried out conforming to a BIBD, as the OICOD reduces to a BIBD when the effect of sample position and carry-over effects are dropped from the model.

Materials and methods

Samples.

Ten hams samples were used, which consisted of 5 individual industrially produced hams (hereafter known as ham 01-05) and 5 other individual hams produced by traditional processes from Bísaro breed (ham 06-10). Samples of approximately 1kg were taken in a parallel direction to the ham bone, vacuum packed and subsequently stored at 10 ºC until analyses began.

Sensory analysis.

A laboratory consumer panel of 90 subjects, comprising of 56 women and 34 men, aged between 18 and 65 years was used in this study. Subjects were students and staff members of the Escola Superior de Tecnologia e Gestão.

Thin slices (1 mm) of ham were obtained using a knife and served immediately to panellists at room temperature (20 -23 ºC) on plastic plates. Sessions were conducted in an eight-booth sensory panel room at room temperature under white fluorescent lighting. Each subject was presented with a total of 4 samples (one per session) labelled with three-digit random number codes. The presentation order of the samples was based on a class of cross-over designs known as Optimal incomplete cross-over designs (Pagès and Périnel 2002), whereby the design is balanced for first order carry-over effects. Using this design, each sample was presented in each position (4 individual tasting periods) the same of times and each sample appeared before and after each of the other samples approximately the same number of times.

Panellists were asked to rate each sample for overall acceptability or liking using a 9-point hedonic scale. The word anchoring the scales were as follows: 1 - Dislike extremely; 2 - Dislike very much; 3 -Dislike moderately; 4 – Dislike slightly; 5 – Neither like or dislike; 6 – Like slightly; 7 – Like moderately; 8 – Like very much; 9 – Like extremely.

Statistical analysis.

Prior to conducting an analysis of variance (ANOVA), histograms based on the frequency of hedonic scores for acceptability stratified according to different criteria, such as sex (female or male), treatment (10 ham samples), type (Industrial or Traditional process) and age (below 25 years, between 25 to 34 years and over 35 years), were plotted based on the Trellis display method (Becker et al. 1996), in order to examine if there might be possible preferences to any one or combination of hams based on those predefined parameters. An ANOVA was subsequently conducted, based on a balanced incomplete block

design (BIBD), whereby individual subjects were blocks and a treatment factor (Presunto) with 10 levels corresponding to each ham. All analysis were carried out using R and its associated libraries (Ihaka and Gentleman 1996).

Results and discussion

Figure 3 shows the frequency of hedonic scores for acceptability for the 10 individual samples among the 90 subjects. The overall mean liking for all 10 hams was 6.02 (Like slightly) and this compared with the mean likings for individual hams suggest that these hams were generally found to be acceptable. However, these histograms did not show that there was probably not a significant difference in the preference for a particular ham.

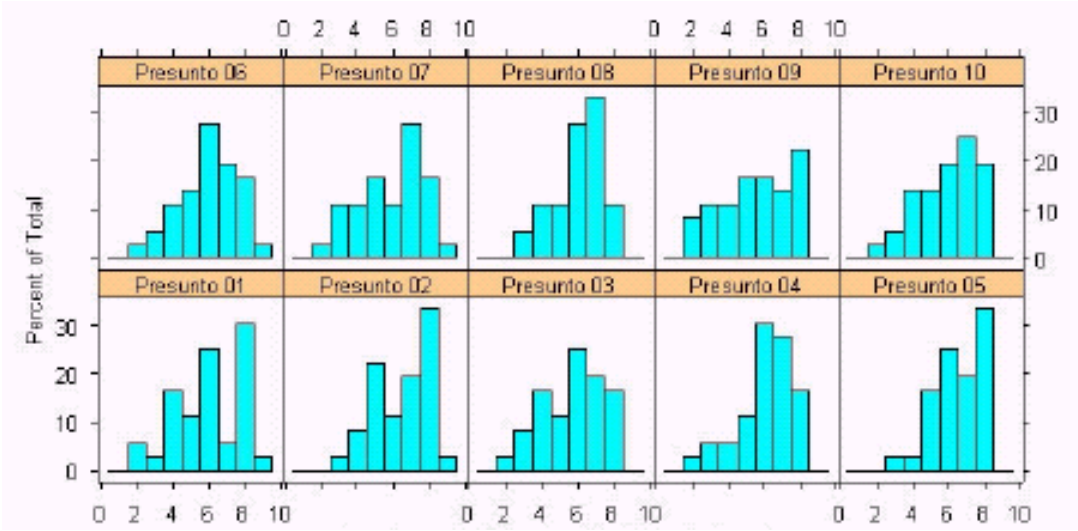

Figure 3. Histograms of the overall acceptability (% of Total responses) based on frequency of hedonic scores for acceptability of 10 individual samples among 90 panellists for different smoked hams produced industrially (01-05) and traditionally (06-10). The mean hedonic scores of 36 presentation of each individual sample from ham 01-10 were as follows: 5.99, 6.35, 5.74, 6.11, 6.25, 5.89, 5.95, 6.25, 5.72, 5.97.

It would seem that, perhaps, there was a slightly higher preference for the industrial hams among women in this study (figure 4). They considered traditionally processed hams to be a lot saltier and fatter than industrial hams. On the other hand, it seemed that men had a slight preference for the traditionally processed hams.

An examination of preferences based on gender for the 10 individual hams seems to reaffirm the previous observation that women generally preferred the industrial samples and men had no specific preferences (figure 5). For example, more than 60% of men had a significant liking for Presunto 10, a traditionally processed ham, whereas, slightly less than 40% of women gave a similar acceptability score (7 or more) for that sample.

However, this observation is not entirely conclusive and an examination of preferences among different aged groups for different genders might offer further explanation to the variation in liking scores. Segmenting the liking scores between industrially and traditionally processed hams with regard to both age group and gender, we can see that women below 25 years have a higher preference for industrial hams (figure 6). As they grow older, even though the overall liking of industrial hams seems to remain the same, more women begin to appreciate traditionally processed hams. However, this conclusion cannot be fully accepted, as there were only 11 women over 34 years as opposed to 32 women under the age of 25 years. Age differences among men did not seem to affect their liking for either type of ham.

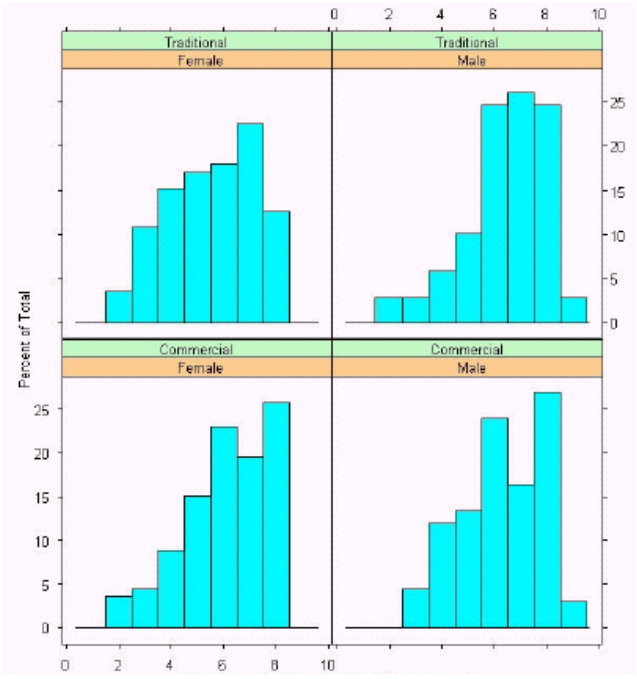

Figure 4. Gender preferences between industrially and traditionally produced smoked hams based on the frequency of hedonic scores (% of Total responses) for overall acceptability. The mean hedonic scores of 36 presentation of each individual sample from ham 01 to 10 were as follows: 5.99, 6.35, 5.74, 6.11, 6.25, 5.89, 5.95, 6.25, 5.72, 5.97.

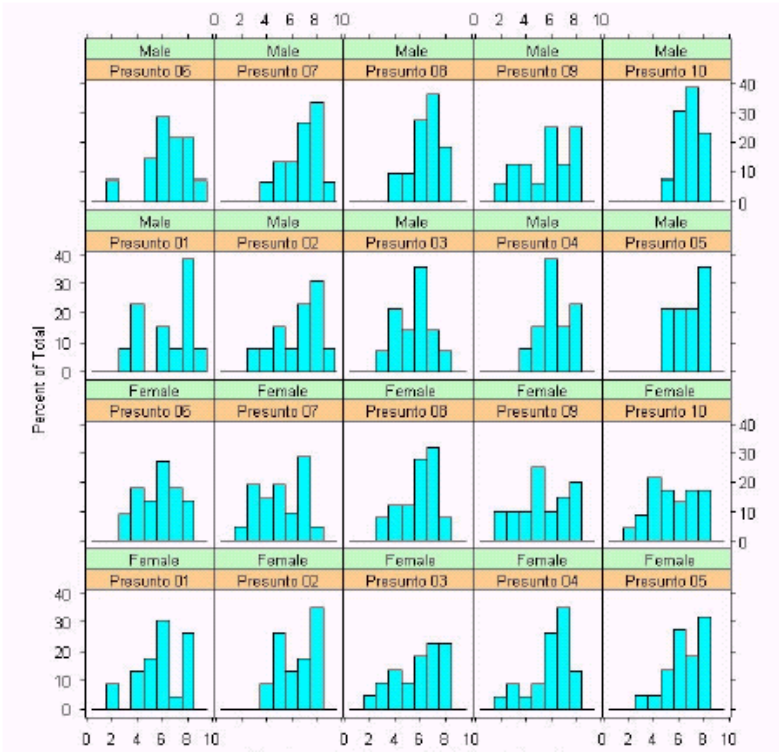

Figure 5. Histograms of difference in overall acceptability (% of Total responses) between males and females for different hams produced either Industrially (01-05) or Traditionally (06-10).

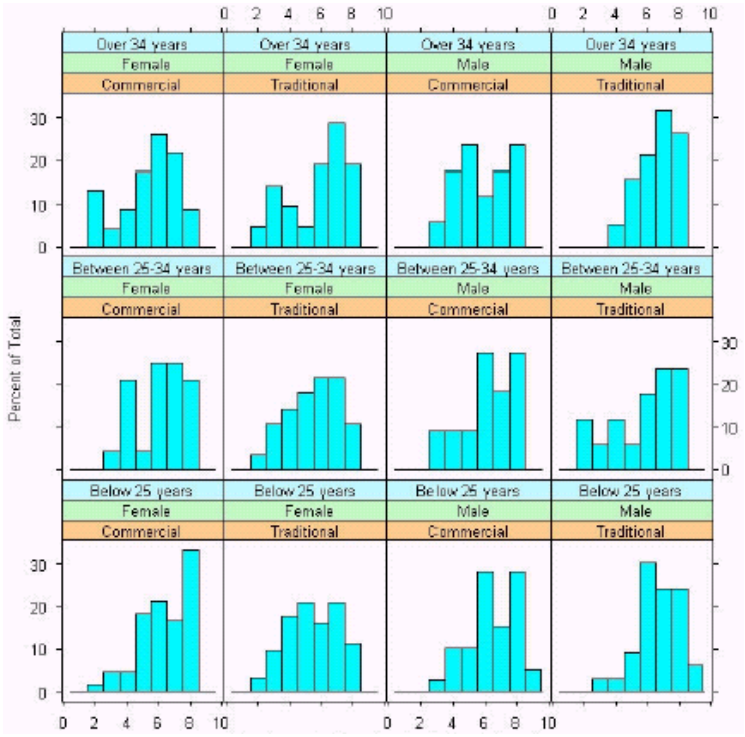

Figure 6. Histograms of difference in overall acceptability (% of Total responses) between males and females from 3 different age groups for hams produced either Industrially (01-05) or Traditionally (06-10).

Table V. Intrablock analysis of variance of Balanced Incomplete Block design for overall acceptability

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-ratio	P-value
Ham (adjusted for panellists)	17.93	9	1.99	0.8221	0.5962
Panellists	339.32	89	3.81		
Error	632.57	261	2.42		

GENERAL CONCLUSIONS

In terms of chemical and microbiological safety Bísaro hams seems to be the best choice by showing less nitrites and, probably due to its higher salt content, less microbiological contamination.

In terms of nutritional quality, Bísaro hams have higher mineral salts and, despite of having a high fat content compared to industrial hams, the fat quality is higher– % of unsaturated fatty acids is higher. UFAs are known to act in the prevention of cardiovascular and brain vascular diseases.

An examination of overall acceptability of smoked hams produced both industrially and by traditional methods did not show any significant preference for any of the 10 individual hams, although all samples were found to be reasonably acceptable. Exploratory graphical analysis indicated a possible segmentation of preferences among subjects based on gender and age. However, an intrablock analysis of variance of the balanced incomplete block showed that there were, in general, no significant preferences among panellists. Overall mean acceptability among samples was 6.02, or given as a like slightly score on the 9-point hedonic scale. It would seem from this initial analysis that a further analysis considering gender and age differences might provide a more realistic interpretation of acceptability of smoked hams among the Portuguese consumers.

Further analysis based on liking of appearance, flavour and aroma may provide a better insight into whether raw materials and processing of these smoked hams contribute to variation in among Portuguese consumer acceptability of these products.

Whatever the reason is – the salt content and/or the fat content of Bísaro hams – that affects the consumers' preferences, it will be a subject for further studies.

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