Meat Science 92 (2012) 62–70

Contents lists available at SciVerse ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effect of slaughter weight and breed on instrumental and sensory meat quality of suckling kids

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ARTICLE INFO

Article history:
Received 20 September 2011
Received in revised form 4 April 2012
Accepted 5 April 2012

Keywords:
Goat
Panel test
Sensory analysis
Colour
Texture

ABSTRACT

The effects of breed and slaughter weight on chemical composition, fatty acid groups, texture, and sensory characteristics of meat of 141 suckling male kids from 5 Spanish breeds were studied. There was a decrease in texture and lightness and hue angle with the increase of the slaughter weight. Fatty acid composition was correlated with the intramuscular fat content. All the breeds except MO had values of n−6/n−3 ratio below 4, which is the healthy limit recommended, and a low atherogenic index as well as a low intramuscular fat content. A multivariate analysis discriminated light kid, which had the most tender and juicy meat, from heavy kid which had more intense kid and milk odours. Blanca Andaluza and Pirenaica had most tender and juicy meat. The effect of slaughter weight on meat traits should be considered separately for each breed to find the most appropriate meat according to consumers preferences.

1. Introduction

Spain has the second largest goat population in Europe (FAOSTAT, 2010). Although most of the goat breeds in Spain are for milk production, there is also a considerable goat meat farming activity (Castel, Micheo, Mena, Fernández, & Sánchez, 2005) due to the fact that many of the breeds are reared in extensive conditions and milking is not considered to be economically feasible. The most widely used systems in goat farming in the Mediterranean countries involve kids fed on their dams' milk, which are slaughtered at low live weights of approximately 10 to 11 kg (Marichal, Castro, Capote, Zamorano, & Arguello, 2003). In fact, 88% of European Union (EU) goats are raised extensively and slaughtered as kids, with carcass weights between 5 and 11 kg and belong to breeds suitable for meat production (Shrestha & Fahmy, 2007). In Spain, the preferred goat meat is that of suckling kids, although it is a product that is less well known than suckling lamb. In 2008 the average carcass weight of goats produced in Spain was 11 kg, with most carcasses (82%) classified as "suckling kids".

In Mediterranean countries, light-coloured meat is associated with the meat of young animals, which is preferred. Spanish consumers associate meat from suckling kid and lamb with tender, juicy, tasty meat and, especially in the case of kid meat, with a high price (Sañudo, Sanchez, & Alfonso, 1998). Meat colour is influenced by several factors in the feeding–breeding system (Alcalde & Negueruela, 2001) such as breed, age/slaughter weight, ultimate pH and many others factors (Ripoll, Alcalde, Horcada, & Panea, 2011). Furthermore, young goat meat is characterized by a low intramuscular fat content, and there is an increasing interest in the lipid composition of edible meat owing to its relationship to human health, particularly to cardiovascular diseases (Hu & Willett, 2002). These health-related factors have been widely studied in cows, sheep and pigs, but very rarely in kid meat.

The aim of this study was to evaluate the effect of breed and slaughter weight on the instrumental (including chemical and sensory) meat quality of suckling kids from several Spanish breeds.

2. Materials and methods

2.1. Animals and sampling

The experimental animals were 141 male suckling kids from five breeds of Spanish meat goats (BA, Blanca Andaluza; BC, Blanca Celtibérica; MO, Moncaína; NE, Negra Serrana-Castiza; PI, Pirenaica) (MARM, 2008) slaughtered at two live weights (Light weight, 7.6 kg ± 0.80 kg; Heavy weight, 11.33 kg ± 1.20 kg). The number of animals per treatment and their slaughter weight are shown in Table 1. All newborn goat kids were fed with maternal colostrum and maternal milk until slaughtered. Goats were grazed on native pastures and supplemented with commercial feed when the pasture was not able to cover their nutritional requirements. When kids reached the target live weight they were slaughtered using standard commercial procedures.

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doi:10.1016/j.meatsci.2012.04.011

Table 1
Chemical analysis of M. *longissimus lumborum*, pH at 3 days and M. *rectus abdominis* instrumental colour of 5 goat breeds (B) at 2 slaughter weights (SW) of suckling kids.

		BA[a]	BC	MO	NE	PI	s.e.	B	SW	B×SW
n	L	13	15	16	15	15				
	H	6	15	16	15	15				
SW, kg	L[b]	7.43^{y}	7.65^{y}	7.44^{y}	7.97^{y}	7.73^{y}	0.266	ns	***	ns
	H	12.32^{x}	11.31^{x}	10.91^{x}	11.19^{x}	11.62^{x}				
pH 3d	L	5.70	5.65	5.88	5.69	5.77	0.081	ns	ns	ns
	H	5.83	5.70	5.68	5.69	5.68				
Moisture[b]	L	78.04	76.79	78.01	77.93	74.94	0.988	ns	ns	ns
	H	77.1	77.02	76.97	77.98	77.26				
Crude protein[b]	L	19.52	20.72	24.11	19.47	22.50	1.816	ns	ns	ns
	H	21.12	21.03	21.06	19.68	20.42				
Fat[b,c]	L	1.15^{b}	1.12^{b}	1.55^{b}	1.45^{b}	2.05^{ax}	0.188	*	ns	ns
	H	1.32	1.30	1.09	1.53	1.37^{y}				
Ash[b]	L	1.09	1.12	1.03	1.11	1.15	0.053	ns	ns	ns
	H	1.01	1.16	1.10	1.10	1.07				
L*	L	52.95	54.76	55.20^{x}	54.38^{x}	53.19^{x}	1.020	*	***	ns
	H	49.86^{b}	53.39^{a}	50.03^{yb}	48.32^{yb}	49.49^{yb}				
a*	L	10.91^{b}	9.31^{b}	10.14^{by}	11.73^{a}	10.30^{by}	0.681	***	ns	**
	H	10.17^{ab}	9.25^{b}	13.81^{ax}	11.11^{a}	12.32^{ax}				
b*	L	20.89^{ax}	16.82^{b}	15.03^{b}	19.60^{a}	14.53^{b}	0.867	***	***	*
	H	14.42^{by}	15.64^{b}	13.39^{bc}	19.26^{a}	12.86^{c}				
h	L	62.14^{a}	61.43^{a}	55.64^{bcx}	58.46^{ab}	54.40^{cx}	2.212	***	***	*
	H	54.87^{a}	59.90^{a}	44.30^{by}	59.57^{a}	45.87^{by}				
C	L	23.65^{ax}	19.40^{b}	18.55^{b}	23.00^{a}	18.05^{b}	0.822	***	*	**
	H	17.68^{by}	18.37^{b}	19.34^{b}	22.05^{a}	18.02^{b}				

[a] BA, Blanca Andaluza; BC, Blanca Celtibérica; MO, Moncaína; NE, Negra Serrana-Castiza; PI, Pirenaica; L, light slaughter weight; H, heavy slaughter weight.
[b] Different superscripts (a,b) indicate significant differences ($P<0.05$) among breeds. Different superscripts (x,y) indicate significant differences ($P<0.05$) between slaughter weights. ns = $P>0.05$, * = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$.
[c] Intramuscular fat content, expressed as percentage of fresh meat.

All procedures were conducted according to the guidelines of EU Council Directive 86/609/EEC (European Communities, 1986) on the protection of animals used for experimental and other scientific purposes.

Carcasses were hung by the Achilles tendon and chilled 24 h at 4 °C. After chilling, both *Longissimus thoracis et lumborum* muscles were removed from the left and right half-carcass sides and sampled. Then, samples were aged for 3 days and frozen. Ultimate pH at 3 days of slaughter was measured on the *Longissimus thoracis* of the right half-carcass with a pH-meter equipped with a Crison 507 penetrating electrode (Crison Instruments S.A., Barcelona, Spain).

2.2. Chemical analyses

To prepare meat for chemical composition analyses, M. longissimus thoracis (LT) of the left half-carcass was minced and freeze-dried in a Virtiss wizard 2.0 lyophilizer (Virtiss SP Scientific, New York, USA) for 7 d at −50 °C and 13.332 Pa, then ground. Meat was weighed before and after freeze-drying to calculate moisture content (Moist). Crude protein was determined following the Dumas procedure (A.O.A.C., 2000) using a nitrogen and protein analyser (Model NA 2100, CE Instruments, Thermoquest SA, Barcelona, Spain) and expressed as a percentage of fresh meat (CP). Intramuscular fat content was quantified using the Ankom Procedure (AOCS Am 5-04) with an Ankom extractor (Model XT10, Ankom Technology, Madrid, Spain) and expressed as a percentage of fresh meat (IMF). Ash content was assessed by dividing the weight before and after ignition in a muffle for 8 h (A.O.A.C., 2000) and expressed as percentage of fresh meat (Ash). Analyses were run in duplicate.

2.3. Instrumental colour

M. *Rectus abdominis* (RA) colour was measured 24 h after slaughter and assessed at two locations on its internal face, after having removed the covering fascia (Ripoll, Joy, Muñoz, & Albertí, 2008). A white tile placed behind the muscle was used to standardize measurements. Instrumental colour was measured using a Minolta CM-2006 d spectrophotometer (Konica Minolta Holdings, Inc, Osaka, Japan) in the CIELAB space (CIE, 1986) with a measured area diameter of 8 mm, including specular component and 0% UV, standard illuminant D65, which simulates daylight (colour temperature 6504 K), 10º observer angle and zero and white calibration. The lightness (L*), redness (a*) and yellowness (b*) parameters were recorded, and hue angle (h) and chroma (C) indexes were calculated as $h = \tan^{-1}(b^*/a^*)*57.29$, expressed in degrees and $C = (a^{*2} + b^{*2})^{0.5}$.

2.4. Texture analysis

LT of the right half-carcass was sampled, vacuum-packed and aged for 3 days. The texture of raw meat was analysed using an Instron shear machine (Model 5543, Instron Limited, Barcelona, Spain) with a modified compression device that prevents transverse elongation of the sample (Lepetit, 1989). Probes were cut with 10×10 mm^2 cross section with the fibre direction parallel to the long dimension of at least 30 mm. During compression, probes were maintained in the cell fitted with two lateral walls to avoid lateral deformation of probes. Probes can expand just along the axis of muscle fibres. Stress was assessed at the maximum compression ratio (C100) and at 20% (C20) and 80% (C80) of maximum compression. The compression ratio was calculated as the initial height of the probe minus the height of the probe at maximum compression divided by the initial height and results are expressed in N/cm^2.

2.5. Fatty acid analysis

The caudal side of the M. *longissimus thoracis* of the left half-carcass was sampled to determine the fatty acid (FA) content of intramuscular fat. The total fatty acids were extracted, methylated and analysed by an adaptation of the method described by (Aldai, Osoro, Barron, & Najera, 2006). Separation and quantification of the fatty acid methyl esters (FAMEs) was carried out using a gas chromatograph (GC, Agilent 6890 N, Inc., California, USA) equipped with a flame ionisation detector (FID) and fitted with a BPX-70 capillary column (120 m, 0.25 mm i.d., 0.2 μm film thickness, SGE, Australia). Individual FAMEs were identified using standards where available (Sigma Chemical Co. Ltd., Poole, UK). Fatty acids were expressed as a percentage of the 32 individual total