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A study of the chemical components which characterize Spanish saucisson

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A chemical study was carried out on eight brands of saucisson—a dry-cured Spanish sausage. Chemical composition was determined (moisture, protein, fat, ash, hydroxyproline, chloride, phosphorus) together with some parameters related to the curing process (pH, water activity, *lactobacillus* and Micrococcaceae counts).

Colour, measured by the formation of nitrous pigments, showed some variability, with Chemical Conversion Indexes between 66 and 79%. The sausages with higher Micrococcaceae content had better colour development. Likewise, low levels of these microorganisms are linked to higher pH, lower lipolysis (acidity value) and a larger amount of residual nitrate.

The parameters related to the possible effects of the curing process on proteins and lipids were also determined. Proteins undergo variable proteolysis depending on brand, as can be seen from the non protein N and total free amino acids contents. Protein fractions undergo changes in solubility, thereby accentuating the differences in sarcoplasmic fraction (18·4–22·7%) and in the denatured protein fraction (30·3–37·1%).

Fatty components undergo lipolysis (measured by acidity value) and oxidation (evaluated by the peroxide value, carbonyl compounds index and TBA value), with considerable variations between brands.

A lower moisture content was observed in the products having lower values for protein, water activity, proteolysis and unsaturated fatty acids and higher values were present for fat, protein denaturation and indexes of fat oxidation. These trends were inverted in sausages with the highest moisture content.

INTRODUCTION

Saucisson is a dry-cured sausage whose consumption in Spain is clearly rising; indeed, current per capita consumption is almost 19 kg per year. Nevertheless, studies on the chemical composition of the commercially-sold product are not available, and the information found in the literature on this kind of Spanish sausage only refers to products from pilot plants with partial aspects of the curing process being outlined (León-Crespo & Millán, 1977, 1978; León-Crespo *et al.*, 1978; Garriga *et al.*, 1988*a,b*; Astiasarán *et al.*, 1990*a*). These studies show how the curing process results in a series of changes for proteins, carbohydrates and lipids, which are reflected in the organoleptic properties of the finished product. Furthermore, the diversity and heterogeneity of the raw materials used in the meat industry for sausage production can also be considered as factors which influence the curing process and, by extension, the chemical composition of sausages sold on the market.

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We have, therefore, carried out a study on the chemical composition of different brands of Spanish saucisson, which can serve as a point of reference for a better interpretation of its characteristics.

MATERIALS AND METHODS

Eight different brands of Spanish saucisson were obtained with four samples form each company being analysed. The parameters of each sample were determined in four replicates. The data shown in the tables are the average values together with their corresponding standard error.

The eight brands purchased were prepared using different recipes and under different conditions from one company to another. Generally, the ingredients used were as follows: lean pork, lean beef, pork back fat, common salt, sugar, nitrate, nitrite, polyphosphates (sodium pyrophosphate and potassium metaphosphate), sodium ascorbate and black pepper. Frozen pieces of pork and beef are then mixed with polyphosphates, nitrite salts and nitrates, and cut in the cutter. Frozen pork fat, previously minced in the cutter, is then added.

The mixture is vacuum mixed, stuffed in a 60 mm diameter sausage natural casing and subjected to fermentation for 3 days, followed by 3 weeks' drying under different temperature and relative humidity (RH) conditions depending on the brands.

Before analysis the casing on each sausage was removed and samples homogeneously minced at 2°C. This procedure was repeated as often as necessary to obtain a representative sample.

Analytical methods

Chemical composition

A.1 Moisture was determined using the International Standard ISO 1442-1973 (ISO, 1973*a*).

A.2 Total protein was analysed using the Kjeldahl method for nitrogen determination.

A.3 Hydroxyproline, expressed as a percentage of hydroxyproline, was determined according to the Official Standard Methods procedure under Spanish Food Legislation (Presidencia del Gobierno, 1979*a,b*, 1982).

A.4 Total fat was determined as follows: (a) quantitative determination using the Tecator apparatus (RAFATEC-II 1050 Extractor) according to International Standard ISO 1443-1973 (ISO, 1973*b*); (b) fat extraction using the Bligh & Dyer method (1959) to obtain a suitable amount of fat for further analysis.

A.5 Total and soluble sugar were determined using the Fehling method.

A.6 Ash was analysed according to the Official Standard Methods procedure under Spanish Food Legislation (Presidencia del Gobierno, 1979*a,b*, 1982).

A.7 Sodium chloride content, expressed as NaCl percentage, was determined according to the AOAC procedure (AOAC, 1984).

A.8 Phosphorus was determined using the Official Standard Methods procedure under Spanish Food Legislation (Presidencia del Gobierno, 1979*a,b*, 1982).

A.9 The pH was determined with the Orion Research potentiometer for solid samples using the International Standard ISO R 2917-1974 (ISO, 1974).

A.10 Water activity was measured using a Novasina Model 5803 water activity meter. The apparatus was calibrated with a barium chloride solution.

B Microbiological parameters

B.1 *Lactobacillus* counts were obtained using an MRS agar (Oxoid).

B.2 Micrococcaceae count was determined using a culture medium composed of agar, pectone, sodium citrate, sodium chloride, potassium nitrate, dextrose and yeast.

C Colour parameters

Total pigments were obtained by the Hornsey method (1956) and Nitrosopigments using the same analysis modified in a later paper (Gorospe *et al.*, 1986). The chemical conversion index is the percentage of nitroso-pigments in the products in relation to total pigments, and represents the amount of nitrosation resulting from the curing process. Nitrate and nitrite levels were determined according to the methods of Volff *et al.* (1974) and Nicholas & Nason (1957), respectively.

D Protein fractions

The following nitrogen fractions were determined: sarcoplasmic protein N, myofibrillar protein N, non-protein N, soluble N in 0·1N NaOH and total N, according to the methods described by Bello *et al.* (1974), who adapted the method described earlier by Helander (1957) in the study of the proteins of muscular tissues. This method involves extraction of samples with buffers of different ionic strengths for the sarcoplasmic (0·08 and pH = 7·4) and myofibrillar (0·1 and pH = 7·4) fractions, with 10% trichloroacetic acid (TCA) for the non-protein N and NaOH for the insoluble protein. The protein insolubility index was calculated as a ratio of insoluble protein to total protein as a percentage. The solubility of sarcoplasmic and myofibrillar protein was calculated as the percentage of total protein from these data.

The determination of total free α-NH_2—N was analysed using the Rosen method (1957), with leucine as the standard.

E Surface activity

The activity emulsion index of solubilized meat proteins was determined according to the Pearce & Kinsella method (1978).

F Parameters related to fat stability

F.1 Iodine value was determined using International Standard ISO 3961-1979 (ISO, 1979).

F.2 Acidity value was determined using International Standard ISO 1740-1980 (ISO, 1980).

F.3 Peroxide value was determined using International Standard ISO 3960-1977 (ISO, 1977).

F.4 Thiobarbituric acid (TBA) value was determined using the Tarladgis *et al.* (1960, 1964) distillation method, complementing it with suitable modifications as suggested by the authors. Spectrophotometric measurements were carried out with the Perkin-Elmer Model Lambda-5 UV/VIS spectrophotometer.

F.5 Carbonyl compounds index, expressed as μmoles C=O per g of fat, was determined by the procedure of Henick *et al.* (1954).

G Free fatty acids composition

G.1 Free fatty acids in the lipid fraction were separated by thin layer Chromatography (TLC). The extracted fat was applied in drop form on plates covered with silica gel G and chromatographed using *n*-hexane/diethyl ether/formic acid (80:20:2; v:v:v) as a solvent, and were identified on spraying with a 0·1% solution of 2',7'-fluorescein dichloride in 95% methanol. Finally, they were scraped, dissolved in *n*-hexane, filtered and methylated for identification.

Table 1. Chemical composition of eight brands of saucissons*

Parameter	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6	Brand No. 7	Brand No. 8
Moisture (%)	35·7±0·16	33·9^a±0·16	33·4^a±0·16	31·7±0·13	38·4^b±0·16	38·9^b±0·13	40·0^c±0·23	39·6^c±0·25
Total protein (%)	29·3^a±0·36	27·4^b±0·16	29·4^a±0·66	27·8^b±0·59	28·7^c±0·47	29·3^a±0·58	28·8^c±0·33	27·3^b±0·72
Hydroxyproline (%)	0·4^a±0·01	0·4^a±0·01	0·5^b±0·01	0·5^b±0·03	0·4^a±0·02	0·4^a±0·04	0·6^c±0·01	0·6^c±0·03
Total fat (%)	49·8^a±0·70	50·6^a±0·71	60·4^b±1·59	60·9^b±0·76	54·3^c±0·32	54·4^c±0·77	50·2^a±0·95	51·6^a±0·79
Total sugar (%)	10·8^a±0·35	10·8^a±0·16	10·1^a±0·42	10·0^a±0·30	9·0^b±0·43	9·5^b±0·57	10·5^a±0·55	10·7^a±0·92
Soluble sugar (%)	2·3^a±0·13	2·2^a±0·06	2·2^a±0·04	2·5^b±0·04	3·1±0·06	2·5^b±0·02	2·4^b±0·10	2·5^b±0·06
Ash (%)	8·2^a±0·05	8·2^a±0·03	8·3^a±0·04	8·0^a±0·06	8·0^a±0·05	8·0^a±0·07	8·7^a±0·04	8·0±0·04
NaCl (%)	7·9^b±0·14	7·5^{a,b}±0·13	7·3^{a,b}±0·14	7·5^{a,b}±0·10	6·1^a±0·02	6·1^a±0·03	8·0^b±0·47	7·5^{a,b}±0·38
Phosphorus (ppm P_2O_5)	106±0·44	103·2^a±0·34	93·5^b±0·65	91·3^b±0·25	92·8^b±0·13	100^a±0·38	104^a±0·25	103^a±0·25

* Any two means followed by the same superscript letter are not significantly different at $p > 0·01$.
All values refer to dry samples

G.2 Identification and quantification of fatty acid methyl esters was done by gas chromatography (GC) according to International Standard ISO 5508-1978 (IS0, 1978*a*) and IS0 5509-1978 (IS0, 1978*b*). Methyl esters were analysed using a Perkin-Elmer Chromatograph (Sigma-300/Dual FID Model) with a Sigma-15 Chromatograph Station programmer using a stainless steel column (2 m × 1·8[11]) coated with 15% DEGS on Chromosorb W-AS 80/100 under the following conditions: (a) carrier gas: nitrogen at 20 ml/min; (b) oven temperature: 185°C (isothermic); (c) detector temperature: 240°C; (d) injector temperature: 250°C. Methyl ester standards of fatty acids (myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, arachidic and arachidonic acids) were obtained from Sigma Chemical and dissolved in *n*-hexane.

H Statistical Analysis

Analysis of variance and a multiple-comparison test of Tukey at 0·01% of level of significance were applied to the data to see if significant differences existed between the different brands of saucisson.

Pearson's correlation analysis was applied to the free fatty acid composition data to see if there were any associations between the different parameters.

RESULTS AND DISCUSSION

Table 1 shows the chemical composition of the analysed saucissons. Moisture varied from 31·7% in Brand 4 to 40·0% in Brand 7. The main components of saucisson are protein (27·3–29·4%) and fat (49·8–60·9%), with these substances providing the basis for the development of the organoleptic characteristics of the sausage during fermentation begun by the microorganisms present (Mottram & Edwards, 1983).

The other chemical composition parameters of saucission vary among the different brands: hydroxyproline (0·4–0·6%), total sugar (9·0–10·8%), soluble sugar (2·2–3·1%), ash (8·0–8·7%), NaCl (6·1–8·0%), and phosphorus (91·3–106·2 ppm P_2O_5).

All the samples were within the requirements laid down by Spanish Food Legislation (Presidencia del Gobierno, 1980).

Table 2 shows pH and water activity values and fermented microorganism counts (*Lactobacillus* and Micrococcaceae). The pH values found (5·02–5·28) can be considered normal for cured sausage (Kramlich *et al.*, 1973). The combination of the acidic pH values and low water activity (0·860–0·895) inhibited the development

Table 2. Parameters related to drying-fermentation process of eight brands of saucissons*

Parameter	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6	Brand No. 7	Brand No. 8
pH	5·10^a±0·04	5·07^a±0·04	5·02^a±0·05	5·09^a±0·05	5·28^b±0·02	5·27^b±0·01	5·19^c±0·02	5·20^c±0·02
Water activity	0·870^a±0·001	0·866^a±0·002	0·865^a±0·002	0·860^a±0·005	0·891^b±0·002	0·893^b±0·002	0·894^b±0·004	0·895^b±0·003
Lactobacillus counts (cfu)	$2·4\times10^6$	$2·5\times10^6$	$2·8\times10^6$	$2·7\times10^6$	$3·0\times10^6$	$3·5\times10^6$	$2·3\times10^6$	$1·9\times10^6$
Micrococcaceae counts (cfu)	$1·9\times10^3$	$2·0\times10^3$	$3·2\times10^3$	$3·3\times10^3$	$0·5\times10^3$	$0·6\times10^3$	$1·8\times10^3$	$1·3\times10^3$

*Any two means followed by the same letter are not significantly different at $p > 0·01$.

Table 3. Colour parameters of eight brands of saucissons*

Parameter	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6	Brand No. 7	Brand No. 8
Total pigments (ppm haematin)	$91{\cdot}2^a \pm 2{\cdot}3$	$92{\cdot}0^a \pm 1{\cdot}2$	$89{\cdot}4^a \pm 2{\cdot}4$	$90{\cdot}1^a \pm 2{\cdot}6$	$80{\cdot}3^b \pm 4{\cdot}3$	$80{\cdot}6^b \pm 1{\cdot}8$	$83{\cdot}2^c \pm 2{\cdot}9$	$85{\cdot}4^c \pm 1{\cdot}5$
Nitrosopigments (ppm haematin)	$60{\cdot}4^a \pm 4{\cdot}1$	$63{\cdot}1^a \pm 3{\cdot}2$	$70{\cdot}6^b \pm 4{\cdot}1$	$68{\cdot}7^b \pm 5{\cdot}1$	$53{\cdot}4^c \pm 4{\cdot}9$	$52{\cdot}6^c \pm 2{\cdot}9$	$60{\cdot}3^a \pm 1{\cdot}7$	$60{\cdot}5^a \pm 2{\cdot}2$
Chemical conversion index (%)	$66{\cdot}2^a \pm 1{\cdot}7$	$68{\cdot}6 \pm 2{\cdot}7$	$79{\cdot}0 \pm 1{\cdot}7$	$76{\cdot}2 \pm 2{\cdot}0$	$66{\cdot}5^a \pm 1{\cdot}1$	$65{\cdot}3^a \pm 1{\cdot}6$	$72{\cdot}5^b \pm 1{\cdot}7$	$70{\cdot}8^b \pm 1{\cdot}5$
Nitrates (ppm KNO_3)	$22{\cdot}3 \pm 0{\cdot}1$	$17{\cdot}8 \pm 0{\cdot}0$	$38{\cdot}1^a \pm 0{\cdot}2$	$38{\cdot}4^a \pm 0{\cdot}2$	$74{\cdot}5^b \pm 0{\cdot}8$	$73{\cdot}6^b \pm 0{\cdot}3$	$11{\cdot}6^c \pm 0{\cdot}1$	$10{\cdot}4^c \pm 0{\cdot}1$
Nitrites[d] (ppm $NaNO_2$)	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr

* Any two means followed by the same superscript letter are not significantly different at $p > 0{\cdot}01$.
[d] Tr: Trace amounts, less than 10 ppm, $NaNO_2$.

of pathogenic microorganisms (Bacus & Brown, 1981), but enabled the fermentative microorganisms to develop correctly, which were selected for their sodium chloride tolerance (Table 1). Brands 1 to 4 have the highest acidity, the lowest available water and the best Micrococcaceae development ($1{\cdot}9 \times 10^3$–$3{\cdot}3 \times 10^3$ cfu). Lactobacilli were the predominant fermentative microorganisms ($1{\cdot}9 \times 10^6$–$3{\cdot}5 \times 10^6$ cfu).

Table 3 shows the colour parameters. There were only trace amounts of nitrite (<10 ppm $NaNO_2$) in all samples, because they are destroyed when the pH becomes acid. The nitrate content was found to be highly variable (10·4–74·5 ppm KNO_3). Santamaria *et al.* (1992) demonstrated the casual formation of nitrates from nitrites during the curing of sausage. The nitrosopigments and chemical conversion index values of Brands 3 and 4 were the highest (nitrosopigments: 70·6 and 68·7 ppm haematin; chemical conversion index: 79·0 and 76·2%, respectively). These brands had the highest Micrococcaceae counts (Table 2), which are mainly responsible for the colour development of cured sausage under suitable environmental conditions of pH and redox potential (Pan & Solberg, 1972). León-Crespo & Millán (1978*a*) obtained lower colour parameter values for saucissons produced in a pilot plant than for the brands used in this study.

In addition to colour, the sausage samples show some differences in texture, flavour and aroma This is explained by the role that proteins and fats may have played during the curing process. Meat proteins are considered to be the chemical components which determine the firmness and appearance of the product (Hermansson *et al.*, 1986). The joint action of salt, lactic acid (from bacterial fermentation) and drying has an effect on the properties of meat proteins, favouring the formation of a gel in the fermented mix (Whiting, 1988).

Table 4 shows the sarcoplasmic and myofibrillar N values, plus the parameters linked to proteolysis in sausage curing: non-protein N and total free amino acids. A higher sarcoplasmic N content (8·51–10·44 mg N/g) than myofibrillar N (7·45–7·98 mg N/g) was observed, with minor but significant differences ($p < 0{\cdot}01$) between samples. The lower myofibrillar N value shows that, when the pH is less than 5·4, the myofibrillar proteins are converted to non-protein N through the enzymatic action of the microorganisms (Klement & Cassens, 1974). The data found on proteolysis (non-protein N and total free amino acids) are similar to the observations of Garriga *et al.* (1988*a,b*), but higher than those described by León-Crespo & Millán (1978) for other Spanish saucissons. The highest non-protein N and total free amino acids values were found in Brands 7 and 8, these saucissons having the highest water activity and pH values (Table 2).

The curing process may lead to changes in the func-

Table 4. Parameters related to nitrogen fractions of eight brands of saucissons*

Parameter	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6	Brand No. 7	Brand No. 8
Sarcoplasmic N (mg N/g)	$8{\cdot}65^a \pm 0{\cdot}36$	$8{\cdot}60^a \pm 0{\cdot}27$	$9{\cdot}14^b \pm 0{\cdot}29$	$8{\cdot}57^a \pm 0{\cdot}21$	$10{\cdot}44^c \pm 0{\cdot}17$	$10{\cdot}07^c \pm 0{\cdot}49$	$8{\cdot}51^a \pm 0{\cdot}25$	$9{\cdot}02^b \pm 0{\cdot}17$
Myofibrillar N (mg N/g)	$7{\cdot}80^a \pm 0{\cdot}18$	$7{\cdot}89^a \pm 0{\cdot}05$	$7{\cdot}45^b \pm 0{\cdot}12$	$7{\cdot}46^b \pm 0{\cdot}20$	$7{\cdot}98 \pm 0{\cdot}09$	$7{\cdot}54 \pm 0{\cdot}13$	$7{\cdot}91^a \pm 0{\cdot}18$	$7{\cdot}70 \pm 0{\cdot}07$
Non-protein N (mg N/g)	$7{\cdot}76^a \pm 0{\cdot}11$	$7{\cdot}66^a \pm 0{\cdot}10$	$7{\cdot}18 \pm 0{\cdot}12$	$6{\cdot}96 \pm 0{\cdot}11$	$7{\cdot}50 \pm 0{\cdot}10$	$7{\cdot}84^b \pm 0{\cdot}15$	$7{\cdot}94^b \pm 0{\cdot}08$	$8{\cdot}10 \pm 0{\cdot}09$
Total free amino acids (mg/g)	$38{\cdot}3 \pm 2{\cdot}01$	$37{\cdot}0 \pm 1{\cdot}71$	$33{\cdot}8^a \pm 2{\cdot}53$	$32{\cdot}3^a \pm 0{\cdot}79$	$37{\cdot}6^b \pm 0{\cdot}49$	$37{\cdot}6^b \pm 0{\cdot}57$	$39{\cdot}8^c \pm 0{\cdot}37$	$39{\cdot}2^c \pm 0{\cdot}49$

*Any two means followed by the same superscript letter are not significantly different at $p > 0{\cdot}01$.
All values refer to dry samples.

Table 5. Parameters related to functional properties of meat proteins of eight brands of saucissons*

Parameter	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6	Brand No. 7	Brand No. 8
Protein insolubility index (%)	$33{\cdot}8^{a}\pm0{\cdot}24$	$35{\cdot}5^{a}\pm0{\cdot}26$	$36{\cdot}0^{b}\pm0{\cdot}16$	$37{\cdot}1^{b}\pm0{\cdot}32$	$30{\cdot}3\pm0{\cdot}68$	$32{\cdot}3\pm0{\cdot}58$	$33{\cdot}1^{a}\pm0{\cdot}57$	$33{\cdot}8^{a}\pm0{\cdot}33$
Sarcoplasmic protein solubility (%)	$18{\cdot}5^{a}\pm0{\cdot}76$	$18{\cdot}4^{a}\pm0{\cdot}61$	$19{\cdot}7^{b}\pm0{\cdot}63$	$19{\cdot}3^{b}\pm0{\cdot}47$	$22{\cdot}7\pm0{\cdot}27$	$21{\cdot}5\pm0{\cdot}54$	$18{\cdot}4^{a}\pm0{\cdot}37$	$19{\cdot}7^{b}\pm0{\cdot}26$
Myofibrillar protein solubility (%)	$16{\cdot}7^{a}\pm0{\cdot}38$	$17{\cdot}2^{b}\pm0{\cdot}12$	$16{\cdot}1^{a}\pm0{\cdot}25$	$16{\cdot}7^{a}\pm0{\cdot}44$	$17{\cdot}4^{b}\pm0{\cdot}20$	$16{\cdot}1^{a}\pm0{\cdot}17$	$17{\cdot}1^{b}\pm0{\cdot}21$	$16{\cdot}8^{a}\pm0{\cdot}16$
Surface activity (m^2/g)	$103{\cdot}2^{a}\pm4{\cdot}82$	$102{\cdot}1^{a}\pm4{\cdot}74$	$105{\cdot}8^{a}\pm4{\cdot}16$	$104{\cdot}9^{a}\pm5{\cdot}19$	$57{\cdot}3^{b}\pm4{\cdot}75$	$47{\cdot}6\pm5{\cdot}81$	$53{\cdot}9^{b}\pm3{\cdot}14$	$60{\cdot}4^{b}\pm6{\cdot}84$

* Any two means followed by the same superscript letter are not significantly different at $p > 0{\cdot}01$.
All values refer to dry samples.

tional properties of protein molecules (Nakai, 1983). Table 5 shows some parameters linked to the functional properties of meat proteins: protein insolubility index, sarcoplasmic and myofibrillar protein solubility, and surface activity of solubilized meat proteins. Although the percentages did not reflect great differences between the samples, surface activity was highly variable, with Brands 1 to 4 showing values twice as high as Brands 5 to 8.

Table 6 shows the parameters related to the lipid stability of saucisson: iodine value, acidity value, peroxide value, TBA value and carbonyl compounds index.

The iodine value did not show significant differences ($p > 0{\cdot}01$) among the samples. The values obtained (64·0–69·6%) are similar to those reported for pork back fat by Flores *et al.* (1988) and for other sausages by Astiasarán *et al.* (1990*b*).

The variability in the acidity values (6·50–10·6 mg KOH/g fat) may be due to the large variation in the lipolytic processes (mainly of microbiological origin) during the curing of the sausages (Cantoni *et al.*, 1967). The values observed were higher than those published for other Spanish saucissons (León-Crespo & Millán, 1977) and for other types of Spanish sausages (Lois *et al.*, 1987; Melgar *et al.*, 1990*a,b*).

The oxidative process was evaluated by the peroxide value, TBA value and carbonyl compounds index. The fatty peroxides are transformed into carbonyl compounds (Cerise *et al.*, 1973) or into malonaldehyde (MA) through the oxidation of polyunsaturated fatty acids during the curing process (Pearson *et al.*, 1983). Brands 1 to 4 show higher values in all three indexes than the other brands, which may indicate greater fat oxidation in these brands.

The composition of free fatty acids is shown in Table 7. These results indicate a considerable variation in the oxidative processes which affect the free fatty acid composition and flavour (Mottram *et al.*, 1982). Multivariate statistical analysis shows a significant correlation between stearic and linoleic acids ($r = -0{\cdot}925$). Furthermore, saturated fatty acids such as myristic and stearic, were also significantly correlated ($r = +0{\cdot}763$) in all samples.

In summary, the brands with the lowest Micrococcaceae counts (5 and 6) had some common characteristics: higher pH, a greater residual nitrate content, higher protein solubility, and less lipolysis and a lower protein insolubility index. The presence of these microorganisms favours the formation of nitrosopigments. In Brands 4 and 7, with the lowest and highest moisture content, respectively, an inverse relationship was observed in some of the parameters. Brand 4, which had the lowest moisture content, had the lowest protein content, water activity and proteolysis,

Table 6. Parameters related to fat stability of eight brands of saucissons*

Parameter	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6	Brand No. 7	Brand No. 8
Iodine value (% I_2)	$64{\cdot}8^{a}\pm0{\cdot}82$	$64{\cdot}0^{a}\pm0{\cdot}81$	$66{\cdot}7^{a}\pm0{\cdot}54$	$66{\cdot}3^{a}\pm0{\cdot}43$	$65{\cdot}5^{a}\pm0{\cdot}48$	$66{\cdot}2^{a}\pm0{\cdot}26$	$68{\cdot}5^{a}\pm0{\cdot}74$	$69{\cdot}6^{a}\pm0{\cdot}45$
Acidity value (mg KOH/g fat)	$8{\cdot}57^{a}\pm0{\cdot}52$	$7{\cdot}70^{a}\pm0{\cdot}23$	$9{\cdot}50^{b}\pm1{\cdot}96$	$10{\cdot}6^{b}\pm3{\cdot}12$	$6{\cdot}77^{c}\pm0{\cdot}37$	$6{\cdot}50^{c}\pm0{\cdot}18$	$8{\cdot}30^{a}\pm0{\cdot}24$	$8{\cdot}39^{a}\pm0{\cdot}38$
Peroxide value (meq O_2/kg fat)	$17{\cdot}5^{a}\pm1{\cdot}89$	$18{\cdot}7^{a}\pm1{\cdot}82$	$19{\cdot}4^{a}\pm1{\cdot}78$	$19{\cdot}2^{a}\pm1{\cdot}95$	$14{\cdot}2^{b}\pm1{\cdot}11$	$13{\cdot}4^{b}\pm1{\cdot}96$	$10{\cdot}5^{c}\pm1{\cdot}58$	$11{\cdot}2^{c}\pm1{\cdot}05$
TBA value (mg MA/kg fat)	$35{\cdot}9^{a}\pm0{\cdot}28$	$36{\cdot}1^{a}\pm0{\cdot}09$	$32{\cdot}7\pm0{\cdot}41$	$35{\cdot}0\pm0{\cdot}12$	$6{\cdot}98\pm0{\cdot}08$	$5{\cdot}32\pm0{\cdot}12$	$1{\cdot}99^{b}\pm0{\cdot}09$	$2{\cdot}00^{b}\pm0{\cdot}12$
Carbonyl compounds index (μmoles C=O/g fat)	$42{\cdot}4^{a}\pm1{\cdot}95$	$43{\cdot}7^{a}\pm1{\cdot}49$	$40{\cdot}6^{b}\pm0{\cdot}36$	$40{\cdot}5^{b}\pm0{\cdot}57$	$35{\cdot}2^{c}\pm0{\cdot}25$	$34{\cdot}3^{c}\pm0{\cdot}30$	$33{\cdot}7^{d}\pm0{\cdot}58$	$33{\cdot}6^{d}\pm0{\cdot}41$

*Any two means followed by the same superscript letter are not significantly different at $p > 0{\cdot}01$.

Table 7. Free fatty acids composition of eight brands of saucissons*

Parameter	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6	Brand No. 7	Brand No. 8
Myristic 14 : 0 (% weight)	2·44±0·06	2·21^a±0·05	2·28^a±0·04	2·67±0·02	2·83^b±0·08	3·18±0·07	2·89^b±0·07	3·02±0·06
Palmitic 16 : 0 (% weight)	22·9^a±0·23	23·3^a±0·34	27·5±0·75	30·6±0·25	24·0^b±0·04	24·4^b±0·05	22·7^a±0·19	22·3^a±0·16
Palmitoleic 16 : 1 (% weight)	4·83^a±0·18	4·93^a±0·19	4·69^a±0·32	5·26±0·36	5·18±0·13	5·23±0·10	4·00^b±0·18	3·98^b±0·14
Stearic 18 : 0 (% weight)	8·89^a±0·05	10·1^b±0·07	16·5^c±0·27	17·4^c±0·19	9·50^a±0·77	9·21^a±0·17	9·84^a±0·06	10·0^b±0·07
Oleic 18 : 1 (% weight)	42·6^a±0·26	43·6^a±0·18	36·3±0·61	33·0±0·11	38·7^b±0·97	38·6^b±0·26	40·6^c±0·21	40·3^c±0·10
Linoleic 18 : 2 (% weight)	15·4^a±0·20	13·4^a±0·23	10·4±0·31	8·43±0·10	15·5^a±0·44	15·6^a±0·12	16·2^a±0·30	16·6^a±0·10
Linolenic 18 : 3 (% weight)	1·00±0·03	0·73±0·07	0·77^a±0·06	0·70^a±0·07	1·19±0·07	1·43±0·09	1·39±0·03	1·62±0·04
Arachidic 20 : 0 (% weight)	0·27±0·01	0·24±0·02	0·31^a±0·02	0·36^b±0·02	0·36^b±0·04	0·30^a±0·03	0·59±0·03	0·55±0·04
Arachidonic 20 : 4 (% weight)	0·29±0·03	0·24±0·05	0·22^a±0·02	0·21^a±0·01	0·19±0·06	0·17±0·07	0·26^b±0·03	0·25^b±0·05

* Any two means followed by the same superscript letter are not significantly different at $p > 0·01$.

and higher protein denaturation. Likewise, it had greater oxidation and lower levels of C_{18} unsaturated fatty acids.

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