



Physicochemical properties, fatty acid profile and sensory characteristics of sheep and goat meat sausages manufactured with different pork fat levels



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ABSTRACT

The effect of three pork backfat levels (0% vs. 10% vs. 30%) on chemical composition, fatty acid profile and sensory properties on sheep and goat meat sausages was studied. All physicochemical parameters were affected by the addition of pork backfat in both types of sausages. Sausages manufactured with 30% of pork backfat showed the lowest moisture and protein contents and the highest total fat content. The lower a_w values in sausages manufactured with higher fat content while in pH happened the reverse situation. The addition of pork backfat modified the total fatty acid profile, prompting a significant drop in the relative percentages of C14:0, C16:0, C17:0, C17:1, C18:0 and TVA (trans-vaccenic acid), together with a marked increase in oleic and linoleic acids. Finally, in goat sausages, the fat content significantly affected sensory parameters: taste, texture and overall acceptability ($P < 0.05$). As expected, all physicochemical parameters were affected by the addition of pork backfat in both types of sausages.

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1. Introduction

In Portugal, sheep and goats are extensively managed and raised for milk and meat (Teixeira, 1995). Lambs and kids produced in Mediterranean countries of the European Union are traditionally commercialized as quality brands with protected designation of origin (PDO) and protected geographical indications (PGI) (Teixeira, Delfa, & Alberti, 1998). However, there are animals that come out of these quality brands, particularly the culled ones or those with weight or age that cannot be considered as a PDO or PGI labels.

These animals have very low consumer acceptability and consequently a low commercial value and a strategy to give value to those animals would be welcome by producers as well as butchers, meat industry or supermarkets. Value may be added to final products by decreasing costs or improving relative value of the final product (McMillin & Brock, 2005). With this goal, there are several recently studies in goat and sheep meat processed products: Cosenza, Williams, Johnson, Sims, and McGowan (2003) evaluated the quality and consumer acceptability of cabrito smoked sausage, using goat meat as the sole meat ingredient;

Polpara, Sornprasitt, and Wattanachant (2008) studied the quality characteristics of raw and canned goat meat in water, brine, oil and Thai curry during storage; Das, Anjaneyulu, Thomas, and Kondiah (2009) studied the effect of different fats on the quality of goat meat patties; Teixeira, Pereira, and Rodrigues (2011) studied the effect of salting, air-drying and ageing processes in a new goat meat product “manta” and Oliveira et al. (2014) evaluated the quality of ewe and goat meat cured product mantas.

The Portuguese traditional sausages are unique products that have usually originated in geographical areas that are, in general, associated with its trade name and have a strong connection to this region and they quality is clearly influenced by breed of animals, reared system, climate and manufacturing technology. A project between a research center (Carcass and Meat Quality and Technology Laboratory of Agrarian School of Bragança), two breeder associations (ANCRAS—Serrana Goat National Association of Breed Producers and ACOB—Bragança Sheep National Association of Breed Producers) and a meat manufacturing industry (Bísaro Salsicharia Tradicional) was developed to add value to these animals, creating two new products, a raw fresh meat sausage from Churra Galega Transmontana ewes and Serrana goats. Thus, the aim of this study was to characterize the physicochemical composition of these sausages and to study the effect of the addition of different pork backfat levels from a local breed Bísaro on chemical composition,

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fatty acid profile and sensory properties of sheep and goat sausages. These sausages from meat of culled sheep and goats allow to valorize animals whose marketing value is very low by producing a product that in a future could be commercialized and consumed in halal and kosher markets.

2. Materials and methods

2.1. Sausages manufacturing and sampling

Two types of fresh sausages were manufactured, mincing and mixing sheep and goat meats with two levels of Bísaro pork backfat fat (10% and 30%) salt (2.4%), peppers (0.3%), sugar (0.1%), water and rendimix®. A control batch without pork fat was also manufactured. Meats used for manufacturing include sheep and goat trimmings from local breeds: Churra Galega Bragançana ewes and Serrana goats aged between 5 and 7 years old, with an average 20 kg carcass weight. Pork meat was also from females weighing between 100 and 120 kg body weight of a local breed, Bísaro. Animals were slaughtered in the official slaughterhouse of Bragança (Trás-os-Montes region—northeast Portugal). Pigs were slaughtered on arrival to reduce the stress once time and distances travelled were relatively short (5 km). Animals were washed and electrically stunned in an appropriate stunning box prior to bleeding. No electrical stimulation of carcasses method was used. Carcasses of pigs were scalding in water at 60 °C. After weighing, carcasses were cooled at 4 °C for 12 and 24 h for pigs and sheep or goats, respectively. Carcasses were previously deboned and cleaned from nerves, tendons and connective tissues before raw meat was processed at the manufacturing meat industry. The mixing was then stuffed into 34–36 mm pork casings, hung and stabilized in a climate chamber at 13 °C and 80% with a relative humidity, packaged in polyamidopolyethylene bags and stored in a refrigerator at 4 °C until laboratory analysis.

For each type of sausages (sheep and goat) and the three treatments (0%, 10% and 30% pork fat), 22 samples were randomly selected from each lot of sausages, for a total of 132 sausages. Samples were divided into the following groups: S0, S10 and S30 for sheep sausages without pork fat and with 10% and 30% of pork fat, respectively; and G0, G10 and G30 for goat sausages without pork fat and with 10% and 30% of pork fat, respectively. Each group studied corresponds to an individual lot, produced in an independent day (six lots in total, six manufacturing days). Three replicates of each sample were analyzed.

2.2. Physicochemical analysis and chemical composition

The measurement of pH was performed according to the Portuguese standard NP 3441 (2008), using a portable potentiometer equipped with a specific electrode penetrator, and calibrated with standard buffers with the following pH 4, 01–7, 02. Water activity was determined using a water activity probe (HygroPalmAw1 rotronic 8303, Bassersdorf, Switzerland) according to (AOAC, 1990). The determination of moisture was performed according to the Portuguese standard NP 1614 (2009). Three to 5 g of sample was added to 5 mL of ethanol. After that, samples were dried in a drying oven (Raypa DO-150, Barcelona, Spain) during 24 h at 103 °C ± 2 °C. Protein determination was carried out following the Portuguese standard NP 1612 (2002) using (Kjeldahl Sampler System K370 and Digest System K-437, Flawil, Switzerland). One and a half to 3 g of sample was put in mineralization tubes with two catalyst tablets and 25 mL of sulfuric acid (97%). After mineralization completion, the distillation procedure was carried out. Finally, the distillate was titrated with hydrochloric acid solution and the required volume record. For total fat content determination, samples were subjected to a liquid-solid extraction using petroleum ether in an extractor apparatus (AnkomHCl Hydrolysis System, Macedon NY, USA) at 90 °C for 60 min. The total fat content was obtained based on gravimetric difference. Ashes were assessed according to the

Portuguese standard NP 1615 (2002). To 3–5 g of sample, we added 1 mL of magnesium acetate in crucibles. After that, the samples were subject to 550 °C ± 25 °C during 5–6 h in muffle furnace (Vulcan BOX Furnace Model 3-550, Yucaipa, USA).

2.3. Fatty acid composition

Total lipids were extracted from 25 g of ground meat sample, according to the Folch, Lees, and Stanley (1957) procedure. Fifty milligrams of fat was used to determine fatty acid profile. Fatty acids were transesterified following the method described by Shehata, de Man, and Alexander (1970) with some modifications; 4 mL of a sodium methoxide (2) solution were added to the fraction, vortexed every 5 min during 20 min at room temperature, then 4 mL of a H₂SO₄ solution (in methanol at 50%), vortexed a few seconds and vortexed again before adding 2 mL of distilled water. Organic phase (containing fatty acids methyl esters) was extracted with 2.5 mL of hexane. Separation and quantification of the FAMES was carried out using a gas chromatograph (GC-Agilent 6890 N; Agilent Technologies Spain, S.L., Madrid, Spain) equipped with a flame ionization detector and an automatic sample injector HP 7683, and using a Supelco SPTM-2560 fused silica capillary column (100 m, 0.25 mm i.d., 0.2 µm film thickness). The chromatographic conditions were as follows: initial column temperature 120 °C, maintaining this temperature for 5 min, programmed to increase at a rate of 5 °C · min⁻¹ up to 200 °C, maintaining this temperature for 2 min, then at 1 °C · min⁻¹ up to 230 °C, maintaining this temperature for 3 min. The injector and detector were maintained at 260 and 280 °C, respectively. Helium was used as the carrier gas at a constant flow-rate of 1.1 mL · min⁻¹, with the column head pressure set at 35.56 psi. The split ratio was 1:50 and 1 µL of solution was injected. Nonadecanoic acid (C19:0) at 0.3 mg · mL⁻¹ was used as internal standard and added to the samples prior methylation. Individual FAMES were identified by comparing their retention times with those of authenticated standards (Supelco 37 component FAME Mix). Data regarding FAME composition were expressed in percentage according to the weight of the total identified FAMES.

2.4. Consumers sensory evaluation

Sensory evaluation of goats and sheep's fresh sausages was performed by a consumers' panel, in accordance with the Portuguese Norm (NP8586-1, 2001). The consumers' panel was constituted by 26 elements from the staff of the Polytechnic Institute of Bragança (aged between 19 and 64 years old) without previous training during two sessions evaluating the following sensory attributes: taste, texture, spiciness and overall acceptability. An unstructured 10 cm scale with anchors at the extremities (from 0 cm—"do not like" to 10 cm—"like very much") was used. Sausages samples were cooked in the grill until the internal temperature reached about 75 °C. Afterwards, sausages were divided into pieces 0.5 cm thick, labeled with random codes and stored at 60–70 °C. During the testing, we provided unsalted crackers and water in order to clean the mouth for each sample.

2.5. Statistical analysis

Data were analysed using the mixed model (Henderson, 1973):

$$y = X\beta + Z\gamma + \varepsilon$$

γ is an unknown vector of random-effects parameters with known design matrix Z , and ε is an unknown random error vector whose elements are no longer required to be independent and homogeneous.

Statistical analysis was performed using the statistical package JMP Pro 11.1.1 by Copyright © 2013 SAS Institute, Inc. Main effects (specie, fat level) and interaction were tested in mixed models as fixed effects (PROC MIXED, SAS) of treatment and the random effects of repeated

measurements of individual sausage and three replications. General mixed models (PROC GLIMMIX, SAS) with identical fixed and random effects were used to find the probability of the differences as a result of treatments (specie and fat level). The predicted means obtained were ranked based on pair-wise least significance differences and compared using the *t* student test and the significant levels of 0.05, 0.01 and 0.001.

For sensorial analysis, a similar model was used with specie, fat level and their interaction as fixed effects. The random effect was excluded and a repeated covariance structure was fitted with session as repetition and sample as subject using the Restricted Maximum Likelihood (REML) Method.

To know which group of variables within the fatty acid profile would be more useful to classify and distinguish the six groups of sausages; a discriminant analysis was performed using the linear, common covariance and the stepwise variable selection methods (PROC DISCRIM, SAS). The efficiency of the discriminant power of the models selected was assessed by the test of the Wilks' lambda value. Results were analysed in terms of the absolute assignment of individuals to the pre-assigned group and the variance explained by each canonical resemblance as well as by the analysis of the scoring coefficients.

3. Results and discussions

3.1. Physicochemical analysis and chemical composition

Table 1 shows the effect of added pork backfat on the pH, a_w and chemical composition of sheep and goat sausages. Regarding a_w , significant ($P < 0.001$) differences were observed among batches. The G30% showed the lowest values (0.92 ± 0.002) compared to control sausages (0.97 ± 0.002), while G10% presented intermediate values (0.95 ± 0.002) in agreement with Gómez and Lorenzo (2013) who observed lower a_w values in sausages manufactured with higher fat content. However, sheep sausages displayed a different behavior, since the S10% showed the lowest values (0.92). In addition, Lorenzo and Franco (2012) and Olivares, Navarro, Salvador, and Flores (2010) did not observe significant ($P > 0.05$) differences in a_w values among sausages manufactured with fat content.

On the other hand, the pH values were affected ($P < 0.001$) by fat content. In our study, both sausages presented higher pH values in samples manufactured with 30% of pork backfat compared to control ones. This result is in agreement with those reported by Lorenzo and Franco (2012) and Olivares et al. (2010) who observed lower pH values in low fat sausages compared to high fat sausages. However, other authors (Liaros, Katsanidis, & Bloukas, 2009; Salazar, García, & Selgas, 2009) did not observe an effect of fat content on pH values. According to pH and

a_w values, meat products can be classified as “easily perishable,” “perishable” and “stable” (Ambrosiadis, Soultos, Abraham, & Bloukas, 2004). The sausages manufactured with sheep and goat meat can be classified in the group of fresh product, high water activity (>0.90), whose conservation is very important to reduce or prevent any kind of alteration/degradation and should be consumed over a period of time indicated for consuming fresh product, usually 72 h.

As expected, both control sausages had higher moisture content than the manufactured with 10 and 30% of pork backfat (Table 1). Similar results were previously reported by other authors (Gómez & Lorenzo, 2013; Lorenzo & Franco, 2012; Lorenzo, Purriños, Bermúdez, Temperan, & Franco, 2011; Olivares et al., 2010) who found higher water levels in low fat sausages. The fat content showed significant differences ($P < 0.001$) among batches. This is an expected result because the batches were manufactured with different fat content. The fat content of the goat and sheep sausages was lower than formulated as the batches contained 11.9% and 21.8% and 20.1% and 23.5% fat for goat and sheep sausages, respectively, instead of the 10 and 30% formulated. Protein content also showed significant differences ($P < 0.001$) among batches, presenting mean values of 18.9%, 16.8% and 14.3% for goat sausages manufactured with 0%, 10% and 30% of pork backfat, respectively, and mean values of 18.2%, 15.5% and 14.1% for sheep sausages manufactured with 0%, 10% and 30% of pork backfat, respectively. This outcome is in agreement with those reported by Gómez and Lorenzo (2013) who noticed lower protein content in sausages manufactured with high fat content. Statistical analysis also showed that ash content decreased significantly ($P < 0.001$) with the increase of fat content in both type of sausages (Table 1) as was observed by Turner, Cassida, and Zerby (2014), who found values between 4.2% and 4.3% in goat meat.

3.2. Fatty acid composition

Table 2 shows the effect of added pork backfat on the fatty acid profile of sheep and goat sausages. The relative percentages of most fatty acids differed significantly as a function of the percentage added pork backfat. Significant ($P < 0.001$) differences were found between goat and sheep sausages regarding saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA). The total amount of SFA in the goat and sheep sausages made with added pork backfat decreased by approximately 6–9% and 2.5–6.5%, respectively compared to the controls.

G0 (control) had the highest levels of C14:0, C14:1, C16:0, C16:1, C17:0, C17:1, C18:0 and TVA, and the lowest level of C18:1n9, C18:1n7, C18:2n6, C18:3n3, C20:0 and C20:1n9. On the other hand, S0 had the highest amounts of C14:0, C14:1, C16:1, C17:0, C17:1, C18:0

Table 1
Predicted values (mean \pm standard error) for physicochemical composition.

	Goat meat sausages			Sheep meat sausages			P-values		
	G0%	G10%	G30%	S0%	S10%	S30%	Species	Fat Level	Sp x FL
a_w	0.97 ± 0.002^A	0.95 ± 0.002^B	0.92 ± 0.002^D	0.94 ± 0.002^C	0.92 ± 0.002^E	0.94 ± 0.002^C	***	***	***
pH	5.94 ± 0.011^{DC}	6.10 ± 0.011^E	6.16 ± 0.011^A	5.93 ± 0.011^{DC}	5.93 ± 0.011^C	6.13 ± 0.011^{BE}	***	***	***
Ash (%)	4.30 ± 0.03^A	4.08 ± 0.03^B	3.75 ± 0.03^C	4.29 ± 0.03^A	4.05 ± 0.03^B	3.70 ± 0.03^C	ns*	***	ns**
Moisture (%)	69.53 ± 0.18^A	66.74 ± 0.18^B	59.46 ± 0.18^C	67.27 ± 0.18^D	60.52 ± 0.18^E	57.86 ± 0.18^F	***	***	***
Protein (%)	18.92 ± 0.08^A	16.78 ± 0.08^C	14.29 ± 0.08^E	18.16 ± 0.08^B	15.48 ± 0.08^D	14.13 ± 0.08^E	***	***	***
Total fat (%)	5.33 ± 0.40^A	11.89 ± 0.40^B	21.81 ± 0.40^C	8.70 ± 0.40^D	20.11 ± 0.40^E	23.50 ± 0.39^F	***	***	***

ns—not significant.

S0 sheep sausages without pork fat.

S10 sheep sausages with 10% of pork fat.

S30 sheep sausages with 30% of pork fat.

G0 goat sausages without pork fat.

G10 goat sausages with 10% of pork fat.

G30 goat sausages with 30% of pork fat.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

Table 2Predicted values (mean \pm standard error) for fatty acids profile.

Fatty acid	Goat meat sausages			Sheep meat sausages			P-values		
	G0%	G10%	G30%	S0%	S10%	S30%	Species	Fat Level	Sp x FL
C12:0	0.14 \pm 0.02 ^A	0.13 \pm 0.02 ^A	0.13 \pm 0.02 ^A	0.10 \pm 0.02 ^A	0.11 \pm 0.02 ^A	0.12 \pm 0.02 ^A	ns	ns	ns
C14:0	2.56 \pm 0.03 ^A	1.94 \pm 0.03 ^D	1.68 \pm 0.03 ^F	2.38 \pm 0.03 ^B	2.07 \pm 0.03 ^C	1.85 \pm 0.03 ^E	ns	*	***
C14:1	0.42 \pm 0.03 ^A	0.12 \pm 0.03 ^B	0.07 \pm 0.03 ^{DB}	0.17 \pm 0.03 ^C	0.09 \pm 0.03 ^{DB}	0.06 \pm 0.03 ^{DB}	***	***	***
C16:0	24.21 \pm 0.15 ^A	23.15 \pm 0.15 ^B	22.42 \pm 0.15 ^C	22.70 \pm 0.15 ^{BC}	22.95 \pm 0.15 ^B	22.75 \pm 0.15 ^{BC}	***	***	***
C16:1	2.57 \pm 0.11 ^A	2.20 \pm 0.11 ^B	2.07 \pm 0.11 ^B	2.31 \pm 0.11 ^B	2.14 \pm 0.11 ^B	2.03 \pm 0.11 ^B	*	***	**
C17:0	1.21 \pm 0.01 ^B	0.67 \pm 0.01 ^D	0.48 \pm 0.01 ^F	1.34 \pm 0.01 ^A	1.00 \pm 0.01 ^C	0.61 \pm 0.01 ^E	***	***	***
C17:1	0.99 \pm 0.02 ^A	0.46 \pm 0.02 ^C	0.34 \pm 0.02 ^D	0.73 \pm 0.02 ^B	0.51 \pm 0.02 ^C	0.36 \pm 0.02 ^D	***	***	***
C18:0	18.97 \pm 0.21 ^A	15.43 \pm 0.21 ^C	12.96 \pm 0.21 ^D	18.50 \pm 0.21 ^A	16.51 \pm 0.21 ^B	13.51 \pm 0.21 ^D	ns**	***	***
C18:1n9t	0.61 \pm 0.14 ^A	0.73 \pm 0.14 ^A	0.37 \pm 0.14 ^A	0.55 \pm 0.14 ^A	0.55 \pm 0.14 ^A	0.40 \pm 0.14 ^A	ns	*	ns
C18:1n9c	38.91 \pm 0.29 ^A	41.36 \pm 0.29 ^{BC}	42.48 \pm 0.29 ^D	40.93 \pm 0.29 ^B	41.28 \pm 0.29 ^B	42.00 \pm 0.29 ^C	***	***	***
C18:1n11t	1.40 \pm 0.18 ^B	0.49 \pm 0.18 ^C	0.58 \pm 0.18 ^{DC}	2.26 \pm 0.18 ^A	1.64 \pm 0.18 ^B	0.84 \pm 0.18 ^C	***	***	***
C18:1n7c	0.95 \pm 0.16 ^{CD}	1.52 \pm 0.16 ^B	2.38 \pm 0.16 ^A	1.14 \pm 0.16 ^{BC}	1.66 \pm 0.16 ^B	2.25 \pm 0.16 ^A	ns	ns	***
C18:2n6c	3.74 \pm 0.46 ^D	8.22 \pm 0.47 ^B	10.60 \pm 0.46 ^A	3.91 \pm 0.46 ^D	6.62 \pm 0.46 ^C	9.95 \pm 0.47 ^A	ns	***	***
C18:3n3c	0.52 \pm 0.02 ^E	0.61 \pm 0.02 ^D	0.68 \pm 0.02 ^C	0.76 \pm 0.02 ^A	0.75 \pm 0.02 ^A	0.75 \pm 0.02 ^A	***	***	***
C20:0	0.09 \pm 0.01 ^E	0.22 \pm 0.01 ^B	0.25 \pm 0.01 ^{AB}	0.14 \pm 0.01 ^D	0.18 \pm 0.01 ^C	0.23 \pm 0.01 ^{AB}	ns	***	***
C20:1n9	0.12 \pm 0.02 ^E	0.74 \pm 0.02 ^C	0.99 \pm 0.02 ^A	0.14 \pm 0.02 ^E	0.55 \pm 0.02 ^D	0.90 \pm 0.02 ^B	***	***	***
SFA	47.79 \pm 0.32 ^F	41.86 \pm 0.33 ^C	38.12 \pm 0.32 ^A	45.82 \pm 0.32 ^E	43.30 \pm 0.32 ^D	39.36 \pm 0.33 ^B	***	***	***
MUFA	46.01 \pm 0.34 ^C	47.69 \pm 0.34 ^B	49.29 \pm 0.34 ^A	48.23 \pm 0.34 ^B	48.48 \pm 0.34 ^{AB}	48.84 \pm 0.34 ^{AB}	***	***	***
PUFA	6.20 \pm 0.47 ^B	10.45 \pm 0.47 ^C	12.59 \pm 0.47 ^A	5.94 \pm 0.47 ^B	8.22 \pm 0.47 ^D	11.80 \pm 0.47 ^A	*	***	***
MUFA + PUFA	52.21 \pm 0.32 ^F	58.14 \pm 0.33 ^C	61.88 \pm 0.32 ^A	54.18 \pm 0.32 ^E	56.70 \pm 0.32 ^D	60.65 \pm 0.33 ^B	ns	*	***
PUFA/SFA	0.13 \pm 0.01 ^D	0.25 \pm 0.01 ^B	0.33 \pm 0.01 ^A	0.13 \pm 0.01 ^D	0.19 \pm 0.01 ^C	0.30 \pm 0.01 ^A	ns	*	***
PUFA-n3	1.08 \pm 0.08 ^B	1.35 \pm 0.08 ^A	0.97 \pm 0.08 ^{BC}	1.11 \pm 0.08 ^B	1.07 \pm 0.08 ^C	0.98 \pm 0.08 ^B	***	***	***
PUFA-n6	5.12 \pm 0.12 ^E	9.47 \pm 0.12 ^C	11.62 \pm 0.12 ^A	4.83 \pm 0.12 ^E	7.47 \pm 0.12 ^D	10.82 \pm 0.12 ^B	***	***	***
PUFA-n6/n3	4.78 \pm 0.42 ^C	7.43 \pm 0.42 ^B	11.97 \pm 0.42 ^A	4.38 \pm 0.42 ^C	7.08 \pm 0.42 ^B	11.08 \pm 0.42 ^A	ns	***	***

ns—not significant.

SFA, saturated fatty acids.

MUFA, monounsaturated fatty acids.

PUFA, polyunsaturated fatty acids.

S0 sheep sausages without pork fat.

S10 sheep sausages with 10% of pork fat.

S30 sheep sausages with 30% of pork fat.

G0 goat sausages without pork fat.

G10 goat sausages with 10% of pork fat.

G30 goat sausages with 30% of pork fat.

* $P < 0.05$.** $P < 0.01$.*** $P < 0.001$.

and TVA, and the lowest level of C18:1n9, C18:1n7, C18:2n6, C20:0 and C20:1n9. The addition of pork backfat modified the total fatty acid profile, prompting a significant drop in the relative percentages of C14:0, C16:0, C17:0, C17:1, C18:0 and TVA, together with a marked increase in C18:1n9 and C18:2n6 fatty acids, the predominant fatty acids in pork backfat (Lorenzo, Montes, Purriños, Cobas, & Franco, 2012).

In both types of sausages, the most abundant fatty acids were, in decreasing order: C18:1n9, C16:0, C18:0 and C18:2n6 fatty acids. The relatively high proportion of the latter in sausages manufactured with added pork backfat (8.85%, on average), which was less than stearic acid, demonstrated the presence of pork backfat as a source of fat in both types of sausages. A similar result was observed by Bovolenta et al. (2008) in sheep sausages manufactured with different pork lard contents. In fact, linoleic acid levels in lean goat and sheep meat (4.27% and 3.24%, respectively, Banskaliyeva, Sahlu, & Goetsch, 2000) are one third of those in pork fat, particularly in dorsal fat (12%, Lorenzo et al., 2012).

The PUFA/SFA ratio is one of the main parameters used to assess the nutritional quality of the lipid fractions of foods. The British Department of Health (1994) recommends a PUFA/SFA ratio between 0.4 and 0.5. In this study, the goat and sheep sausages showed ratios between 0.13 and 0.33. In this sense, the addition of pork backfat improved this ratio, prompting a significant ($P < 0.05$) increase, showing the highest ratios the sausages manufactured with 30% of pork backfat. The percentage of desirable fatty acids (DFA) was defined by Rhee (1992) as follows: PUFA + MUFA + C18:0. The DFA values of goat and sheep sausages manufactured with 30% of pork backfat were higher than control sausages (data not shown).

According to Banskaliyeva et al. (2000), the (C18:0 + C18:1)/C16:0 ratio reflects the potential effects of the different types of lipids on human health. In this study, G30 presented the highest values (2.47) compared to control sausages (2.39). However, sheep sausages showed a different behavior, showing the control groups the highest ratios. Finally, the n-6/n-3 ratio increased with the addition of pork backfat, showing the highest values in both sausages manufactured with 30% of pork backfat.

3.3. Consumers evaluation

The influence of added pork backfat on the sensory characteristics of sheep and goat sausages is presented in Table 3. In both types of sausages, the fat content significantly affected sensory parameters: taste ($P < 0.01$), overall acceptability ($P < 0.001$) and texture ($P < 0.001$). However, in spicy taste no display marked differences was displayed ($P > 0.05$). Concerning taste attribute, G30 showed the highest scores (7.23) compared to control (5.09) and G10 (5.75). This finding is in disagreement with those reported by Lorenzo and Franco (2012) who found higher scores for intensity taste attribute in sausages manufactured with 10% of pork fat compared to those manufactured with 30% of pork fat.

On the other hand, in both types of sausages, control samples presented higher scores for spicy taste attribute (4.83 and 5.36 for goat and sheep sausages, respectively) compared to sausages manufactured with pork fat (Table 3). Fat content significantly ($P < 0.001$) affected the texture parameter in goat and sheep sausages, since control sausages presented the lowest scores. The observed differences in the perception

Table 3Predicted values (means \pm standard error) for de consumer's evaluation.

	Goat meat sausages			Sheep meat sausages			P-values		
	G0%	G10%	G30%	S0%	S10%	S30%	Species	Fat Level	Sp x FL
Taste	5.09 \pm 0.05 ^E	5.75 \pm 0.05 ^B	7.23 \pm 0.05 ^A	5.88 \pm 0.05 ^D	6.37 \pm 0.05 ^B	6.10 \pm 0.05 ^C	ns	**	***
Spicy taste	4.83 \pm 0.55 ^A	4.61 \pm 0.55 ^A	4.78 \pm 0.55 ^A	5.36 \pm 0.56 ^A	4.13 \pm 0.56 ^A	4.02 \pm 0.56 ^A	ns*	ns	ns
Texture	5.18 \pm 0.06 ^D	6.17 \pm 0.06 ^C	7.56 \pm 0.06 ^A	5.40 \pm 0.04 ^D	6.83 \pm 0.04 ^B	6.27 \pm 0.04 ^{DB}	ns	***	***
Overall acceptability	5.12 \pm 0.06 ^E	5.92 \pm 0.06 ^C	7.42 \pm 0.06 ^A	5.59 \pm 0.05 ^D	6.67 \pm 0.05 ^B	5.95 \pm 0.05 ^B	***	***	***

ns—not significant.

S0 sheep sausages without pork fat.

S10 sheep sausages with 10% of pork fat.

S30 sheep sausages with 30% of pork fat.

G0 goat sausages without pork fat.

G10 goat sausages with 10% of pork fat.

G30 goat sausages with 30% of pork fat.

* $P < 0.05$.** $P < 0.01$.*** $P < 0.001$.

of texture attribute provided evidence that the lower abundance of fat content within the ground lean goat meat the higher force required to penetrate the sausage and the degree of deformation of the goat sausages before breaking. This result was in agreement with [Lorenzo and Franco \(2012\)](#) who reported that sausages with 30% of fat had the lowest scores for hardness in foal dry-cured sausages produced with three different fat levels (10%, 20% and 30% of fat).

Finally, overall acceptability was significantly ($P < 0.001$) affected by fat level and specie in both types of sausages. The goat sausages manufactured with higher fat content presented the highest scores (5.2 vs. 5.9 vs. 7.4 for control and 10 and 30% of pork fat added, respectively). This result is in disagreement with those noticed by [Lorenzo and Franco \(2012\)](#) who reported greater sensory characteristics for low and medium fat sausages.

3.4. Discriminant analysis

The F values of all variables considered in the discriminant analysis carried out to determine if the six sausages groups could be distinguished on the basis of the fatty acids profile are shown in [Table 4](#). The stepwise method selected the following variables in 3 steps: C17:0, C20:1n9 and C18:3n3.

Scatter plot of the first two canonical variables of the six sausages groups considered ([Fig. 1](#)) showed that groups were discriminated with great accuracy with a total of 99.9% of variance explained, 91.19% and 8.75% for canonical 1 and canonical 2 functions, respectively. The first canonical function discriminates sausages manufactured with pork backfat that appeared on the positive side of the axis from the

both control groups (manufactured without pork backfat) that are on the negative side of the axis.

The model accept a significant third canonical variable ($P < 0.01$), explaining a further 0.5% more of the total variance, and the 3D canonical plot in [Fig. 2](#) shows that the model could discriminate the six groups of sausages with 100% a total variance explained accurately. The total of individuals of each group was assigned in the correct group pre-assigned, for 100% of classified correctly and the model is highly significant ($P < 0.0001$) for 0.00027 Wilks' lambda value.

The margaric acid in association with the eicosenoic and rumelenic fatty acids could be to discriminate goat and sheep sausages with different pork backfat percentages from the "halal" or "kosher" sausages without any quantity of pork backfat added. [Xu, Cai, Cui, Ye, and Yu \(2012\)](#) have studied the use of the discriminant analysis to discriminate the pork in halal and non-halal Chinese ham sausages. Also, [Ortiz-Somovilla, España-España, De Pedro-Sanz, and Gaitán-Jurado \(2005\)](#) used the discriminant analysis to differentiate Iberian pork meat from standard pork meat and to detect any mixture levels of them in fresh sausages. Thus, the discriminant function would be an important traceability tool. This information would be interesting to producers and meat industry but also to consumers that need a guarantee at the moment to consume pork fat free sausages.

3.5. General product evaluation

Results show that the fat level is most important factor to determine the quality of the sausages. Even though all sausages were appreciated by consumers the G30%, followed by S10% were the preferred ones. Once goat meat is leaner than sheep meat, consumers prefer the goat sausages with the highest fat content and sheep sausages with the medium fat content. As already mentioned, the addition of pork backfat will reduce the amount of SFA, increase MUFA and PUFA and improve the ratio PUFA/SFA. The consumer preference will encounter with the best characteristics observed in the physico-chemical analyses determined in this study. We also noted that over 88% of consumers buy any of the products presented (data not shown). This fact allows us to say that there will be market for any of the fresh sausages presented in this work. It is important to note that the goat and sheep sausages without pork backfat would be directed marketing to halal and Kosher consumers.

4. Conclusions

Fresh sheep and goat sausages made with meat from culled animals is an interesting way to valorize a product with very low market acceptability, satisfying the interest of producers and introducing in the

Table 4

F values of all variables used in the discriminant analysis.

Variable	F ratio	Prob > F
C12:0	3.206	0.0092978
C14:0	665.666	0.0000000
C14:1	134.894	0.0000000
C16:0	89.850	0.0000000
C16:1	15.439	0.0000000
C17:0	3026.60	0.0000000
C17:1	821.753	0.0000000
C18:0	704.459	0.0000000
C18:1n9c	89.899	0.0000000
C18:1n7c	61.101	0.0000000
C18:2n6c	200.602	0.0000000
C20:0	188.857	0.0000000
C20:1n9	1971.70	0.0000000
C18:3n3	87.632	0.0000000

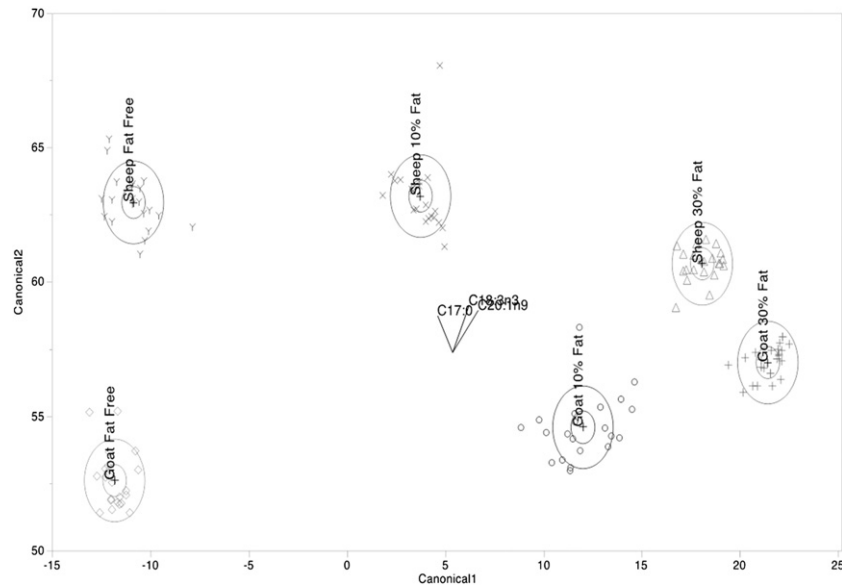


Fig. 1. Scatter plot of the first two canonical variables, of the six sausages groups considered (○, G10%; +, G30%; ◇, G0; ×, S10%; △, S30%; ▽, S0).

market a new meat product. All physicochemical parameters were affected by the addition of pork backfat in both types of sausages. The addition of pork backfat modified the total fatty acid profile, prompting a significant drop in the relative percentages of the major fatty acids of sheep and goat meat. With the addition of pork fat has been observed an increase in oleic and linoleic acids. The addition of pork backfat in sausages led to an increase of PUFA/SFA ratio. It should be noted that the ratio PUFA n6/n3 is impaired with the addition of pork backfat. Overall acceptability was significantly affected by fat level and the species in goat and sheep sausages. The goat sausages manufactured with higher fat content presented the highest scores of consumer preference.

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Canonical Plot 3D

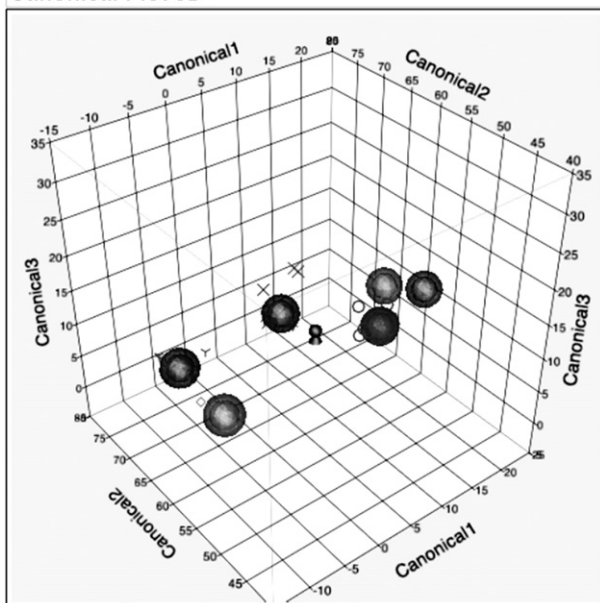


Fig. 2. Three-dimensional canonical plot considered (○, G10%; +, G30%; ◇, G0; ×, S10%; △, S30%; ▽, S0).

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