Sensory acceptability of slow fermented sausages based on fat content and ripening time.

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Abstract

Low fat dry fermented sausages were manufactured using controlled ripening conditions and a slow fermented process. The effect of fat content and ripening time on the chemical, colour, texture parameters and sensory acceptability of fermented sausages was studied. The fat reduction in slow fermented sausages produced an increase in the pH decline during the first stage of the process that was favored by the higher water content of the low fat sausages. Fat reduction did not affect the external appearance and there was an absence of defects but lower fat content resulted in lower sausage lightness. The sausage texture in low fat sausages was affected by an increase in chewiness and at longer ripening times, an increase in hardness. The sensory acceptability of the fermented sausages analyzed by internal preference mapping depended on the different preference patterns of consumers. A group of consumers preferred sausages with high and medium fat content and high ripening time. The second group of consumers preferred sausages with low ripening time regardless of fat content except for the appearance for which these consumers preferred sausages of high ripening time. Finally, the limit to produce high acceptability low fat fermented sausages was 16 % fat content in the raw mixture that it is half of the usual content of dry fermented sausages.

Keywords: fermented sausages, low fat, sensory acceptability, ripening.

1. Introduction

Dry fermented sausages are meat products with high fat content. Commercial sausages have fat contents around 32% directly after manufacture, but as a result of drying this value rise to about 40-50% (Wirth, 1988). Fat is responsible for various properties of dry fermented sausages. Firstly, from a physiological point of view, fat acts as a source of essential fatty acids and fat soluble vitamins and constitutes the most concentrated source of energy in the diet (9 kcal/g) (Mela, 1990). Secondly, fat contributes to the flavour, texture, mouthfeel, juiciness and lubricity, which determine the quality and acceptability of dry sausages. Finally, the granulated fat has a further technological function in the manufacture of dry fermented sausages. It helps to loosen up the sausage mixture in order to facilitate the continuous release of moisture from the inner layer of the sausage; a process absolutely necessary for undisturbed fermentation and flavour development (Wirth, 1988).

In recent years, increased concerns about the potential health risks associated with the consumption of high-fat foods has led the food industry to develop new formulations or modify traditional food products to contain less fat (Mendoza, García, Casas & Selgas, 2001). One of the strategies for the development of low-fat fermented sausages was the reduction of fat content and the simultaneous addition of non-lipid fat replacers in order to minimize texture defects (Muguerza, Gimeno, Ansorena & Astiasarán, 2004). In this regard, the addition of inulin, cereal and fruit fibres, and short-chain fructooligosaccharides obtained satisfactory results for the reduction of fat content in dry fermented sausages (Mendoza et al., 2001; García, Domínguez, Galvez, Casas & Selgas, 2002; Salazar, García, & Selgas, 2009). Other strategies were focused on the replacement of pork back fat by olive oil in order to have a positive effect on consumer health (Bloukas, Paneras & Fournitzis, 1997; Muguerza, Fista, Ansorena, Astiasarán, & Bloukas 2002; Muguerza, Ansorena, Bloukas, & Astiasarán 2003;

Koutsopoulos, Koutsimanis & Bloukas, 2008; Del Nobile, Conte, Incoronato, Panza, Sevi & Marino, 2009).

Dry fermented sausages are the most difficult among meat products as far as fat reduction is concerned. Excessive fat reduction leads to harder or rubbery dry meat products due to higher weight losses (Keeton, 1994) and also, it results in unacceptable appearance produced by the presence of wrinkled surfaces and case hardening (Muguerza et al., 2002). However, these defects can be avoided if appropriate processing or climatic conditions are applied as suggested Wirth (1988). This author indicated that fat reduced fermented sausages of acceptable standard can be made with fat contents in the raw material of about 15 %, which rises to 20-30% in the finished product. Recently, Liaros, Katsanidis, & Bloukas (2009) have proposed the use of vacuum packaging during ripening as an effective technique to improve external appearance in low fat fermented sausages. However, high fat sausages still have highest acceptability scores (Mendoza et al., 2001) not only due to their appearance but also to other sensory characteristics such as texture and flavour. So, it is necessary to determine the effect of fat reduction on consumer acceptability in order to elucidate the limit of fat reduction. Moreover, processing conditions should be extremely controlled to avoid the appearance of case hardening therefore; we proposed the use of a slow fermented process to obtain low fat fermented sausages with high organoleptic quality.

Therefore the aim of this study was to determine the limit of fat reduction based on consumer acceptability and taking into consideration the effect of the ripening process.

2. Materials and methods

2.1 Dry fermented sausages

Three batches of dry fermented sausages (20 kg meat batter for each batch) with different pork back fat contents (10 %, 20 % or 30 %) were manufactured; low fat (LF), medium fat (MF) and high fat (HF) respectively. The lean pork and the pork back fat were ground through a 10 mm diameter mincing plate and vacuum minced with the following additives (g/kg): sodium chloride (27), lactose (20), dextrin (20), sodium caseinate (20), glucose (7), sodium ascorbate (0.5), sodium nitrite (0.15) and potassium nitrate (0.15). Also, commercial starter culture (0.1) SP-318 was added (Danisco, Cultor, Madrid, España) containing *Lactobacillus sakei*, *Pediococcus pentosaceus*, *Staphylococcus xylosus*, and *S. carnosus*. The meat mixture was maintained at 3-5 °C for 24 h and then was stuffed into collagen casings (Fibran, S.A., Girona, España, 75-80 mm diameter) the final weight of each sausage being 700 g. Approximately 30 sausages were obtained in each batch. The sausages were dried during 42 d at 10 °C and 80-90 % relative humidity (RH). After 32 d of processing, the temperature was increased at 12 °C during 4 d and finally, dried during 17 d at 10°C and 75-85 % RH. The total drying time was 63 d (figure 1). Temperature and RH of the ripening chambers were continuously recorded. In order to control de ripening process, two sausages from each treatment were weighted almost each day to control weight losses that were expressed as a percentage of the initial weight. Also, two other sausages from each batch were used to control the pH by introducing a pH meter HI 99163 (Hanna Instruments Inc., Hoonsocket, USA) into the centre of the sausage as described by ISO 2917 (1999).

From each batch (LF, MF and HF), 200 g of the minced meat mixture were collected and at day 9, 18, 42 and 63, four sausages from each batch were randomly chosen in order to study the effect of two factors: ripening time and fat content. In each sample colour analyses were done and then, 150 g of the sample were minced and used for moisture, water activity and pH analyses. The remaining minced sample was vacuum packed and frozen at -20 °C for subsequent analyses (protein and lipid contents). All the results were expressed as the mean of

four replicates at each sampling time. Finally, at 42 and 63 days of the drying process four sausages from each batch were taken for sensory and texture analyses.

2.2 Chemical analyses (pH, water activity, moisture, protein, and total lipids)

The pH in the laboratory was measured as described by ISO 2917 (1999) by introducing a portable pH-meter (HI 99163, Hanna Instruments Inc., Hoonsocket, USA) into a mixture of sausage and water (1:1). Water activity was determined using a FASt-lab (Gbx, Romans sur Isère Cédex, France) water activity meter, previously calibrated with sodium chloride and potassium sulphate.

Moisture content was determined according to the official method for analysis of meat products BOE (1979) by dehydration at 100 °C until constant weight. Nitrogen content was determined by the Kjeldahl method and protein estimated by multiplying the nitrogen content by 6.25. Total lipids were extracted from 5 g of minced sausage according to the method of Folch, Lees and Sloane Stanley (1957), using dichloromethane:methanol (2:1) instead of chloroform:methanol (2:1) as solvent. The extracts were dried in a rotating vacuum evaporator and weighted to determine the total lipid content.

2.3. Colour measurement

Colour measurements were carried out using a CR-410 colorimeter (Minolta Chroma Meter Measuring Head, Osaka, Japan) with D65 illuminant. Each sausage was cut and the colour of the slices was measured three times for each analytical point. L*, a*, b* scale coordinates were obtained: L*(lightness), a* (redness) and b* (yellowness). Before each series of measurements, the instrument was calibrated using a white ceramic tile.

2.4. Texture profile analysis (TPA)

Instrumental texture was measured with a TA-XT.plus Texture Analyzer using the Texture Exponent software (version 2.0.7.0. Stable Microsystems, Godalming, UK). Dry fermented sausage slices (4 x 1.5 cm) and cubes (2 x 2 x 1.5 cm) were evaluated due to the possible effect of the external layers on texture parameters. The test speed was 1 mm s⁻¹ with a strain of 50 % of the original cube height for samples stored 42 days and a strain of 25% of the original cube height for samples stored 63 days and a 5 s interval between compression cycles. A trigger force of 5 g was selected. The compression was performed using a 75 mm diameter aluminium plate (P/75). The samples were compressed twice to give a TPA from which the three primary textural parameters (Pons and Fiszman, 1996) were obtained: hardness (the peak force during the first compression cycle), springiness (the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite) and cohesiveness (the ratio of the positive force area during the second compression portion to the positive force area during the first compression), as well as the secondary parameter chewiness (the product of hardness, cohesiveness and springiness). Twelve samples per batch (LF, MF, HF) and ripening time (42 and 63 d) were measured.

2.5. Sensory analysis

75 consumers, 45 female and 30 male, who consumed dry fermented sausages on a regular basis, were used for the study. Testing was carried out in a sensory laboratory equipped with individual booths (ISO 8589, 1988). The casing was removed and then, the sausages were cut in slices of approximately 4 mm thickness and finally served at room temperature on white plastic dishes. Water and unsalted toasts were provided to cleanse the palate between samples. Consumers tasted, in two different sessions, three samples (HF, MF and LF) at each ripening time (42 and 63 d) identified with random, three-digit codes, following a balanced complete block experimental design. For each sample, consumers scored

the overall acceptability as well as the acceptability of appearance, flavour, taste, hardness and juiciness using a 9-box scale labelled on the top with “dislike very much”, in the middle “neither like nor dislike” and on the bottom “like very much”. Data acquisition was performed using Compusense five release 5.0 software (Compusense Inc., Guelph, Ont., Canada).

2.6. Statistical analysis

Two-way analysis of variance (ANOVA) (ripening time, fat level and interaction ripening time x fat level) was performed on the instrumental and sensory parameters to evaluate differences among samples. The differences among batches in texture parameters were also analysed by two-way analysis of variance (ANOVA) (fat level and sausage shape). Besides, Internal Preference Mapping applied to the individual hedonic rates on all samples was performed (van Kleef, van Trijp, and Luning, 2006). For each product, the coordinates on the preference space determined by the first two components are kept. Then, consumers’ hedonic ratings are regressed onto these coordinates, and plot into the map. After performing the internal preference mapping technique, cluster analysis is carried out in order to classify consumers according to their preference patterns. Agglomerative Hierarchical Clustering (AHC) was performed using Euclidian distance, with Ward’s method as the aggregation criterion (XLStat 2006 Agglomerative hierarchical clustering). A dissimilarity plot was used to determine how many clusters were appropriate for each analysis. A dendrogram was then employed to determine the cluster structure of the data and support the decision that it was made using the dissimilarity plot. Statistical analysis of instrumental parameters was performed using the SPSS 12 package program and statistical analysis of sensory parameters was performed using the statistical software XLSTAT, 2009.4.03 (Addinsoft, Barcelona, Spain).

3. Results

3.1 Chemical analyses

The fat content of the slow fermented sausages was lower than the formulated as the batches contained 13.2, 16.5 and 19.3 % fat instead of the 10, 20 and 30 % formulated (table 1). The lower fat content was due to variation in the trimming of pork meat. However, the batches contained significant differences in fat contents that were useful for the study. The protein content was similar among batches although at 9, 18 and 42 d, the protein content was significantly lower in the HF sausages than in LF sausage. The reduction in moisture during ripening produced the increase in protein and fat contents as observed in table 1. At the end of the process the sausages reached a fat content of 22.0, 24.1 and 28.4 % fat in LF, MF and HF, respectively. The fat content of the sausages expressed in dry matter (dm) was 34.8, 39.1 and 43.1 % while the protein content in dm was 54.6, 49.5 and 43.8 % for LF, MF and HF, respectively.

Figure 1 shows the weight losses during the ripening process as well as the temperature and relative humidity applied in the ripening chamber. No significant differences were detected in weight losses among batches until 50 d of ripening meaning that the slow ripening conditions were properly controlled to minimize differences. Only at 63 d, the LF batch showed a higher significant loss than MF and HF batches. This fact did not produce differences in the external appearance of the sausages. Many of the studies done to reduce fat content in fermented sausages reported higher weight losses in sausages with lower fat contents (Bloukas, et al., 1997; Papadima and Bloukas, 1999; Muguerza et al., 2002; Liaros et al., 2009) probably due to the ripening conditions applied as all of them used higher temperatures (around 20°C) during the first ripening days producing fermented sausages in shorter ripening times of around 30 d.

The pH was measured directly in the sausages to control the fermentation (figure 2a) however, a highest standard deviation was observed than measuring the pH in the lab with an equal mixture of sausage and water (figure 2b). When the pH was measured in the lab, it was obtained a significant effect of ripening time, fat level and the interaction of fat level and ripening time ($p < 0.001$). The pH decreased from 5.9 to 4.6 in 18 d (figure 2b). A similar trend was reported for slow dry fermented sausages (Ordoñez, Hierro, Bruna & de la Hoz, 1999; Marco, Navarro & Flores, 2008; Olivares, Navarro & Flores, 2009). With respect to fat content, the decrease in fat produced a faster pH decline that was significantly different at 9 d of processing ($p < 0.001$) although in the further ripening times there were no differences among batches. This faster pH decrease in low fat sausages, was also detected by Soyer, Ertas & Uzümcüoglu (2003) although other authors have not reported an effect of fat on pH decline probably because it is highly dependent on the fermentation process (Bloukas et al., 1997; Muguerza et al., 2002; Salazar et al. 2009).

In addition, the moisture content of the sausages was different among batches (Table 1). As expected it was highest in LF sausages although at 42 and 63d there were not differences among batches. The LF batch showed a higher water content decline than the HF batch during the first 18 days. Water activity levels decreased from 0.96 to 0.87 during ripening in all batches (figure 2c) and they were not affected by fat content ($p > 0.05$) as also reported Mendoza et al. (2001) and García et al. (2002). The highest water activity of LF sausages could be related with the highest pH decline of this batch (figure 2b) as this difference was only detected at 9 d that it is when the highest significant differences ($p < 0.001$) in pH were also detected.

Fat level and ripening time affected the lightness (L^*) and redness (a^*) ($p < 0.001$) of the sausages, while the yellowness (b^*) was only affected by the ripening time ($p < 0.001$) (Figure 3). In relation to L^* values, a decrease was observed during ripening, since sausages

became darker due to weight loss. Moreover, higher fat content resulted in lighter ($p < 0.001$) sausages as previously observed Mugerza et al. (2002) and Soyer et al. (2003). With respect to a^* values, an increase in redness was observed at day 9 due to the formation of nitrosylmyoglobin, followed by a decrease during ripening ($p < 0.001$) (Figure 3). Moreover, HF sausages had the lowest redness ($p < 0.001$) as observed Soyer et al. (2003). Finally, a decrease in yellowness ($p < 0.001$) was detected in all batches as previously reported Mugerza et al. (2002).

3.2. Texture profile analysis (TPA)

TPA parameters of sausages analyzed at 42 and 63 d of ripening were summarized in tables 2 and 3, respectively. The sausages were analyzed in two shapes, slices and cubes, due to the possible effect of the external layers on texture parameters. Two factors were considered for statistical analysis, fat content and shape. No differences in hardness and springiness due to fat content were found at 42 d of ripening. However, the sausages with lower fat content showed a significant higher value of cohesiveness and chewiness but only when they were analyzed in slice shape. At 63 days of ripening, the sausages showed significant differences due to fat content in hardness and chewiness and again, these differences were only detected in the slices. The low fat samples showed the highest hardness and chewiness. The increase in hardness and chewiness have been reported by several authors in low fat dry fermented sausages (Salazar et al., 2009; García et al., 2002) while other authors only reported an increase in hardness (Mendoza et al., 2001; Liaros et al., 2009).

The sausage geometry also had a significant effect as both types of samples (slices and cubes) showed significant differences among them in hardness and chewiness at 42 d of ripening whereas at 63 d of ripening the differences were in hardness, chewiness and cohesiveness. At

both ripening times, the cubes were less hardness than the slice samples as expected because cubes were extracted from the inside of sausages where moisture content is highest.

In summary, the fat reduction in dry fermented sausages had a significant effect on the sausage texture however, sample preparation and ripening time significantly affected the observed differences. The differences were appreciated when the whole slice was analyzed rather than a portion of it. Moreover, the significant increase in hardness due to fat reduction was only detected at longer ripening times due to the loss of moisture content. In addition, the fat reduction was responsible for an increase in chewiness regardless of ripening time.

3.3. Sensory analysis

The effect of fat reduction and ripening time on the sensory acceptability of fermented sausages has not been elucidated. Therefore, the fermented sausages were analysed by consumers at two different ripening times (42 and 63 d). The slow fermented process prevented the appearance of external defects such as dry edges and shrunken diameter so, the external appearance of sausage batches was very similar (Figure 4). This is in accordance with weight losses because the LF batch did not show differences during the process until 50 d where the losses were around 2 % higher than MF and HF batches (figure 1).

The purpose of this study was to elucidate which instrumental measurements are related to the consumer acceptance. Therefore, the information obtained from the internal “map” of consumers and products was related to selected instrumental parameters (colour parameters, hardness and fat content).

An internal preference mapping of the sensory attribute “overall acceptability” was performed and the results were a sample map and a consumer map, corresponding to the scores and loadings of the Principal Components Analysis (PCA). Preference mapping examines individual consumers’ acceptability instead of average hedonic ratings and takes into account

heterogeneous acceptability degrees across consumers. Internal preference mapping informs about which products are preferred by consumers and allows to visually identify clusters of consumers with similar preference patterns (Guinard, Uotani and Schlich, 2001; Jaeger, Andani, Wakeling and MacFie, 1998). For the purpose of understanding consumer responses, the preferences were also analysed by cluster analysis using Euclidean distances. Internal preference mapping biplot representation of the consumers' acceptability, samples and instrumental parameters on the basis of the first two components was shown in figure 5. The PCA of the preference scores showed that about 59 % of the variation in the preferences was explained by the two first principal components. Preference component 1 was related to MF63, HF63, HF42, MF42 and LF42 batches and to instrumental parameter 'hardness' and colour (L^* , a^* and b^*). Preference component 2 was related to HF63, LF63 and MF42 samples and to 'fat content' and ' L^* ' colour parameter. Consumers were distributed into two clusters by the second component (figure 5). The largest group of consumers fell into the right quadrants with 50 consumers (cluster 1) and the other group was situated in the left quadrants with 25 consumers (cluster 2). Cluster 1 basically liked the MF63 sample which was related to hardness and fat content. Cluster 2 liked HF42 sample following by the MF42 sample. These samples were related to the fat content, colour properties and lower hardness. Few consumers preferred LF42 sample. In addition, samples with high and low fat content at 63 d of ripening time (HF63 and LF63) were not preferred by consumers.

Internal preference mapping of the other sensory attributes analyzed were similar to "overall acceptability" mapping although the number of consumers on each cluster varied from one attribute to another. 44 and 30 consumers for "appearance", 31 and 43 consumers for "flavour", 46 and 29 consumers for "taste", 38 and 37 consumers for "hardness" and 37 and 38 consumers for "juiciness".

As can be seen in figure 5, samples preference was different for each cluster. For this reason the mean value of the different sensory attributes (overall acceptability, appearance, flavour, taste, hardness and juiciness) scored by each consumer cluster was studied by one-way ANOVA (figure 6). Cluster 1 preferred samples with high and medium fat content and high ripening time as much overall acceptability as the other sensory attributes studied. However, cluster 2 preferred samples with low ripening time regardless of fat content except for “appearance” attribute, for which high ripening time samples were favoured (figure 6). These results summarized the conclusions obtained with internal preference mapping.

Previous sensory analyses performed on dry fermented sausages indicated that low fat fermented sausages had lower external and cross section appearance (Liaros et al., 2009), higher hardness, lower juiciness, lower colour and higher saltiness and taste (Mendoza et al., 2001), higher colour, lower odour and taste and lower appearance (Muguerza et al., 2002) and lower hardness and higher smoke odour (Bovolenta, Boscolo, Dovier, Morgante, Pallotti & Piasentier, 2008) than high fat fermented sausages. However, none of them were able to elucidate how these changes affect consumer’s acceptability in order to establish the minimum limit of fat reduction.

Conclusions

In summary, slow fermented process was able to produce low fat fermented sausages without negative effect on the external appearance, only a lower sausage lightness in the cross section was appreciated. Fat reduction in fermented sausages affected the texture by an increase in chewiness and at longer ripening times, an increase in hardness. Although the sensory acceptability of fermented sausages depended on the different preference patterns of consumers, it can be concluded that fermented sausages with low fat content (13 % in the raw

mixture, LF) were less appreciated by consumers. On the other hand, fat content of 16 % (MF) in the raw sausage mixture was the limit to produce fermented sausages with high consumer acceptability that it is half of the usual content present in fermented sausages.

Acknowledgements

Financial support from AGL 2009-08787 from Ministry of Science and Innovation (Spain) and FEDER funds are fully acknowledged. The predoctoral scholarship from GVA (Generalitat Valenciana, Spain) to A. Olivares is also acknowledged. The authors are grateful to M. P. Valero and A.R Hernández for technical assistance.

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Figure legends

Figure 1. Processing conditions (T^a and RH) applied in the manufacture of slow fermented sausages. Weight losses of the different batches; LF ($\square$), MF($\circ$) and HF(Δ).

Figure 2. Changes in pH (pH directly in the sausage (a) and pH in the lab (b)) and water activity values (c) during the ripening of dry sausages manufactured with different pork back fat contents; low fat (LF, □), medium fat (MF, ○) and high fat (HF, Δ). Symbols represent the mean and standard error of the mean.

Figure 3. Changes in L*, a* and b* values during the ripening of dry sausages manufactured with different pork back fat contents; low fat (LF, □), medium fat (MF, ○) and high fat (HF, Δ). Symbols represent the mean and standard error of the mean.

Figure 4. Effect of fat content and ripening time on external and cross section appearance of fermented sausages.

Figure 5. Internal preference mapping biplot representation of the consumers' acceptability (black circles: cluster 1; grey triangles: cluster 2), samples and instrumental parameters on the basis of the first two components.

Figure 6. Mean values of the different sensory attributes scored by each consumer cluster. Identical letters for each cluster indicate that there is not significant difference at $p>0.05$ (Tukey test).