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The chemical and sensory qualities of smoked blood sausage made with the edible by-products of goat slaughter

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ABSTRACT

The aim was to evaluate smoked blood sausage prepared using goat blood (50%), viscera (10%) and meat fragments (20%). Microbiological, chemical and sensory evaluations were conducted. The quality analyses showed that smoked goat blood sausage is rich in high biological value proteins, amino acids, essential fatty acids, and iron (26.65 mg/100 g). The smoked goat blood sausage was rated to have a sensory acceptance of greater than 80%. The use of edible by-products from the slaughter of goats in the formulation of smoked blood sausage is viable because it uses low-cost raw materials; furthermore, the utilisation of these by-products can generate income for producers, allowing them to offer a meat product of high nutritional and sensory quality.

1. Introduction

After slaughter, the goat carcass is usually the only part considered as a commercial material. Other edible non-carcass components, namely the organs, viscera, blood and other by-products, are discarded. The inefficient use of these slaughter by-products presents an economic problem for slaughterhouses, and improper disposal may cause diseases and public health problems.

Animal blood has been studied in recent years as a low cost source of nutrients, especially protein (18 g/100 g) and iron (30 mg/100 g), with functional and sensory properties that are acceptable for human consumption (Fontes, 2006; Gorbatov, 1988; Pereira, 2000; Santos, 2007). In European countries, meat products composed of blood and viscera are popular, such as *Morcilla de Burgos* in Spain (Santos, Gonzáles-Fernández, Jaime, & Rovira, 2003), *Chouriço Alentejano*, *Chouriço Mouro* and *Morcela de Assar* in Portugal (Roseiro, Santos, Almeida, & Vieira, 1998), *Cavourmas* in Greece (Arvanitoyannis, Bloukas, Pappa, & Psomiadou, 2000) and *Blutwurst* in Germany (Stiebing, 1990). In Brazil, according to Santos et al. (2008), the blood and viscera produced at slaughter are used in the preparation of dishes such as *buchada* (goat), chopped meat (goat and lamb) and *sarapatel* (pork).

We have been developing differentiated products, such as goat *mortadella* (Guerra et al., 2011), salted lamb and goat meat (Costa et al., 2011) and lamb pâté (Dalmás, Bezerra, Morgano, Milani, & Madruga, 2011), to demonstrate alternative uses for goat and lamb components. A literature review revealed no studies examining the quality of smoked goat blood sausage. Therefore, this study aimed to develop and assess the chemical, microbiological and sensory attributes of a smoked blood sausage made with goat trimmings, blood and viscera.

2. Material and methods

2.1. The production of smoked goat blood sausage

A total of 23.0 kg of smoked goat blood sausages were produced in 3 replicates using meat trimmings, blood and viscera (heart and kidney) of 12 native goat breeds (Table 1). The goats were aged 18–24 months and had a live weight of 28 ± 2 kg at slaughter. The formulation was obtained from preliminary studies in which 3 formulations were processed in 3 replicates with different blood (30 to 50%) and viscera concentrations (10 to 30%). The three formulations were submitted to mineral profile analysis (AOAC, 2000) and sensory tests using the focus group method, which was planned and performed as recommended by Della Lucia and Minim (2006) and Lalor, Madden, Mckenzie, and Wall (2011). The formulation described in Table 1 was selected for further tests because it exhibited the highest iron content and the best sensory evaluation results.

In the preparation of the smoked goat blood sausage, the meat and viscera were first cleaned to remove the excess fat and membranes. The blood was sieved to separate and remove suspended solids. The skin was ground along with the meat, viscera and fat using a table mill, and the blood, additives and spices were added to the comminuted mixture and mixed. An artificial collagen casing (50 mm in diameter) was filled with the mixture using a horizontal filler (Siemsen Ltda., ES-08, Santa Catarina, Brazil).

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Table 1
Formulation of smoked chorizo made with blood and guts of goats.

	Composition (kg)	Composition (%)
Raw material[a]		
Blood	11.50	50.0
Guts (heart and kidneys)	2.30	10.0
Meat (trimmings)	4.60	20.0
Fat	1.84	8.0
Pig skin	2.76	12.0
Ingredients[b]		
Manioc starch	1.15	1.15
Onion	0.92	0.92
Salt	0.58	0.58
Nitrite and sodium nitrate (Hungarian Powder III)	0.09	0.09
Stabilizing (INS 451i)	0.09	0.09
Dehydrated parsley	0.05	0.05
Black pepper	0.02	0.02
Garlic powder	0.02	0.02
Marjoram	0.02	0.02
Cumin	0.01	0.01
Nutmeg	0.01	0.01

[a] The smoked sausage made with goat blood was prepared with raw material (blood, guts, meat fragments, bacon and pork skin) as 100% of the formulation.
[b] The ingredients were added in relation to the total weight of raw materials.

After filling, the smoked blood sausages were cooked in an open pan at 80 °C until the temperature of the geometric centre reached 75 °C, followed by cooling and storage at 4 °C. Later, the sausages were smoked (8 h at 55 °C) in a smoking chamber (Fessmann, T1900, Winnenden, Germany), followed by cooling and vacuum packaging (TECMAC, nylon-poly, 18×25 cm, 18 μm thickness and capacity of up to 500 g). Finally, the sausages were stored at 4 °C for a period not exceeding 15 days until all analyses were performed.

2.2. Microbiological assessment

The microbiological parameters of the smoked goat blood sausage were assessed according to APHA (2001). The reference criteria used were established by RDC Resolution No. 12, item (i), which states that coliforms at 45 °C/g, *Staphylococcus* coagulase positive/g, *Salmonella* spp./25 g and reducing sulphite *Clostridium* must be analysed for blood-based products and derivatives (Brasil. Ministério da Saúde, 2001). Microbiological assessments were performed 24 h after processing the smoked goat blood sausage to determine the hygienic–sanitary conditions of the samples for sensory evaluation.

2.3. Physicochemical and physical assessment and mineral, amino acid and fatty acid profiling

Water activity (Aw), pH, moisture, ash and protein parameters were assessed as described by AOAC (2000), and the lipid content was assessed as described by Folch, Lees, and Sloane Stanley (1957). The mineral composition (P, K, Ca, Na, Mg, Cu, Zn and Fe) was determined according to AOAC (2000) using plasma emission spectroscopy (BAIRS ICP-OES 2000, Massachusetts, USA) equipped with a radio frequency source at 40 MHz, a peristaltic pump, a spray chamber and spraying technology (Dalmás et al., 2011).

The fatty acid profile was determined as described by Hartmann and Lago (1973) using a gas chromatograph (VARIAN GC-430, California, USA) coupled to a flame ionisation detector and a 60 m×0.25 mm fused silica capillary column (VARIAN, CP WAX 52 CB) with 0.25 μm-thick film. Helium was used as the carrier gas (flow rate 1 mL/min). The initial oven temperature was 100 °C which was then increased to 240 °C at 2.5 °C per minute and held at the maximum temperature for 20 min, resulting in a total run time of 76 min. For the quantification of total cholesterol, isocratic elution on an INERTSIL C18 column chromatograph (4.6 mm×150 mm×5 mm) was performed (Bragagnolo & Rodriguez-Amaya, 2002). The chromatographic separation was carried out at a constant flow (1 mL/min) at 30 °C with a run time of 10 min.

The amino acid composition was determined in samples that had been hydrolysed with 6 N doubly distilled hydrochloric acid, followed by pre-column derivatisation of free amino acids with phenyl isothiocyanate (PITC), (White, Hart, & Fry, 1986). The separation of phenyl thiocarbamyl (PTC) amino acid derivatives was performed in a chromatograph (VARIAN, Waters 2690, California, USA) coupled to a C18 PICO-TAG column (3.9 mm×150 mm).

The assessment of the colour coordinates (L*, a*, b*) was performed using a digital chroma meter (Konica Minolta, Model CHROMA METER CR-400, Osaka, Japan) according to Abularach, Rocha, and Felício (1998). Shear force (SF) was measured as described by Wheeler et al. (1997). The shear force was applied perpendicular to the meat fibres using a TA.XT Plus Universal Texture Analyzer (STABLE MICRO SYSTEMS®, 1997) equipped with a Warner–Bratzler type blade.

2.4. Sensory evaluation

In the sensory characterisation, acceptance and purchase intent tests were performed as proposed by Meilgaard, Civille, and Carr (1991) and by Stone and Sidel (2004). These tests assessed colour, aroma, flavour, texture, juiciness and overall acceptability using a 9-point hedonic scale ranging from 1 (extremely disliked) to 9 (extremely liked). Sixty potential consumers between 18 and 33 years of age (57.4% males and 42.6% females) who reported an affinity for blood and viscera-based products were selected and recruited.

3. Results and discussion

3.1. The chemical quality of the smoked goat blood sausage

As shown in Table 2, the smoked goat blood sausage contained high levels of protein (19.80 g/100 g) and iron (26.65 mg/100 g). Santos et al. (2003) and Herrera (2006) reported lower protein values for *Morcilla de Burgos* and *Morcilla de León*, respectively, compared to the smoked goat blood sausage. The higher blood concentration used in the preparation of smoked goat blood sausage (50%) compared to *Morcilla* (30%) may be the cause of the difference in protein values.

The iron contents of the smoked blood sausage were slightly higher than those obtained by the National Institute for Health and Welfare (2010) for *Verivanukas*, a blood-based sausage of Finnish origin. The use of viscera may have influenced the iron content of products containing these tissues. Casey (1992) studied the nutritional quality of various goat organs and found high iron contents in the heart (4.40 mg/100 g), kidneys (9.78 mg/100 g), liver (7.82 mg/100 g) and spleen (34.79 mg/100 g). Santos et al. (2003) assessed *Morcilla de Burgos* and found iron content (23.48 mg/100 g) similar to that measured in this study.

An intake of 51.4 g of smoked goat blood sausage fully meets the daily iron needs of adults over the age of 18 (13.7 mg/day) as recommended by the FAO (2001). For daily iron needs of adult women over the age of 18, 110.3 g of smoked goat blood sausage satisfies 100% of the recommended average daily intake, which is 29.4 mg / day.

Essential amino acids accounted for 48.4% of the total amino acid content of the smoked goat blood sausage, which indicates that the sausage is an excellent source of histidine, lysine, valine and leucine (Table 3). Smoked goat blood sausage had average chemical scores above 1.0 for all amino acids (Pires, Oliveira, Rosa, & Costa, 2006), indicating that no amino acids were limiting. Therefore, this sausage can be considered a source of high biological value protein, providing more than the recommended daily value of essential amino acids for adults (FAO, 2007).

In a study on the nutritional characteristics of *mortadella* formulated with mixtures of pork blood and whey protein concentrate, Santos