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Evaluation of goat mortadella prepared with different levels of fat and goat meat from discarded animals

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ABSTRACT

The objectives of this study were to develop a value added product, goat mortadella, using meat from discarded animals; to evaluate pork fat at various levels of inclusion in mortadella in an effort to reduce the fat content of the product; to determine consumer acceptability; and to determine the physico-chemical properties of this goat product. Three goat mortadella formulations were manufactured containing 10, 20 and 30% pork fat. The sensory characteristics, microbiological and proximate analysis, starch, chlorides, pH, water activity (Aw), water holding capacity (WHC), emulsion stability and CIE colour characteristics (i.e. a^*, b^* and L^*) of the mortadella were evaluated. The total number of thermotolerant coliforms, *Staphylococcus aureus*, *Salmonella* and *Clostridium* sulphite-reducers in the goat mortadella were in accordance with Brazilian legislation. Consumer panellists detected significant differences ($P < 0.05$) in appearance, colour, odour, flavour, texture and overall acceptance among the goat mortadella formulations. The goat mortadella prepared with 10% fat was rated the highest. In addition, approximately 70% of the panellists commented that they would purchase the goat mortadella. The percentages of moisture and protein were reduced as the percentages of fat added to the formulation increased. The goat mortadella with 30% fat had higher ($P < 0.05$) fat, ash, emulsion stability, WHC and b^* contents than those with 10 and 20% fat. The use of meat from discarded goats in the preparation of mortadella allows getting the most from this material, and the addition of 10% fat resulted in a goat mortadella with better acceptance and lowest fat content.

1. Introduction

In recent years, the raising of slaughter goats in the market has become an important cash-generating activity through the production of meat and milk, products of high biological value, skins of excellent quality, and the use of other carcass components in the fabrication of sausages and prepared meals (Gipson, 1999; Madruga, 2009). However, it is well-known that the technological use of goat meat has been little explored and therefore less goat-derived products are commercialized in open markets, supermarkets and meat houses, compared to beef, pork and poultry products (Cosenza et al., 2003). However, the food industry is increasingly accepting the challenge of developing products and technology destined to increase production and acceptance of goat-derived products (Madruga, 2009; Silva et al., 1999).

In Brazil, there is a direct preference for consumption of young animals denominated as 'cabrito' (kid goat), characterized as being more tender and succulent and as having

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Table 1
Formulations of goat mortadella prepared with different levels of meat and fat.

Ingredients[a]	Formulation – lipid percentage		
	10%	20%	30%
Goat meat	90	80	70
Pork fat	10	20	30
Ice	8	8	8
Polyphosphate	0.35	0.35	0.35
Curing salt	0.30	0.30	0.30
Antioxidant	0.75	0.75	0.75
Starch	3	3	3
Condiments for mortadella	0.75	0.75	0.75
Flavour enhancer	0.1	0.1	0.1
Black pepper	0.1	0.1	0.1
Garlic powder	0.1	0.1	0.1
Smoke aroma	0.15	0.15	0.15
Salt	1.5	1.5	1.5

[a]Quantities are percentages. Ice and other ingredients were based upon the 100% goat meat and pork fat.

less intense flavour and odour characteristics (Beserra et al., 2004; Devendra and Owen, 1983). However, adult or discarded animals and carcasses do not have the same acceptance for direct consumption, as they are considered to have less tenderness and a firmer texture, which are associated with a more intense, undesirable, characteristic flavour and odour, making it more difficult to commercialize them (Madruga et al., 2008). Consequently, better use of these meat sources is a major challenge in developing value-added goat meat products.

Mortadella is globally one of the most accepted processed meat products (Tóldrá et al., 2010). In Brazil its consumption has become popular, especially being a product prepared from various animal types, and due to legislation that allows its broad classification (Madruga, 2009; Silva et al., 1999). Nevertheless, the use of meat from small ruminants in the preparation of these products is not common except for those that are homemade. The commercial potential of these meats will only be developed if studies are carried out, and technology developed, to allow these products to be processed, industrialized and commercialized.

In this context, the objectives of this study were to develop a value added product, goat mortadella, using meat from discarded animals; to evaluate the inclusion of pork fat at various levels in an effort to reduce the fat content of the product; and to determine consumer acceptability and the physico-chemical properties of this goat product.

2. Materials and methods

2.1. Product development

Thirty-six-month old Saanen and Anglo-Nubian goats, with average live weights of 50 ± 1.7 kg, were supplied by the Brazilian Agricultural Research Corporation (Goats and Sheep EMBRAPA). The animals were slaughtered after fasting for 17 h, when water only was available. The warm carcasses were held at room temperature (around 30 °C) for 6–8 h and then chilled for 24 h at 2 °C. The leg, shoulder, rib, neck and loin cuts were removed from chilled carcasses and separately vacuum packaged, frozen and stored at −20 °C prior to processing.

Emulsion-type mortadella (Tóldrá et al., 2010) was manufactured with raw goat meat, leg, shoulder, rib, neck and loin cuts, pork fat and additives (Table 1). The proportions of different cuts were maintained for uniformity among the formulations, and the genetic types of the animals were not considered.

Three mortadella formulations were prepared, and to each was added either 10, 20 or 30% of pork fat (Table 1), such that the formulations consisted of the maximum value described in the Brazilian legislation, which states 30% of lipids in mortadella composition (Brazil, 2000).

Goat mortadella was produced in three batches of 10 kg for each treatment. The goat mortadella was prepared according to the standard procedure for mortadella. Lean goat meat and pork fat were ground through 9 mm plates by a grinder and emulsified meat batter was made using a cutter (JAMAR, K-10 model, São Paulo, Brazil). The meat batter was stuffed into a casing and placed in an 85 °C waterbath to cook to an internal temperature of 72 °C. The goat mortadella was cooled with ice water for 20 min, the surface air-dried at room temperature and then vacuum-packaged. The mortadella was stored at 4 °C and the analyses conducted within 8 d.

2.2. Microbiological and physico-chemical characterization of goat mortadella

Goat mortadella, raw goat meat and the processing equipment were submitted to microbiological analysis for the total number of thermotolerant coliforms, *Salmonella* screening, and a *Staphylococcus aureus* and *Clostridium* sulphite-reducers count, in accordance with the described methodology (Brazil, 2003).

To evaluate the physico-chemical characteristics of the mortadella, analyses were carried out in triplicate and all reagents were of analytical grade. Moisture, ash, protein, chloride and starch were determined according to AOAC (2000). Lipid was extracted following the method described by Folch et al. (1957). The emulsion stability was determined according to Parks and Carpenter (1987).

To measure the water-holding capacity (WHC), a sample (approximately 1 g of protein) of the ground mortadella was transferred to a centrifuge tube containing 20 mL of cold distilled water and centrifuged (Excelsa II 206BL, São Paulo, Brazil) at 2000 × *g* for 10 min. The supernatant was removed and its volume was subtracted from the 20 mL total volume, and the result expressed as a percentage of water expelled (Grau and Hamm, 1953). The pH was measured on a digital pH meter (Digimed, model PS3, São Paulo, Brazil) with a glass electrode. Water activity was measured with Aqualab CX2 equipment.

The surface colour of goat mortadella was measured after a 10-min bloom at room temperature (Minolta Chromameter 200, Minolta, Japan). Colour measurements were made using the CIE L^*, a^* and b^* system (where L^* measures relative lightness, a^* relative redness and b^* relative yellowness), with the mean of three measurements taken across the same cross-section of product. The chromameter was calibrated on a red tile (Y = 15.6, x = 0.446 and y = 0.313) before measuring colour. The measuring head was set to D65 lighting with the 2 standard observer and an 8 mm aperture.

2.3. Consumer sensory evaluation

To perform the sensory evaluation, 80 potential consumers were selected among post-graduate students and employees of the Federal University of Paraíba. They were selected for their fondness for mortadella and goat products, and all had the habit of consuming goat meat or mortadella. They were aged 20–54, with 58% females and 42% males. Sensory evaluation was performed throughout the acceptance and purchase intention tests, which were carried out according to the methodology proposed by Meilgaard et al. (1991) and Stone and Sidel (1993).

The panellists were instructed to evaluate the three goat mortadella formulations for appearance, colour, odour, flavour, goat flavour and overall acceptance using a nine-point hedonic scale where 1 = dislike extremely, 5 = neither like or dislike, and 9 = like extremely. The panellists were also submitted to a purchase intention test, using a five-point hedonic scale where 1 = certainly buy, 3 = may buy/may not buy, and 5 = certainly would not buy.

The goat mortadella was cut into pieces 2 cm thick and served at room temperature. All samples were served with crackers and ambient temperature water so that panellists could cleanse their palates before evaluating each sample.

Table 2
Microbiological counts and screening for *Salmonella* (average values) of goat mortadella prepared with different levels of meat and fat.

Parameters	Formulation	Lipid percentage		Raw goat meat	Processing equipment	Legislation[a]
	10%	20%	30%			
Clostridium sulphite-reducers (CFU/g)[b]	<1.0	<1.0	<1.0	<1.0	<1.0	5×10^2
Salmonella presence/absence in 25 g	Absence	Absence	Absence	Absence	Absence	Absence
Staphylococcus aureus (CFU/g)	<1.0	<1.0	<1.0	<1.0	<1.0	3×10^3
Thermotolerant coliforms (MPN/g)[c]	<0.3	<0.3	<0.3	10	<0.3	10^3

[a] Brazil (2003).
[b] Colony Forming Units per g (CFU/g).
[c] Most Probable Number per g (MPN/g).

2.4. Statistical analysis

Data were subjected to analysis of variance and the means compared by *t*-test for a completely randomized design in a 3×1 factorial arrangement (three levels of pork fat) with three replicates. Differences in means among treatments were evaluated for significance using the General Linear model of the SAS program (SAS Institute, 1996).

3. Results and discussion

The average values for the counts of *Clostridium* sulphite-reducers, *S. aureus*, total thermotolerant coliforms, and *Salmonella* screening in the goat mortadella, raw goat meat and processing equipments are shown in Table 2. All researched microorganisms had counts sufficiently low to meet legislative standards (Brazil, 2003). The excellent microbiological quality of the mortadella was due to the quality of raw materials used, in combination with good production practices in preparing the products, which efficiently maintain quality and safety of the mortadella.

Physico-chemical quality for goat mortadella is presented in Table 3. Starch, pH, water activity and intensity of redness (a^*) contents were not significantly different for goat mortadella formulated with different percentages of fat (Table 3). The percentage of moisture in the mortadella tended to decrease with increased fat content; this was due to the high level of moisture in goat meat, with average values of 76% (Guerra, 2010). High moisture in mortadella contributes to a better texture and succulence of the final product (Allais, 2010).

It is important to emphasize that only the formulation with 10% fat added had a moisture percentage (65.75%) above the legislated limit, i.e. a maximum moisture of 65% for mortadella (Brazil, 2000). The formulations with 20 and 30% fat added were within recommended standards.

As found for the moisture parameter, the protein levels decreased with increased lipid percentages and the consequent reduction in the levels of goat meat added. Protein values in the three formulations were in accordance with Brazilian legislation, which requires that the mortadella contain ≥12% protein (Brazil, 2000).

There were no significant differences in starch content among the three formulations, and the values were in accordance with legislation, which recommends the addition of <5% (Brazil, 2000). As expected the Aw and pH values of the mortadella did not vary between the three formulations: average Aw = 0.97, and pH of 6.3 stayed close to neutral. There was a significant difference in chlorides between the treatment with 20% lipids, the highest concentration, and the other formulations.

The greater the percentage of emulsion stability, the less the loss of liquids, and so the more stable the product is in relation to thermal treatment (Allais, 2010). In the present study, the formulation with 30% added fat showed the greatest percentage of emulsion stability, followed by the others in descending order of fat content. Emulsion stability was probably related to the lipid composition of pork fat added to the goat mortadella, and it is worth mentioning that an increase in fat will increase the availability of free molecules or radicals to make links with protein or water, and even stabilize the emulsion. The only significant difference ($P < 0.05$) in WHC was the greater WHC in formulation to which 30% fat was added. Consequently, the addition of

Table 3
Physico-chemical parameters (medium ± standard deviation) of goat mortadella prepared with different levels of goat meat and fat.

Parameters	Formulation – lipid percentage		
	10%[a]	20%	30%
Moisture (g/100 g)	65.75a ± 0.80	59.01b ± 2.05	50.50c ± 1.04
Ash (g/100 g)	2.47b ± 0.25	2.40b ± 0.33	2.56a ± 0.15
Protein (g/100 g)	17.97a ± 0.90	14.96b ± 0.50	12.76c ± 0.60
Lipid (g/100 g)	9.43c ± 0.90	17.55b ± 1.36	26.68a ± 1.23
Starch (g/100 g)	3.73a ± 0.05	3.74a ± 0.05	3.75a ± 0.05
Chloride (g/100 g)	1.76b ± 0.20	1.89a ± 0.20	1.73b ± 0.20
Emulsion stability (g/100 g)	87.25c ± 0.63	90.33b ± 0.55	91.58a ± 0.36
Water holding capacity (g/100 mL)	81.24b ± 2.31	81.41b ± 2.81	84.35a ± 2.48
pH	6.30a ± 0.39	6.34a ± 0.33	6.31a ± 0.36
Water activity	0.975a ± 0.00	0.974a ± 0.33	0.971a ± 0.00
L^*	53.05b ± 1.80	58.00a ± 2.22	57.61a ± 2.43
a^*	12.83a ± 1.48	12.64a ± 1.30	12.22a ± 1.80
b^*	9.71b ± 0.615	10.06a ± 0.50	10.46a ± 0.63

[a] Different letters on the same line indicate significant differences at $P < 0.05$ using Tukey's test.

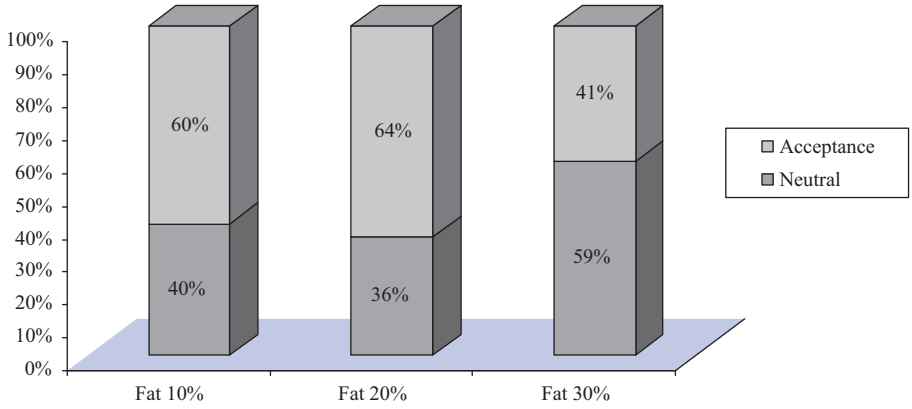

Fig. 1. Profile of purchasing intentions for goat mortadella prepared with different levels of goat meat and fat.

different percentages of fat contributed significantly to the emulsion stability and WHC of the formulations, avoiding drip loss from the packaging.

The greater the value of L^*, the lighter coloured was the sample. The addition of high percentages of fat caused mortadella to have lighter colouring, which was not beneficial in relation to the sensory evaluation. In this study, the greatest values of L^* were for goat mortadella prepared with 20 or 30% fat. For parameter a^* there were no significant differences between treatments; however, for parameter b^* there was a significant ($P < 0.05$) difference when mortadella to which 10% fat was added was compared to the others – the mortadella with 20 and 30% fat had higher values for the yellow colour intensity, due to the greater percentage of added fat.

Consumer panellists detected significant sensory differences ($P < 0.05$) among the three goat mortadella formulations (Table 4). These products were rated in the range of 6.0–7.6, indicating that goat mortadella was well liked. Addition of fat had a significant effect ($P < 0.05$) on all sensory parameters of the mortadella. The scores for appearance, colour, odour, flavour and total acceptance were higher in the formulation with 10% fat added with compared with 20 and 30%.

In regard to the goat flavour attribute, there was no significant difference between the formulations. The spontaneous comments on the evaluation forms indicated that the panellists could not perceive the characteristic goat flavour in the mortadella, which explains the similarities between acceptance percentages for this attribute and the flavour attribute. For all the other evaluated attributes, there were only differences when comparing the formulations to which 10% fat were added to the others (i.e. 20 and 30%).

Goat mortadella prepared with 10% fat received the highest scores (> 7.0) for appearance, colour, odour, flavour and overall acceptance, with the exception of texture, which was the lowest of the three formulations. The low score for the formulation with 10% fat added is related to the low amount of lipids in the meat product, which affected the texture.

In a study of goat mortadella, Martins (1998) obtained lower average scores than the results of the present study for sensory attributes: i.e. flavour (5.2), colour (4.6), aroma (4.4), texture (4.4) and general acceptance (5.0). The higher scores in the present study are possibly due to the recruiting and selection of the panellists who had a liking for mortadella and goat products.

The attributed scores of purchasing intentions for goat mortadella were rated in the range of 3.0–4.0, which represents the item-neutral 'may buy, may not buy' and 'may possibly buy' on the scale used; i.e. 3.8, 3.8 and 3.5 for mortadella added with 10, 20 and 30% fat, respectively. In contrast to results for the isolated analysis of each sensory attribute evaluated by the hedonic scale, where acceptance percentages were >70% when evaluated in relation to purchase intention, the acceptance percentages were <70% (Fig. 1). This may be explained by the fact that goat mortadella is not a daily consumption item for panellists, and that mortadella prepared with beef or poultry is readily available at retail stores (Martins, 1998).

Table 4
Sensory quality (medium scores ± standard deviation) of goat mortadella prepared with different levels of goat meat and fat.

Parameters	Formulation – lipid percentage		
	10%[a]	20%	30%
Appearance	7.4a ± 1.06	7.0b ± 1.30	6.7b ± 0.17
Colour	7.4a ± 1.02	6.7b ± 1.47	6.5b ± 1.36
Odour	7.5a ± 1.02	7.0b ± 1.57	6.7c ± 1.52
Flavour	7.6a ± 1.20	7.0ab ± 1.59	6.5b ± 1.62
Goat flavour	6.9a ± 1.34	6.7a ± 1.58	6.4a ± 1.51
Texture	6.0b ± 1.49	6.9a ± 1.58	6.5ab ± 1.83
Overall acceptance	7.3a ± 1.17	7.1ab ± 1.28	6.7b ± 1.48

[a] Different letters on the same line indicate significant differences at $P < 0.05$ using Tukey's test.

4. Conclusion

The results showed that an acceptable value-added goat meat product can be produced, considering that all the formulations were accepted when sensorially evaluated. The goat mortadella to which 10% of lipids was added had the highest percentage of meat, and was the preferred choice of the consumers. The goat mortadella manufactured in this study complied with legislative demands

concerning microbiological and physico-chemical parameters, except for moisture levels of the formulation prepared with 10% fat, which exceeded the maximum limit of 65%.

Considering that goat meat from discarded animals is a low-cost raw material, its use in the preparation of mortadella allows for a better use of this material and for diversification of processed meat products offered. It adds value to the product and increases revenue for producers.

Conflict of interest

None declared.

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