Effect of the type of fat on the sensory attributes and instrumental texture parameters of reduced-fat non-acid fermented sausages

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Abstract— **The objective of this study was the assessment of the effect of three different types of fat on the sensory attributes and instrumental texture parameters of reduced-fat non-acid fermented sausages. Four different batches were prepared: control (ham lean with no added fat), 5% pork backfat, 5% sunflower oil and 5% diacylglycerols (DAGs). The sausages were dried for two months and stored in modified atmosphere for one month. A Texture Profile Analysis (TPA; 50% compression) and sensory evaluation (8 trained panellist; non-structured 10-point scoring scale) were carried out. Texture (both instrumental and sensory) was significantly affected by the type of fat. Control samples showed the highest instrumental and sensory hardness and chewiness whereas sunflower oil samples showed the lowest values. Control samples showed a less round shape than the ones with added fats. Sunflower oil and DAG sausages showed also lower saltiness. Additionally, sunflower oil sausages showed the highest flavour intensity, ease to peel and overall liking. In conclusion, the addition of 5% backfat, sunflower oil or DAGs improves the appearance, texture, flavour and overall liking of reduced-fat non-acid fermented sausages. Furthermore, sunflower oil is a promising ingredient to reduce the negative effects on the sensory properties caused by the fat reduction in such meat products.**

Keywords— **Sunflower oil, diacylglycerols (DAGs), fat-reduced sausages, texture.**

I. INTRODUCTION

The production of dry-fermented sausages is of great importance in many European countries. In Spain, one-fifth of the total meat products manufactured are dry-cured sausages [1]. Traditional dry-fermented sausages can be an important source of fat with content up to 50% [2]. Pork backfat used in fermented sausages is rich in saturated fatty acids (SFA's) and cholesterol. Many studies have demonstrated that a high intake of SFA's and cholesterol is linked to the development of obesity, diabetes, coronary heart disease, liver dysfunction and atherosclerotic vascular disease [3-4]. In consequence, sanitary authorities recommend lowering the intake of SFAs and cholesterol and a higher intake of monounsaturated and polyunsaturated fatty acids (MUFA's and PUFA's respectively) [5]. Thus, the reduction of saturated animal fats and its substitution by other fats with healthier fatty acid profiles are two of the main goals pursued by the meat industry. Some vegetable oils are rich in MUFA's and PUFA's and have been used as animal fat replacers in many studies: olive oil in *salami* [6-7] and *chorizo de Pamplona* (a traditional type of Spanish dry-fermented sausage) [8], soy oil in *chorizo de Pamplona* [9], linseed oil in *cervelat* (Dutch style fermented sausages) [10] and *chorizo de Pamplona* [11-12] and palm and cotton seed oils in semi-cured sausages [13].

Pork fat is naturally structured as triacylglycerols (TAGs). By treatment with enzymes (lipase-catalysed glycerolysis) TAGs can be converted to diacylglycerols (DAGs) leading to changes in the physical and chemical properties of the fat. DAGs have beneficial effects on the texture and improve the water and fat retention [14]. In addition, DAGs have been reported to result in a lower fat accumulation in the human body compared to TAGs [15-18].

Sunflower oil has been used as fat replacer in frankfurters [19-20] but, as far as we are concerned, no studies about fat-reduced dry-fermented sausages with sunflower oil or DAGs have been published.

The purpose of the present study was to evaluate the effect of pork backfat, sunflower oil and DAGs on the instrumental texture parameters and sensory characteristics of non-acid fermented sausages. In addition, a reformulation of traditional high-fat meat products is carried out both quantitatively (reduction of pork backfat) and qualitatively (replacement of saturated animal fat by other fats with healthier lipid profiles).

II. MATERIALS AND METHODS

A. Sausages preparation and drying

Four batches of fat-reduced non-acid fermented sausages of 12 kg each were prepared: control (100% pork ham lean), backfat (95% pork ham lean : 5% pork backfat), sunflower oil (95% pork ham lean : 5% sunflower oil) and DAGs (95% pork ham lean : 5% DAGs). The ham lean was trimmed of fat and minced at Ø 8 mm. The back fat and oils were mixed in a grinder (Dito-Sama K55, Dito-Sama S.A., Aubusson, France) with 1 kg of meat until forming a paste that was added to the rest of the meat. The mixture of ham lean and fat was minced at Ø 3 mm. The following ingredients per kilogram of meat were added to the formulation: NaCl 20 g, black pepper 1.50 g, lactose 20 g, potassium lactate (78% purity) 20 g, sodium ascorbate 0.5 g, sodium nitrite 0.15 g and potassium nitrate 0.15 g. The sausages were stuffed into Ø 50 mm Fibran casings, immersed in a water and mould (*Penicillium candidum*) bath and hung to dry for two months with increasing temperature from 3 to 18° C and decreasing 95 to 70% relative humidity.

The parameter used to establish the drying level was the water content on a defatted-dry-matter basis (X_{DFDM}) expressed in kg H_2O/kg DFDM. The sausages were periodically weighted until reaching the optimal drying level. The drying level was established by comparison with control samples which were cut and sensorially evaluated. The samples were packaged in polyamide-polyethylene bags (Sacoliva, Sabadell, Spain) with modified atmosphere (80% N_2 : 20% CO_2) and stored at 3° C for one month. Two replicates of the experiment were carried out.

B. Texture Profile Analysis

Five sausages per batch were analysed. Three specimens of height 15 mm were cut from each sausage. The specimens were wrapped in film to avoid drying and stored at 15° C for 24 h. A modified Texture Profile Analysis (TPA) test [21] was performed to evaluate the sausages using a RT/5 Universal MTS Alliance texture analyser (SEM, Barcelona, Spain). The samples were compressed twice to 50% of their original height using a crosshead speed of 1 mm/s. The following parameters were determined: hardness (N/cm^2), maximum force required to compress the sample (H); chewiness (N/cm^2), work to masticate the sample to swallowing ($S \times H \times$ Cohesiveness).

Photographs of the specimens were taken and used to calculate their areas with the Image Pro Plus 6.3 program. TPA values for hardness and chewiness were corrected by area and expressed as N/cm^2.

C. Sensory Analysis

The generation and selection of the descriptors was carried out by open discussion in one session. The four products were evaluated for appearance (round shape), flavour (general intensity, saltiness), tactile texture (ease to peel) and texture in mouth (hardness, springiness, crumbliness, chewiness). The overall liking of the products was also evaluated. A non-structured 10-point scoring scale [22] was used, where 0 means absence or very low intensity of the descriptor and 10 means very high intensity of the descriptor. Eight trained panellists performed the sensory analysis on 5 mm thick slices. Evaluation was carried out in eight sessions (four sessions per replicate of the experiment). One sausage per batch was tested in each session.

D. Data analysis

Statistical analysis was carried out with the SAS statistical package [23]. A General Linear Model (GLM) was used to analyse the effect of the fat type on the instrumental texture and sensory parameters. The model for instrumental texture analysis included fat type, replica and their interactions as fixed effects. The ANOVA test for sensory analysis data was performed on the mean score (8 panellists) for each sausage. The model included fat type, replica and session as fixed effects. The interactions not statistically significant were dropped from the model. Differences among means were tested with the Tukey test ($P < 0.05$).

III. RESULTS AND DISCUSSION

The obtained final products could be considered as reduced fat sausages because their fat content was more than a 30% lower than the commercial products of this type commonly with fat contents over 25%.

Table 1 shows the results obtained for instrumental hardness and chewiness according to the type of added fat. As it was expected, controls showed the highest hardness (208.90 N/cm^2) whereas sunflower oil sausages gave the lowest value (113.45 N/cm^2). The higher hardness of the control could be related to their higher weight loss (60% vs. 57% of the batches with added fat) (Fig. 1). This positive correlation between hardness and weight loss was also reported by Muguerza et al. [24]. Control also showed the highest chewiness (11.82 N/cm^2) while sunflower oil and DAG sausages gave the lowest values (7.73 and 8.51 N/cm^2 respectively) with no significant differences between them. Thus, sunflower oil and DAG showed a softer texture than backfat sausages. The results are in agreement with the studies of Muguerza et al. [8-9] where the replacement of pork backfat by olive and soy oils in dry-fermented sausages resulted on a softer texture.

Table 1: Texture Profile Analysis parameters (least-squares means) of reduced-fat non-acid fermented sausages according to the type of added fat

Parameters (N/cm^2)	Control	Backfat	Sunfl.	DAG	RMSE[A]
Hardness	208.90^a	158.93^b	113.45^d	139.59^c	10.213
Chewiness	11.82^a	9.89^b	7.73^c	8.51^c	0.772

[a,b,c,d] Within a row, least-squares means with different superscripts differ (*P* < 0.05).
[A] Root mean square error.

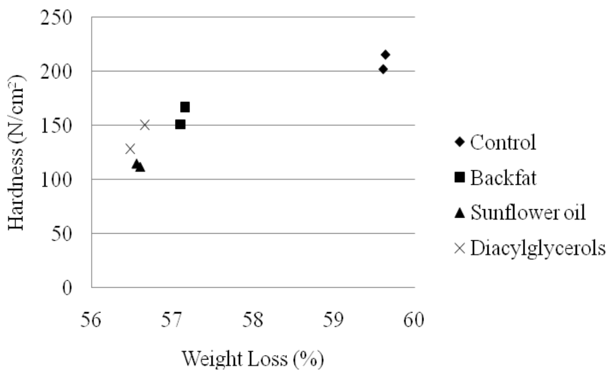

Fig.1. Instrumental TPA hardness vs. weight loss of non-acid dry-fermented sausages according to the type of added fat (means of each replicate of the experiment)

Sensory attributes were significantly affected by the type of added fat as it is shown in Table 2. DAG sausages showed a rounder shape than the rest whereas control sausages gave the lowest score for this parameter. The lower values observed in control sausages could be related to their higher drying level (40% of their initial weight with regard to 43% of the other batches) and their lower fat content. DAG and sunflower oil sausages showed higher flavour intensity than backfat sausages. These two types of sausage were also rated as less salty than the rest. These results should be taken into account in the near future as products with healthier fat profiles could be perceived by the consumers as more desirable than the traditional ones. With respect to the texture in mouth, control sausages showed the highest hardness and chewiness while sunflower oil sausages showed the lowest values for these two parameters. The results agree with those obtained by Bloukas et al. [25] where dry-fermented sausages with olive oil incorporated as liquid (replacement of 10 and 20% of the total fat content) showed a softer texture than the controls with 33% pork backfat. Therefore, the addition of sunflower oil could improve the texture of dry-fermented sausages as they could be rated as softer. Sunflower oil sausages were easier to peel than the rest. Control sausages showed the lowest score for this attribute as it was expected due to their lower fat content and the consequent higher adherence of the casing. Finally, sunflower oil sausages obtained the highest overall liking (7.0) followed by the backfat (6.3), DAG (5.9) and control sausages (4.4) respectively. The control received a score considered as unacceptable compared to the sausages with added fat. Thus, fat improves the texture of dry-fermented sausages as it is well known, but an added fat content of 5% could result on products with a positive acceptance despite the low fat level.

Table 2: Sensory attributes (least-squares means) of reduced-fat non-acid fermented sausages according to the type of added fat

Attributes[A]	Control	Backfat	Sunfl.	DAG	RMSE[B]
Round shape	4.4^c	5.8^b	6.1^b	7.0^a	0.642
Ease to peel	5.4^c	6.9^b	9.2^a	6.6^b	0.268
Flav. intensity	6.3^a	5.5^b	5.9^b	5.4^b	0.336
Saltiness	3.6^a	3.6^a	3.3^b	3.3^b	0.262
Hardness	8.5^a	6.1^c	5.0^d	6.5^b	0.247
Springiness	3.7^a	2.6^b	2.1^c	3.0^b	0.311
Chewiness	7.9^a	5.6^b	4.6^c	6.0^b	0.272
Overall liking	4.4^d	6.3^b	7.0^a	5.9^c	0.249

[a,b,c,d] Within a row, least-squares means with different superscripts differ (*P* < 0.05).
[A] Linear non-structured scale (0-10).
[B] Root mean square error.

IV. CONCLUSION

The addition of 5% backfat, sunflower oil or DAGs improves the appearance, texture, flavour and overall liking of reduced-fat non-acid fermented sausages. Sunflower oil is a promising ingredient to reduce the negative effect on the sensory properties caused by the fat reduction (i.e. high hardness, chewiness and low crumbliness) in reduced-fat non-acid fermented sausages.

ACKNOWLEDGMENT

The authors gratefully acknowledge from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project Q-PORKCHAINS FOOD-CT-2007-036245. The authors would also like to acknowledge the contribution of Jordi Garcia and Marta Baret in the preparation and processing of the samples.

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