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Abstract

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Microbiological quality and sensory evaluation of new cured products obtained from sheep and goat meat

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Abstract.

The present work aims to study the effect of species and seasoning time on the physicochemical, microbiological and sensory characteristics of cured legs of sheep and goats. Three cure periods were used: two for sheep and one for goat legs. Legs of lamb were cured for 7 and 8 months whereas legs of goat were cured for 8 months only. Samples were evaluated regarding pH, water activity and indicators of food microbial quality and safety. A trained panel carried out the sensory analysis, with aroma, texture, appearance and taste being the evaluated parameters. Significant differences were detected between the amount of aerobic mesophiles of the products cured during 7 months and the sheep legs cured during 8 months. Moulds and yeasts were between $1.81 \times 10^6 \pm 1.73 \times 10^6$ and $3.97 \times 10^6 \pm 5.45 \times 10^6$ colony-forming units/g, whereas total coliforms varied from $2.80 \times 10^2 \pm 4.13 \times 10^2$ to $1.31 \times 10^4 \pm 2.39 \times 10^4$. All samples were negative for toxigenic species. Concerning sensory analysis, hardness and taste persistence were the attributes that presented the highest and the lowest discriminative power, respectively. In general, the panel was able to characterise and distinguish the samples. The cured legs of goats were characterised as harder and as less succulent than those obtained from sheep. Sheep meat with larger time of cure was the brightest, whereas the one with a smaller time of cure was the most succulent. However, goat meat presented higher values of rancid and acid flavour. Sheep meat submitted to longer processing presented the most intense flavour and sheep meat with an inferior cure period presented the lowest intensity in all flavour attributes. This paper describes, for the first time in Portugal, the production and characterisation of cured legs of sheep and goats as a strategy to enhance economic value to good quality products obtained from animals of second category.

Additional keywords: cured legs, microbiological analysis, sensory analysis.

Introduction

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Meat is a source of a high variety of nutrients as proteins, group B vitamin and minerals. It is easily digested and necessary for essential physiologic functions, meaning its consumption is considered essential for a healthy life (Schnettler *et al*. 2009).

The consumption of goat and sheep meat has been increasing during the past 20 years, due to its nutritional and sensory features (Karami *et al*. 2011). However, despite this increasing popularity, its production is currently facing a difficult period, mainly due to the rural depopulation and more demanding agricultural politics (Stanisz *et al*. 2009).

In this context, one of the pathways that the producers can follow in order to overcome the current situation and to achieve a competitive advantage, is to find innovative products (Grunert *et al*. 2004). Examples of this innovation include the development of salted, smoked or air-dried products from meat of older and culled animals (Molinero *et al*. 2008). These dry-cured products, obtained from beef (Molinero *et al*. 2008), bresaola (Paleari *et al*. 2008) or pastirma (Kaban 2009), are in high demand. Moreover, although less frequently, these can be obtained from small ruminant meat (Teixeira *et al*. 2011).

Besides preferring diverse and convenient food, consumers also require products that are safe and of consistent quality (Scollan *et al*. 2006). Particular emphasis must be given to microbial spoilage that causes foods to be undesirable or unacceptable for human consumption. Several studies have considered the *Enterobacteriaceae* to be the most important bacteria in the spoilage of different kinds of dry-cured hams (García *et al*. 2000). In addition, species of the genera *Serratia*, *Salmonella*, *Escherichia*, *Hafnia* and lactic bacteria have also been lauded as playing an important role (Martín *et*

al. 2006).

The present paper reports the formulation, the microbial and sensory evaluation of two new meat products obtained from legs of culled sheep and goat that had low economic value, with the final aim of providing high-quality, differentiated, value-added products.

Materials and methods

Sheep and goat carcasses were directly acquired from the Serrana National Association of Breed Producers (Mirandela, Portugal) and Churra Galega Bragançana Breed Association (Bragança, Portugal) and we did not experiment with live animals. The research project was approved by the ADI (Innovation Agency) Program PROTEC, SI I&DT (Incentive Scheme for Innovation and Technological Development) – Projects in Co-Promotion by Portuguese Education and Science Ministry and Economy Ministry.

Animals

Twenty-one animals were used, 14 Churra Galega Bragançana sheep and seven Serrana goats, between 8 and 12 years old, with 20.0 ± 1.9 kg of carcass weight. Due to their age and weight, these animals have low commercial value. The production system and the animal's diet were based on natural feeding, with hay and straw as supplement. Animals were slaughtered in the official slaughterhouse of Bragança. After slaughter, carcasses were cooled at 4 ± 1°C for an aging period of 4 days. Later, carcasses were divided into quarters and legs from the right part of the carcass, weighing ~3 kg, were removed by cutting perpendicularly through the vertebral column near the anterior part of the ilium.

Regarding processed meat products, methodologies were applied identical to those used in the production of ham. A fabrication diagram can be observed in Fig. 1. Legs were dry-salted with coarse marine salt, forming mounds on the floor. The salting period was determined according to the pieces' weight, as 1 kg corresponds to 1 day of salting. The temperature of the salting room was between 2°C and 5°C and the relative humidity between 80% and 90%. Legs were identified and accommodated in perforated trays (with outflow, allowing the liquid salt to exit). Afterwards, a layer of 5 mm of coarse marine salt was distributed over the legs so they were completely covered. At salting middle time legs were turned upwards and the salt was reset as before. After the salting period all visible salt was removed with a brush.

Fig. 1. Flow diagram presenting the steps involved in the processing of sheep and goat legs to form the cured products.
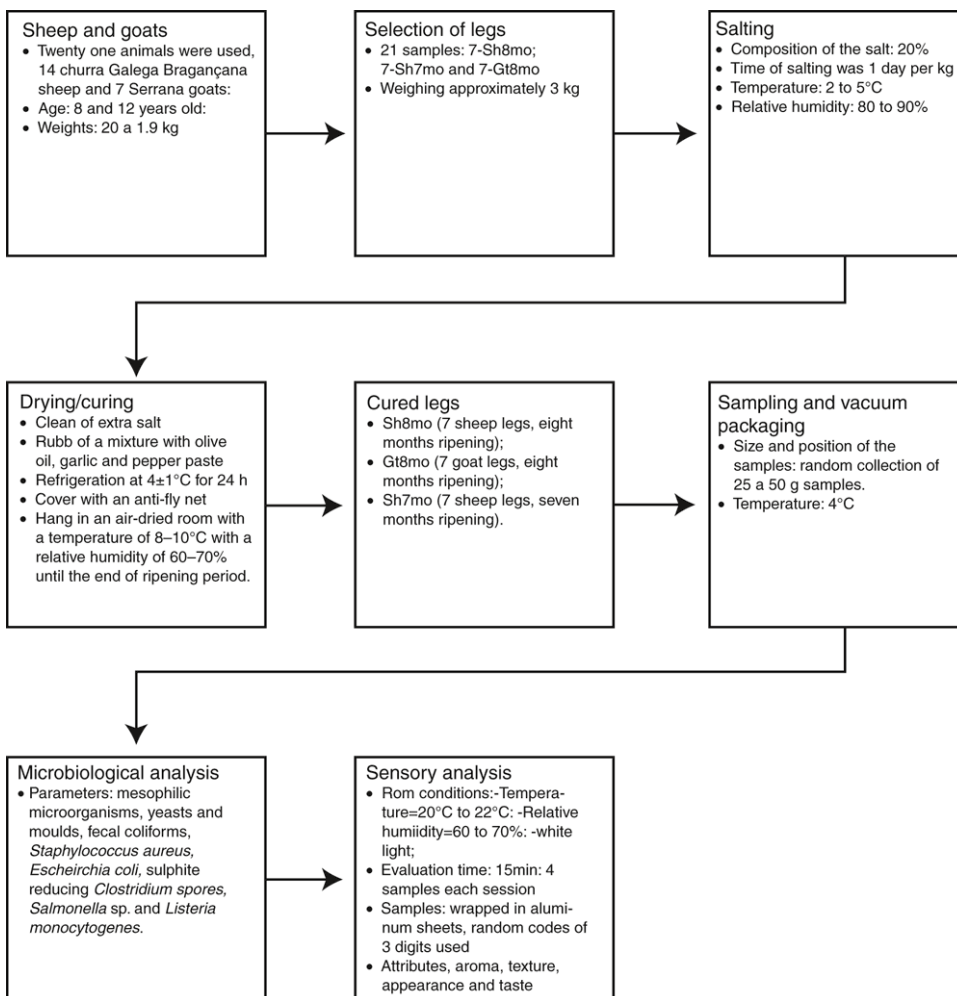
Afterwards, and before drying, legs had their surface rubbed with a mixture of olive oil, garlic and pepper paste and refrigerated at 4 ± 1°C for 24 h before handling the pieces covered with an anti-fly net into an air-dried room with a temperature of 8-10°C with a relative humidity of 60–70% until the end of the ripening period. Sheep legs were submitted to two different curing processes, whereas goats were all submitted to the same processing. Therefore, we considered three treatments: Sh8mo (seven sheep legs, 8 months' ripening) and Gt8mo (seven goat legs, 8 months' ripening) and Sh7mo (seven sheep legs, 7 months' ripening).

Physicochemical analyses

pH and water activity measurements

At the end of the ripening period, pH was determined on the *semimembranosus* muscle of the legs with a pH meter HI 99163 (HANNA® instruments, Woonsocket, RI, USA). Water activity (a_w) in raw fresh meat and at the end of the fabrication process of legs was measured using the *HygroPalm AW1* (Rotronic Instruments Corp., New York, NY, USA) with a probe measuring over the range 0–1, with room temperature control.

Microbiological analyses

All tests were performed in triplicate (3*21 analytical samples) on the product obtained at the end of the ripening period.

Commercial quality parameters: mesophilic microorganisms, yeasts and moulds, indicators of sanitary quality: faecal coliforms, *Staphylococcus aureus*, *Escherichia coli*, and safety indicators: sulfite reducing *Clostridium* spores, *Salmonella* sp. and *Listeria monocytogenes* were assessed. Samples were randomly collected from the surface and depth of the leg. Samples were homogenised to make them representative of all legs.

Ten grams of each sample were homogenised into 90 mL of peptone water solvent (NP-1829 1982) and decimal dilutions were prepared into the same solvent. Aerobic mesophiles bacteria were incubated at 30°C for 72 h and counted onto standard plate count agar (NP-ISO-4833 2003). Moulds and yeasts were incubated at temperature between 20°C and 25°C for 5 days and counted onto potato dextrose agar (NP-2077 1985). Microbial counts were expressed as colony-forming units per gram of sample (CFU/g).

The determinations of coliforms and *Escherichia coli* were carried out with a commercial SimPlate system of Bio Control kit. *Escherichia coli* were recognised as the fluorescent wells upon exposure to UV light at 365 nm. Regarding the sulfite-reducing clostridia counting, aliquots of 10 mL, 5 mL and 1 mL of the initial suspension were inhibited and then incubated at 37°C for 48 h onto tryptose sulfite agar. A black precipitate around the colonies indicated the presence of these spores (NP-ISO-15213 2003). *Staphylococcus aureus* were assessed on Baird-Parker enhanced with egg yolk, according to the protocol of NP-4400–1 (2002). The detection of *Salmonella* sp. in the samples was carried out using the immunodifusion 1–2 test, which is a patented single-use test for Salmonella used by analysts worldwide and recognised as the AOAC 989.13 (AOAC 1998). The detection of *Listeria monocytogenes* was conducted in accordance with the method CHROMagar Listeria Method (AFNOR validated method in 2001).

Isolation and identification of yeasts

The API 20C AUX system (BioMérieux SA-69280, Marcy-l'Etoile, France), a commercial kit for the evaluation of the assimilation of 19 carbon sources, was used according to the instructions in the identification of the isolated yeasts. All panels were read for growth according to the API 20C AUX-analytical profile index.

Sensory analyses

A trained taste panel of nine panellists performed sensory analysis in seven sessions, and four samples in each session were evaluated. In each session two repetitions of two different products were evaluated. Different combinations were used in each session. Different samples of all three products in a total of 28 samples were evaluated by each panellist. Taste, flavour, texture and appearance were the parameters evaluated. The whole training process obeyed the protocols established by the Portuguese Standard NP-ISO 8586–1 (2001). A 10-cm continuous, unstructured and anchored at the ends scale was used. The left anchor corresponded to the lowest intensity and the right anchor to the higher intensity of the respective attribute. Tests were performed in the taste room of the Agriculture School of the Polytechnic Institute of Bragança. During sessions, room temperature was controlled to be maintained between 20°C and 22°C. Room relative humidity ranged between 60% and 70% and the light was white. Samples were always presented in the same conditions for all panellists in a randomised order and balanced encoding of three-digit numbers. As this is a cured product, it needs no cooking treatment. Thus, samples were given to the panellists at room temperature. A thin (1 mm thick, 3–4 cm width, and 7–8 cm length) slice of the product (guaranteeing that *semimembranosus*, *semitendinosus* and *biceps femoris* muscles were included in the portion) was cut from the whole treated leg and wrapped in an aluminium sheet, and then tasted by the panellists. The methodology used was described previously by Guerrero (2000) and by the Portuguese Standards NP-ISO 8586–1 (2001).

Statistical analyses

After completion of all tests, collecting and organising data, statistical analysis was performed. For microbiological data, because they did not follow a Normal distribution, a non-parametric Kruskal–Wallis ANOVA was performed, SPSS software for the system Microsoft Windows, version 19.0 was used. Results are shown as mean values and standard deviations. *P*-values less than or equal to 0.05 were considered statistically significant. Sensory data were assessed by generalised procrustes analysis, a powerful multivariate technique extensively used in sensory evaluation, according to the tutorial indicated on the internet page of XLSTAT (generalised procrustes analysis) (Addinsoft 2015). Generalised procrustes analysis was used to minimise the differences between panel assessors, identify the consensus between them,

and summarise results in a three-dimensional representation (products, attributes and panellists), thereby making it easier to interpret and identify main conclusions (Rodrigues and Teixeira 2009, 2013). The data matrices of 3 (meat samples) by 19 (sensory attributes) for the nine panellists (configurations) were matched to find a consensus using the XLSTAT version 2011, an Excel software add-in (Addinsoft, New York, NY, USA). The procedure Characterisation of the Product was performed, using the same software, to check which characteristics could discriminate the products more significantly. This procedure gives us the main characteristics of each product. The output values obtained from the Characterisation of the Product procedure of XLStat software (Addinsoft 2015) are the results of the model used, Y = P (product effect) + J (Judge effect), based on the work of Husson and Pagès (2003).

Results and discussion

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Physiochemical composition

Water activity and pH are important physicochemical factors that influence enzymatic reactions, survival and growth of food microorganisms. As such, it is important to study and monitor these parameters, in order to ensure the safety of the product till its consumption (Ordóñez and Hoz 2007). The results obtained for a_w at the end of ripening of the cured legs are presented on Table 1 and were significantly different ($P < 0.001$) between treatments.

Table 1. Mean values ± standard deviation of pH and water activity (a_w) of the different type of cured legs
In each column, different letters (a,b) following the mean values represent the existence of significant differences ($P < 0.05$)

Samples	a_w	s.e.m.	pH	s.e.m.
Sh8mo	0.86a	0.040	6.28a	0.055
Sh7mo	0.86a	0.040	6.17a	0.055
Gt8mo	0.83b	0.040	6.28a	0.060
P-value	<0.001	–	0.187	–

The values determined for this parameter for Sh8mo, Sh7mo and Gt8mo were 0.86, 0.86 and 0.83, respectively. It is worth mentioning that the product obtained from goat meat presented slightly smaller values of a_w, when compared with those of sheep. These results were not in agreement with the findings of Teixeira *et al*. (2011), where the obtained values ranged between 0.79 and 0.84, when they studied the physicochemical quality of meat from sheep and goat, salted and dried for 120 days. These differences may be assigned to the longer period of seasoning (Teixeira *et al*. 2011). Our results are in agreement with those obtained by Villalobos-Delgado *et al*. (2014) concerning the sheep results. These authors found a_w ranged between 0.88 for external and 0.89 for internal in the muscle of dry-cured lamb legs. According to Feiner (2006), the values between 0.60 and 0.90 are intermediate moisture that meat products provide microbial stability at ambient temperature. Also Molinero *et al*. (2008) and Paleari *et al*. (2003) found that a_w values correspond to correctly cured products. There were no significant differences found ($P = 0.187$) between samples regarding pH, and the values for Sh7mo, Sh8mo and Gt8mo were 6.17, 6.28 and 6.28, respectively. Similar values were obtained by Jay (2005) and Teixeira *et al*. (2011) in cured meat of sheep and goats. Also similar results were obtained by Villalobos-Delgado *et al*. (2014) in the final product of dry-cured lamb legs with pH 6.02.

Microbiological evaluation

The prevailing of a particular microbial association on meat depends on diverse factors (intrinsic, processing, extrinsic, implicit and emergent) that persist during processing, transportation and storage of the food product (Nychas *et al*. 2008). Due to the absence of microbiologic specifications regarding the products under study we used the requirements available for carcasses and mature meat products, such as dry-cured hams.

Commercial quality indicators
Mesophilic aerobic microorganisms

Table 2 shows the mean values and standard deviations for the CFU per gram of the studied microorganisms and Table 3 gathers the results of the Kruskal–Wallis test, a non-parametric analysis.

Table 2. Mean values ± s.d. (minimum-maximum) of microbiological analyses performed to the cured legs of sheep and goat; CFU/g
CFU, colony-forming units

Variables	Samples		
	Sh8mo	Gt8mo	Sh7mo
Aerobics mesophylic variation	$8.59 \times 10^5 \pm 2.39 \times 10^6$ $(5.27 \times 10^3 - 1.35 \times 10^7)$	$3.97 \times 10^5 \pm 5.34 \times 10^5$ $(1.17 \times 10^4 - 1.61 \times 10^6)$	$7.18 \times 10^4 \pm 1.42 \times 10^5$ $(<10 - 7.18 \times 10^5)$
Moulds and yeasts variation	$3.97 \times 10^6 \pm 5.45 \times 10^6$ $(<10 - 2.19 \times 10^7)$	$1.81 \times 10^6 \pm 1.73 \times 10^6$ $(<10 - 6.09 \times 10^6)$	$3.73 \times 10^6 \pm 5.18 \times 10^6$ $(<10 - 1.34 \times 10^7)$
Staphylococcus aureus	<10	<10	<10
Total coliforms (NMP/g) Variation	$1.31 \times 10^4 \pm 2.39 \times 10^4$ $(<10 - 7.38 \times 10^4)$	$2.80 \times 10^2 \pm 4.13 \times 10^2$ $(<10 - 1.2 \times 10^3)$	$8 \times 10^2 \pm 2.55 \times 10^2$ $(4 \times 10^2 - 1.20 \times 10^3)$
Faecal coliforms (*E.coli*)	<10	<10	<10
Clostridium spores (in 0.01 g)	Absent	Absent	Absent
Salmonella spp. (in 25 g)	Absent	Absent	Absent
Listeria monocytogenes (in 25 g)	Absent	Absent	Absent

Table 3. Ranks resulting from the non-parametric analyses of the microorganisms found in the different products

Different letters (a,b) in the same column represent significant differences between the orders (ranks) obtained after data transformation, which allows comparing order average values in a one-way ANOVA using the Kruskal-Wallis test. A significance level of α = 0.05 was used

Variables	Sh8mo	s.e.m.	Gt8mo	s.e.m.	Sh7mo	s.e.m.
Mesophilic microrganisms	63.51a	3.57	67.38a	4.49	33.25b	4.06
Moulds and yeasts	59.48a	4.30	53.93a	4.55	49.17a	5.49
Total coliforms	19.54a	2.52	11.00b	2.98	23.54a	2.72

The level of contamination for mesophilic aerobic microorganisms for sheep meat cured during more time (Sh8mo) varied between 5.27×10^3 and 1.35×10^7 CFU/g. Sheep meat cured during less time (Sh7mo) presented values between <10 and 7.18×10^5, whereas goat leg meat presented levels of mesophilic microorganisms that ranged between 1.17×10^4 and 1.61×10^6 CFU/g. These results suggest that the hygienic conditions during the discount and/or the temperature conditions during the storage were more appropriate for product Sh7mo and Gt8mo than for the Sh8mo treatment. However, it was verified that the time of curing had influence on the amount of mesophilic aerobic microorganisms, as Sh8mo and Gt8mo differed significantly ($P < 0.001$) from Sh7mo. These values are in accordance with the regulation CE 1441/2007 for carcasses of goats and sheep. Mesophilic microorganisms have not been described as potential causes of spoilage of dry-cured ham, even though counts greater than 6 log CFU/g of unidentified total aerobic populations have been reported in spoiled 'Serrano' and Iberian dry-cured pork hams (García *et al*. 2000).

Moulds and yeasts

Moulds and yeasts present on meat are, generally, psicotrophic and capable of growing in conditions in which bacteria cannot commonly develop (Ross and Nichols 2000). The proliferation of moulds and yeasts on meat leads to changes in the flavour and aroma, being the most commonly present genus *Candida* spp., *Cryptococcus* spp., *Debaryomyces* spp., *Hansenula* spp., *Pichia* spp., *Saccharomyces* spp. and *Trichospora* spp. (Khachatouranis and Arora 2000). Values obtained for moulds and yeasts are shown in Tables 2 and 3. The product obtained from sheep meat using treatment 1 presents values that varied between <10 and 2.19×10^7 CFU/g, and the product obtained from sheep with less time of cure between <10 and 1.34×10^7 CFU/g. Regarding samples from goat meat, the amount of moulds and yeasts was between <10 and 6.09×10^6 CFU/g.

Values obtained for these microorganisms were not significantly different between the three products under study. Results obtained are in agreement with the values found by Serio *et al*. (2009), who studied sliced dry-cured hams commercialised in Brazil. Similar values were also found by Menezes *et al*. (2010), in their study of the hygienic-sanitary quality of the sliced pork hams.

Hygienic-sanitary indicators

Total and faecal coliforms

The values obtained for total coliforms and *Escherichia coli*, indicators of food sanitary quality, are shown in Tables 2 and 3. The presence of a high number of these microorganisms or the members of the *Enterobacteriacea*e family in processed foods can indicate inadequate processing or contamination after processing; being dirty equipment or the manipulation without care for hygiene the most frequent causes (Franco and Landgraf 2005). Portuguese legislation does not have specific regulations for this parameter, however, in agreement with the resolution RDC no. 12 (A Resolução RDC 2001) of the National Agency of the Surveillance Sanitary (ANVISA), in maturated meat products, coliforms levels are allowed up to 10^3 NMP (most probable number)/g. Only sheep meat cured during more time overcame this limit ($1.31 \times 10^4 \pm 2.39 \times 10^4$ NMP/g), suggesting that contamination occurred during the manufacture or after processing. This determination of coliforms in ham is very important, considering that Fang *et al*. (2003) found this group of microorganisms in 88% of the samples of ham analysed. With respect to the amount of *E. coli*, the product obtained from goat's meat (Gt8mo) differed significantly ($P < 0.05$) from that obtained from sheep meat (Sh8mo and Sh7mo), and the product Gh8mo presented the

lowest level of contamination. Phillips *et al*. (2006), found *E. coli* in carcasses and boneless samples. In addition, they also found the presence of this pathogen in legs and shoulders, with respective mean values of 0.44 and 0.63 log 10 CFU/cm^2, even though this bacteria was absent on the frozen boneless meat (Phillips *et al*. 2013).

Staphylococcus aureus

The Resolution RDC no. 12 (2001) of the ANVISA establishes the maximum tolerance for *Staphylococcus* positive coagulase up to 5×10^3 CFU/g in maturated meat products. *Staphylococcus aureus* is important to the food industry, as it is considered the third most important cause of disease in the world among reported food-borne illnesses (Normanno *et al*. 2005). The amount of *S. aureus* detected was <10 CFU/g for all the samples under study. These results show appropriate manipulation of food, suggesting that cleaning of utensils, equipment and manipulators was adequate.

Safety indicators

Safety indicators, such as *Salmonella* spp., spores of sulfite-reducing *Clostridium* and *Listeria monocytogenes* were absent in all analysed samples suggesting that they were innocuous for consumers. In their study, Fai *et al*. (2004) verified the presence of *Salmonella* spp. in ham samples obtained from a supermarket in Fortaleza. Phillips *et al*. (2006) found *Salmonella* in samples of carcasses and boneless products and Voidarou *et al*. (2006) observed the presence of spores of clostridium sulfite-reducers in samples of ham of swine analysed. Studies conducted with turkey 'Blanquet' and turkey ham, verified the absence of *Listeria* spp. in the whole products and great amounts in the sliced products, suggesting the possibility of an inadequate manipulation in the moment of slicing and storage (Araújo *et al*. 2002). The presence of *L. monocytogenes* has been related with the existence of cross contaminations during the slicing in industrial units (Pérez-Rodríguez *et al*. 2010). As microbiological criteria are absent for these products, we considered the limits proposed by Santos *et al*. (2005) for ready-to-eat food (*Staphylococcus* coagulase positive $\geq 10^2 \leq 10^4$ CFU/g; mesophilic $>10^5$ CFU/g; yeasts $>10^4$ CFU/g; moulds $>10^2$ CFU/g; coliforms $>10^3$ CFU/g and *E. coli* ≥ 10 CFU/g). According to these limits, it can be considered that the salted legs of sheep and goat have a satisfactory microbiological quality. Comparing our results with the previously reported studies the product obtained in our study has an excellent quality.

Correlations between a_w, pH and the microbiote of the cured legs of sheep and goats

Correlations among a_w, pH and the several analysed microbiological parameters are summarised in Table 4.

Table 4. Correlations between the numbers of mesophylic microrganisms, moulds and yeasts, water activity (a_w) and pH

Fungi – moulds and yeasts; the values in bold are significantly different ($P < 0.05$) from zero (0), $n = 21$

| Variables	Total coliforms	Mesophylic	Moulds and yeasts	a_w
Mesophylic	−0.083 (0.631)	–	–	–
Fungi	0.306 (0.070)	−0.111 ($P = 0.254$)	–	–
a_w	0.321 (0.064)	−0.045 ($P = 0.657$)	**0.477 ($P < 0.001$)**	–
pH	0.128 (0.470)	−0.003 ($P = 0.973$)	−0.073 ($P = 0.455$)	**−0.278 ($P = 0.005$)**

Moulds and yeasts were significantly highly correlated with a_w ($P < 0.001$). No correlations between coliforms or mesophylic microorganisms and the physical parameters of pH and a_w were verified. Absence of correlation between these microorganisms and the physical factors, despite their reported high sensitivity to a_w and pH by Jay (2005), may be related with the low number of CFU/g found on the analysed products.

Yeasts identification

Yeasts play diverse roles in affecting the quality and safety of food products, what justifies their quantification and further identification (El-Sharoud *et al*. 2009). There were identified five species of yeasts; *Candida famata* (*Debaryomyces hansenii*), *Candida zeylonoides*, *Candida norvegensis*, *Candida sphaerica* and *Rodothorula mucilaginosa* (Fig. 2).

Fig. 2. Average percentages of the yeast species found in the different cured products.
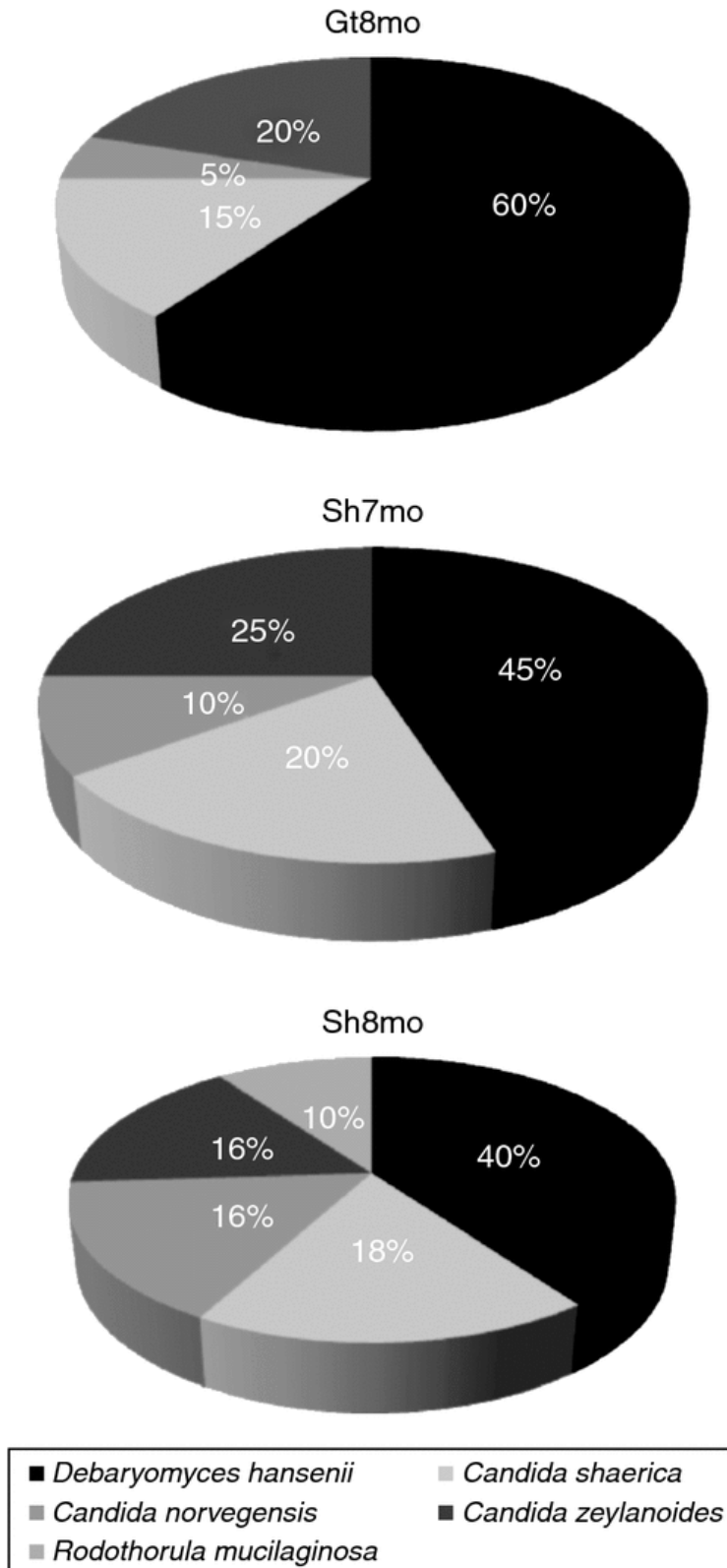
Four of the five found species belonged to the gender Candida (*famata*, *zeylanoides*, *norvegensis*, *shaerica*), with *Candida famata* being the predominant yeast in all of the analysed products where yeasts were quantified. It was present in 60% of the samples of goats (Gt8mo), 45% of the sheep samples with less time of cure (Sh7mo) and 40% of the sheep samples with more time of cure (Sh8mo). *Debaryomyces* spp. has been reported that has a positive impact on the volatile compounds involved in flavour development of dry-cured meat products inoculated with other microorganisms as mixed starter cultures (Martín *et al.* 2006). However, this yeast is not considered a pathogenic agent for man and it was never related with any disease of the food forum. It has been described that its resistance to salt does not depend on a specific gene but in a group of factors that cooperate among themselves and check its halotolerancy (Prista *et al.* 2005). *Rhodotorula mucilaginosa* was just found in the samples of Sh8mo, in a percentage of 10%. It is a common inhabitant of the atmosphere, and can act as an indicator of lack of hygiene during handling, processing and packaging. *Candida zeylanoides* was identified in 25%, 20%, and 16% of the samples of Sh7mo, Gt8mo and Sh8mo, respectively. *Candida*

shaerica was identified in 15% of the samples of Gt8mo, 18% of the Sh8mo and in 20% of the Sh7mo. *Candida norvegensis* was present in 16%, 10% and 5% in the samples of Sh8mo, Sh7mo and Gt8mo, respectively. These facts are in agreement with Junqueira *et al*. (2012). It is reported that these yeasts rarely cause infection in humans but their presence can originate diseases in immunodepressed patients.

Sensory analyses

According to the literature, meat tenderness and flavour appear to be the most important sensory characteristics that determine meat quality (Sañudo *et al*. 1996).

Fig. 3 shows a factorial map, according to the objects configuration (treatment type and their sensory characteristics), obtained after performing generalised procrustes analysis.

Fig. 3. Consensus configuration: joint representation of correlation between sensory traits and first two dimensions and groups of animal meat coordinates for the sheep and goat cured leg sensory analysis. F1 = first principal component of generalised procrustes analysis (GPA); F2 = second principal component of GPA; Sh7mo – sheep leg cured 7 months; Sh8mo – sheep leg cured 8 months; Gt8mo – goat leg cured 7 months. Hard – hardness; String – stringiness; Bright – brightness; Juici – juiciness; RanAr – rancid aroma; AciAr – acid aroma; YellApp – yellow appearance; SweAr – sweet aroma; RedApp – red appearance; Marb – marbling; MeatTas – meat taste; AciTas – acid taste; SweInt – sweet intensity; MeatAr – meat aroma; RanTas – rancid taste; SalTas – salty taste; ArInt – aroma intensity; TasPer – taste persistence; TasInt – taste intensity.
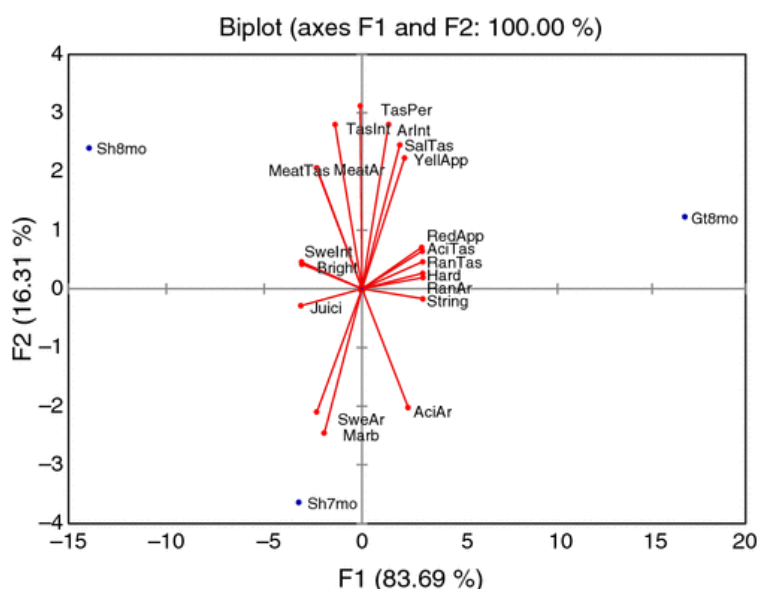
Two factors could explain total variability of data. The first dimension explained 83.69% of the variability and the second the remaining 16.31%.

Analysis of Fig. 3 allows to conclude that goat legs present higher values of rancid flavour and acid flavour, and sheep legs with 8 months of cure present the most intense meat flavour, however sheep legs with 7 months of cure present the smallest intensity in all flavour attributes, because it was placed in the opposite direction of the vectors of the same attributes. It has been observed, that goats' cured legs had higher rancid aroma; less time cured sheep legs (Sh7mo) present higher values of sweet aroma and smaller aroma intensity; and sheep legs with larger cure time (Sh8mo) present higher meat aroma. These results are not corroborated by Rodrigues *et al*. (2011). They verified higher values of odour intensity and flavour in sheep cured meat relative to goats' cured meat.

Concerning appearance, less time cured sheep legs (Sh7mo) present a higher value of marbling, goats' meat had a larger intensity of red colour and sheep meat cured longer (Sh8mo) showed larger bright intensity.

Regarding texture, sheep legs cured for less time (Sh7mo) were juicier, whereas goat legs were harder. These results are corroborated by Rodrigues *et al*. (2011) in cured meat (salted and dry). Treatments were clearly discriminated and identified by the panellists, forming much separated groups, with Gt8mo located in the first quadrant, Sh8mo in the second and Sh7mo in the third. It means that the three treatments have different characteristics and the evaluation of the panellists for the different types of samples was quite consensual.

Table 5 contains the characteristics ordered from the one that has the highest discriminating power to the one that has the lowest discriminating power on the meat samples. Associated test values and *P*-values are displayed. These values were obtained as an output from the Characterisation of the Product procedure of XLStat software (Addinsoft 2015), based on the work of Husson and Pagès (2003).

Table 5. Characteristics ordered from the one that has the highest discriminating power to the one that has the lowest discriminating power on the evaluation of the different types of cured legs

Means by group, pooled s.e.m. and associated test values (a statistical parameter obtained as the sum of the effect of Product and Judge, Y = Product effect + Judge effect) and their significance (*P*-values) are displayed. Means represent the average score given by judges in an unstructured scale of 10 cm, anchored at the extremes (0 – sensation absence and 10 – extremely intense sensation). Letters a and b represent the average for each sensory attribute that stand out positively and negatively, respectively

Descriptors	Gt8mo	St8mo	Sh7mo	s.e.m.	Test values	*P*-values
Hardness	8.418a	4.558b	4.164b	0.41	5.232	<0.001
Stringiness	7.587a	5.051b	4.905b	0.33	3.982	<0.001
Brightness	3.880b	5.672a	5.010	0.24	3.728	<0.001
Juiciness	3.835b	6.528a	6.861a	0.40	3.656	<0.001
Rancid aroma	5.043a	4.201	3.486b	0.33	2.577	0.005
Acid aroma	4.832a	4.027	3.407b	0.34	2.273	0.012
Yellow appearance	5.804a	5.221	4.572b	0.25	2.010	0.022
Sweet aroma	3.331b	4.027	4.369a	0.30	1.893	0.029
Red appearance	6.186a	4.982	5.142	0.36	1.742	0.041
Marbling	3.372b	3.775	4.243a	0.25	1.634	0.051
Meat taste	4.735b	5.955a	5.338	0.27	1.604	0.054
Acid taste	5.178	4.384	3.949	0.38	1.458	0.072
Sweet taste	3.231b	4.042	3.992	0.36	1.427	0.077
Meat aroma	4.665	5.563	5.054	0.32	1.112	0.133
Rancid taste	4.619	4.111	3.432	0.34	0.982	0.163
Salty taste	5.466	5.186	4.590	0.23	0.960	0.168
Taste intensity	5.792	6.185	6.492	0.21	0.484	0.314
Aroma intensity	5.685	5.633	5.131	0.30	0.482	0.315
Taste persistence	5.945	6.042	6.457	0.23	-0.284	0.612

Hardness presents the highest power to discriminate, followed by the stringiness, brightness, juiciness, rancid aroma intensity, acid aroma intensity. Flavour persistence is the attribute with less power to discriminate the products.

Respecting Gt8mo (Table 5) hardness was the most positively highlighted parameter, followed by stringiness, muscle red appearance, rancid aroma intensity, acid aroma intensity and fat yellow appearance. Juiciness was negatively highlighted followed by brightness, meat taste, and sweet aroma intensity.

Regarding sheep legs cured for more time (St8mo), brightness, juiciness and meat flavour were the attributes that present the highest coefficients, and hardness and stringiness the smallest.

Sheep legs cured for less time (Sh7mo) presented higher juiciness, marbling and sweet flavour intensity. Smaller coefficients for the hardness, stringiness and intensity of rancid aroma are observed.

These results are similar to the ones found by several authors. Costa *et al*. (2008) stated that sheep meat is softer and juicier than goat meat. According to Wood (1990), a high correlation between juiciness and the amount of meat fat exists. This can justify the characterisation done by panellists, relatively to this parameter, because, they characterised the sheep cured legs as being juicier than the goats'. These results were also corroborated by the observations of Rodrigues *et al*. (2011) when studying the sensory analysis of goat and sheep salted and dry meat.

Conclusions

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1. The results were within the limits stipulated by the consulted specifications;

2. There were not found significant differences regarding the commercial quality parameters of the samples Sh8mo, Gt8mo and Sh7mo;

3. Concerning the sanitary quality, total coliforms were only detected in reduced levels in some of the analysed samples, presenting goat meat with the lower values;

4. The number of total coliforms of goat's meat differed significantly (*P* < 0.05) from that obtained for the sheep products obtained with the two treatments (Sh8mo and Sh7mo);

5. Safety indicators were absent in all the analysed samples, suggesting that this product is safe for the consumer;

6. A highly significant positive correlation was verified between the pH and a_w and moulds and yeasts;

7. The panellists were able to distinguish the different treatments;

8. The legs cured goats were characterised as harder and less juicy when compared with the products obtained from sheep meat;

9. Sheep meat with longer time of cure (Sh8mo) was the brightest and sheep meat with smaller time of cure (Sh7mo)

was the most succulent;

10. Goat meat presented higher values of rancid and acid flavour;

11. Sheep meat submitted to more transformation presented the most intense flavour and cured sheep in less time had the lowest intensity in all the attributes of taste;

12. Findings reported here suggest that the analysed products have the appropriate conditions to be well accepted by the consumers, but further research is needed on the impact of the storage, initial and final microbiota, tendency to organoleptic changes and shelf-lifetime of the final product.

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