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Goat meat quality. Effects of salting, air-drying and ageing processes☆

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ABSTRACT

The effects of ageing, salting, and air-drying processes in color and water activity were studied in the *subscapular* and *semimembranosus* muscles. Also, characteristics as pH, color, water activity, water-holding capacity, texture and determination of the heminic pigments were assessed on raw meat of *longissimus thoracis et lumborum* muscle.

Animals were slaughtered at the Bragança slaughterhouse. Carcasses weighing between 16.6 kg and 24.4 kg were cooled at 4 °C during 72 h and 120 h, corresponding to ageing 1 and ageing 2 treatments, respectively. Carcasses were then deboned, divided into quarters and submitted to a salting process for 60 h and drought for 48 h.

The process of salting had a great influence in all color parameters (L*, a*, b*, H* and C*). During salting process the values of Hue (H*) became higher while Chroma (C*) lower, making the meat darker. The b* index showed changes according salting process, as it was higher for ageing 1. Water activity (a_w) decreased with salting and air-drying processes, important for the product preservation. The texture was the most influenced parameter by ageing process. The longer period of ageing makes the meat tender and reduces the toughness.

1. Introduction

Goat meat is one of the most consumed meats in the World and according to Teixeira (2003) Portugal traditionally consumes specially kid meat in Easter and Christmas. Goat meat represents an important part of food consumption and is one of the main products of several traditional dishes in Mediterranean diet and as referred by Teixeira et al. (1995), consumers value low-fat, high-quality products. Nevertheless, meat from heavier animals and particularly the older ones as well as culled goats are not very well appreciated. Such meat is more suitable to process as drought, cured with salts or smoked meat products (Webb et al., 2005). Particularly in Spain, as well as in other European countries as Italy, the draught animals as well as the culled goats were slaughtered, salted, smoked and air dried following a recipe for cured ham laid down 2000 years ago (Sterling and Jones, 2000). This product was called *cecina*, after the Latin *siccina* that means cured meat, and nowadays is being made with top quality beef also designated popularly as "beef ham". This product also comes as *cecina de cabra* and *cecina de castro*n, made from the legs of goat meat called as "goat ham" (Hierro et al., 2004), as well *violin di capra* an Italy typical goat dry-cured goat ham (Fratianni et al., 2008). Also in Brazil, particularly in north east the manufacturing of fermented sausages containing goat meat is an alternative use of meat from old animals (Nassu et al., 2003) and to increase the added value of dry salted goat and sheep meats (Madruga et al., 2005). Devatkal and Naveena (2010) have recently studied the effect of salt and other products as kinnow and pomegrade on color and oxidative stability of goat meat during refrigerated storage. So, the use of processes as salting, smoking and air-drying to preserve meat products was a practice before the global usage of refrigeration but nowa-

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days becomes more and more important as a way to recover old recipes for upgrading meat products. So, the objective of the present work was to study a strategy, which gives value-added to meat from culled goats, which have a very low commercial price, developing a new meat product.

2. Material and methods

2.1. Animals and meat processing

Ten culled goats from *Serrana* breed, between 5 and 9 years old were used. All animals were selected from the cull of the experimental flock of the Agrarian Scholl of Polytechnic Institute of Bragança and were submitted at the same feeding system, which consisted in daily natural grassland and 200 g of concentrate supplement during lactation period. Animals were slaughtered in the Bragança commercial abattoir. The average carcass weight was between 16.6 kg and 24.4 kg. After slaughter carcasses were cooled at 4 °C, and submitted to two ageing treatments, five for 72 h (ageing 1) and the other five for 120 h (ageing 2). Carcasses were divided into quarters by a straight cut from a point close to the lower edge of the backbone at the 13th rib and then deboned. Fresh meat characteristics such as pH, color, water activity, water-holding capacity (WHC), texture and determination of heminic pigments were assessed in the *longissimus thoracis et lumborum* muscle (MTL), as described below. The boneless meat was then submitted to a salting process for 60 h followed by 48 h air-dried at 8–10 °C. The product processes fabrication involved the following stages: 1 – deboning; 2 – salting and staking meat pieces into piles, separating each one from the other by a 5 cm of coarse marine salt during 60 h; 3 – stumbling each 12 h throwing down the upper-most piles; 4 – washing to remove the excess of salt; 5 – air-drying at 8–10 °C during 48 h and finally 6 – vacuum packaging. During salting, stumbling and air-drying meat samples were collected for instrumental measurements and analysis.

2.2. Instrumental measurements

According to the definition of processing/fabrication method the effects of ageing, salting and drying on physical characteristics of meat such as color and water activity (a_W) were assessed in *subscapularis* and *semimembranosus* muscles. Also physical color parameters were assessed in salting and air-dried samples meat.

The pH was measured immediately before cutting carcasses in MTL using the equipment Crison, pH-metro 507 and a 52-32 spear electrode. Meat color was obtained in fresh meat samples in MTL as well as in salting and air-dried samples in *subscapularis* and *semimembranosus* muscle, using a chromameter Minolta CR 300 and the coordinates lightness (L*), redness (a*) and yellowness (b*) according to CIE (1986). The Hue (H*) and Croma (C*) coordinates were calculated using the color parameters. The WHC was measured according to Honikel (1998). Meat samples were placed inside a bag into a water bath heated at 70 °C. After cooled, the muscle was cut (the cut line parallel to the muscle fibres direction) in pieces of about 2 cm long and 1 cm^2 section, and measured (8 repetitions for sample) the maximum shear force (SF) in kgf with an *Instron* press equipped with a Warner-Bratzler cell (WBSF). Water activity (a_W) was analyzed by AOAC (1990) procedures as a measure of water content and was assessed using the *HygroPalm* a_W1 with a probe measuring over the range 0–1 a_W or 0–100% relative humidity, with a temperature control of measurements. Haem pigments were obtained using the reflectance of the exposed surface by spectroscopy by a *Spectronic Unicam* 20 *Genesys e mode* l4001/4. The method is based on the muscle pigment content by Hornsey (1956). The spectrophotometer was adjusted to 512 nm as isobestic point (Stewart et al., 1965) and the reflectance data of the meat surface were used to obtain the deoxymyoglobin (Mb), oxymyoglobin (MbO2) and metmyoglobin (MMb). Results were expressed in total pigments as OD*8.82 (mg of myoglobin/g of muscle).

2.3. Statistical analyses

The experimental design was completely random. Parameters such as pH, water-holding capacity, texture, pigments, water activity and color, in fresh meat, during salting and air-drying, were analyzed. The effect of ageing was studied.

Table 1
Ageing effect on fresh meat color and physical properties. Results correspond to the means ± standard deviation.

	Effect of ageing		Significance
	Ageing 1	Ageing 2	
Color parameters			
L*	33.0 ± 3.82	32.3 ± 3.06	NS
a*	17.4 ± 2.26[a]	14.4 ± 2.87[b]	**
b*	8.0 ± 1.89[a]	6.0 ± 1.55[b]	**
H*	24.5 ± 4.46	22.3 ± 2.69	NS
C*	140.4 ± 43.85[a]	89.7 ± 37.73[b]	**
Physical parameters			
pH	5.8 ± 0.23	5.8 ± 0.21	NS
a_w	0.98 ± 0.009[a]	0.97 ± 0.002[b]	**
WHC	28.6 ± 5.82	22.1 ± 3.59	NS
DO*8.82[1]	5.3 ± 1.18	5.8 ± 0.86	NS
SF (kgf/cm^2)	9.9 ± 2.04[a]	6.7 ± 1.29[b]	**

[1] DO*8.82 – corresponds to mg myoglobin/g fresh muscle.
Means in the same column with different superscripts differ significantly: *$P < 0.05$; **$P < 0.01$; NS – not significant.

Fresh meat pH, color, and a_w as well as pigment determination, water-holding capacity and texture, and color and aw during salting and air-drying data were submitted to an analysis of variance, with ageing as only treatment with two levels (72 e 120 h). One-way ANOVA procedure from SPSS software for Windows, version 17.0, was used.

3. Results and discussion

The fresh meat characteristics according to ageing are shown in Table 1. The pH, WHC and pigments were not affected by meat ageing process which significantly influenced the a* and b* meat color parameters and as a result the Chroma (C*) value of ageing 2 which was lower than ageing 1 (140.4 *vs* 89.7). The differences verified for C* put in evidence, according to Young et al. (1999) that the knowledge that blooming is slow in the first 24 h post-rigor, casts doubt on the value of subjective or objective color assessments made in chillers. However the color changes of a* and b* reflected myoglobin oxidation during refrigeration as has been pointed out by Kannan et al. (2001). Nevertheless, using different experimental conditions and different muscle samples, Dzudie et al. (2000b) studying the effect of curing time on quality of goat ham found that pH and WHC were significantly affected. Paleari et al. (2002) comparing curing and fermentation of goat meat found pH values relatively higher than the present study (6.48 *vs* 5.8).

Ageing had a significant positive effect in reducing a_W and meat shear force. The most affected meat quality parameter observed for ageing processing was texture, 6.7 kgf and 9.0 kgf for ageing 2 or 1, respectively. Dzudie and Okubanjo (1999) observed a reduction of shear force with tumbling time processing of goat hams. Also Dzudie et al. (2000a) found that shear force was the main characteristic affected by curing process of goat loins.

On Table 2 is shown the effect of salting processing in the meat color. The C* parameter of ageing 2 was significantly lower than ageing 1 during salting process while the H* was higher, 64.6 *vs* 76.9 and 39.2 *vs* 35.2, respectively. Also redness (a*) of meat aged for 120 h was lower than meat aged only for 72 h. Salting time had a signifi-

Table 2
Ageing and salting time effects on meat color properties. Results correspond to the means ± standard error.

	Experimental conditions	L*	a*	b*	H*	C*
Ageing treatment	1	33.8 ± 0.18	10.9 ± 0.16^{a}	6.6 ± 0.09	35.2 ± 0.52^{b}	76.9 ± 1.63^{a}
	2	34.2 ± 0.18	9.3 ± 0.16^{b}	6.6 ± 0.09	39.2 ± 0.52^{a}	64.6 ± 1.63^{b}
Salting time (hours)	0	34.5 ± 0.30^{a}	19.0 ± 0.27^{a}	8.3 ± 0.16^{a}	23.7 ± 0.89^{d}	159.0 ± 2.82^{a}
	12	33.3 ± 0.30^{b}	13.6 ± 0.27^{b}	6.1 ± 0.16^{b}	25.5 ± 0.89^{d}	87.1 ± 2.82^{b}
	24	33.6 ± 0.30^{ab}	9.3 ± 0.27^{c}	6.1 ± 0.16^{b}	35.8 ± 0.89^{c}	57.4 ± 2.82^{c}
	36	33.9 ± 0.30^{ab}	7.0 ± 0.27^{d}	6.1 ± 0.16^{b}	42.5 ± 0.89^{b}	43.6 ± 2.82^{d}
	48	34.3 ± 0.30^{ab}	5.9 ± 0.27^{de}	6.3 ± 0.16^{b}	47.3 ± 0.89^{a}	38.4 ± 2.82^{d}
	60	34.7 ± 0.30^{a}	5.8 ± 0.27^{e}	6.5 ± 0.16^{b}	48.3 ± 0.89^{a}	38.7 ± 2.82^{d}
Effects	Ageing	NS	***	NS	***	***
	Salting time	**	***	***	***	***
	A × ST	*	***	*	***	***

Means in the same column with different superscripts differ significantly: *P < 0.05; **P < 0.01; ***P < 0.001; NS – not significant.

Table 3
Ageing and air-drying time effects on meat color properties. Results correspond to the means ± standard error.

	Experimental conditions	L*	a*	b*	H*	C*
Ageing treatment	1	32.2 ± 0.28	4.5 ± 0.12	6.5 ± 0.16^{a}	54.8 ± 0.67	30.7 ± 1.42^{a}
	2	32.0 ± 0.28	4.3 ± 0.12	5.9 ± 0.16^{b}	53.5 ± 0.67	26.7 ± 1.42^{b}
Air-drying time (hours)	24	32.9 ± 0.28^{a}	4.5 ± 0.12	6.5 ± 0.16^{a}	55.1 ± 0.67^{a}	29.8 ± 1.42
	48	31.3 ± 0.28^{b}	4.4 ± 0.12	6.0 ± 0.16^{b}	53.2 ± 0.67^{b}	27.6 ± 1.42
Effects	Ageing	NS	NS	*	NS	*
	Air-drying time	***	NS	*	*	NS
	A × ADT	NS	NS	NS	NS	NS

Means in the same column with different superscripts differ significantly: *P < 0.05; **P < 0.01; ***P < 0.001; NS – not significant.

cant effect on all meat color variables, increasing the H* and diminishing a*, b* and C*. L* reduced from the beginning of salting until 12 h, and then increased until the end of the process. A significant interaction between ageing and salting time was observed, meaning that meat samples aged for different times behaved differently with salting time. Similar effects of salting and storage on lightness and redness (a*) on ground goat meat were found by Devatkal and Naveena (2010).

On Table 3 is shown the effect of air-drying process in the meat color. During the air-drying process the b* and C* values were higher for ageing 1 than ageing 2 (30.7 *vs* 20.7) making the meat darker. This means that ageing makes the meat color less yellow and less vivid. Air-drying reduced L*, b* and C* values. Meat samples became less luminous, yellow and vivid with the air-drying process. As well as Devatkal and Naveena (2010) we also found that yellowness (b*) showed an inconsistent trend during storage.

There was a significant ageing effect on a_W in the salting and air-drying processes (Table 4). Water activity (a_W) of Ageing 1 meat samples dropped from 0.98 in fresh meat to 0.86 in salted meat to 0.76 in air-dried meat. In ageing 2 meat samples the same variable (a_W) dropped from 0.97 in fresh meat to 0.87 in salted meat and to 0.79 in air-dried meat The same effect was found by Nassu et al. (2003) in fermented goat meat sausages as well as Paleari et al. (2002, 2003) studying several animal species but particularly when comparing between raw and cured goat meat (a_W between 0.94 and 0.88). The a_W values were very similar to the water activity found by Torres et al. (1994) for the Charqui, a typical Brazilian meat product obtained by salting and sun-drying beef.

Table 4
Salting and air-drying effects, according to ageing, on water activity (a_W). Results correspond to means ± standard deviation.

a_W	Ageing 1	Ageing 2	Significance
Fresh meat	0.98 ± 0.003	0.97 ± 0.003	NS
Salting	0.86 ± 0.003	0.87 ± 0.003	***
Air-drying	0.76 ± 0.003	0.79 ± 0.003	***

Means in the same column with different superscripts differ significantly: *P < 0.05; **P < 0.01; ***P < 0.001; NS – not significant.

4. Conclusion

The changes of a* and b* verified reflected the myoglobin oxidation during refrigeration and ageing process. Salting and air-drying affect the C* and H* parameters making the meat darker and reducing the water activity which was extremely important for final product preservation. The ageing process is important in terms of meat texture, since longer ageing periods make the meat tender and reduces the toughness.

Conflict of interest

None of the authors (Alfredo Teixeira and Sandra Rodrigues) has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the paper entitled “Goat meat quality. Effects of salting, air-drying and ageing processes”.

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