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# Effect of sex and carcass weight on sensory quality of goat meat of Cabrito Transmontano<sup>1</sup>

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**ABSTRACT:** The main purpose of this work was the characterization of Cabrito Transmontano goat kid carcass and meat, which is a Protected Origin Designation product. The effects of sex and carcass weight were studied. Sensory attributes of toughness, juiciness, flavor intensity, flavor quality, odor intensity, fiber presence (stringy), sweet intensity, and overall acceptability were evaluated in 60 males and females allocated to 3 carcass weight groups: 4, 6, and 8 kg. Sensory quality of meat was evaluated by a trained taste panel of 11 experts in 5 sessions. Generalized Procrustes analysis was performed, and 93% of total variability was explained by the 2 first factors (axes). Correlation between sen-

sory traits and factors 1 and 2 allowed the factors to be renamed as toughness/aroma and juiciness/acceptability, respectively. Procrustes analysis indicated that a sex effect was detected by experts. Meat from males presented greater juiciness, flavor quality, and general acceptability than did meat from females. Cabrito Transmontano Protected Origin Designation includes animals from 4 to 9 kg of carcass weight. However, differences among them can be important, because the taste panel found differences between animals from distinct carcass weight ranges. Lighter weight carcasses were considered more tender with less flavor and odor intensity than heavier carcasses.

**Key words:** Cabrito Transmontano, goat/kid, meat, Procrustes analysis, sensory trait

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## INTRODUCTION

Milk-fed kid “cabrito” is characterized by a low fat content, particularly intramuscular and subcutaneous fat (Babiker et al., 1990; Johnson et al., 1995). In Portugal, as well as in other south Mediterranean countries, the demand for goat meat is from milk-fed kids, 4 to 8 wk old, from milk-goat herds. Kids are cooked according to a classical cuisine in which the traditional method is to grill or roast the whole carcass, using animals with a carcass weight of 7 to 10 kg. Traditional consumption peaks are Easter and Christmas, and ideal carcasses are mainly light-weight carcasses that are fresh, rose colored, tender, and fatless (Teixeira, 2003). Consumers value low-fat, high-quality products and therefore, there is increasing potential development of the goat meat market (Teixeira et al., 1995). Moreover, recent European Union policy to deintensify

animal production and the possibility of sustainable development of otherwise useless marginal Mediterranean areas have led to renewed interest in extensive rearing systems where goat production has a fundamental role (Teixeira et al., 1998).

Although many studies have reported the influence of nutritional characteristics on purchase choice, sensory properties are also important in affecting meat acceptability (Horsfield and Taylor, 1976). Sensory analysis performed by trained panelists is the most appropriate tool to explain differences between treatments as perceived by humans. However, sensory evaluation of meat has often been misused. Frequently, preference variables are included in descriptive profiling studies, whereas in other studies, the differences between different products are discussed only in terms of overall acceptability (Risvik, 1994).

In fact, sensory attributes have great importance for consumers, producers, and retailers but also to all people interested in meat quality and technology. Compared with other species, few studies in goats are known, particularly with respect to sensory evaluation. Therefore, the aims of the study were to determine the effects of sex and carcass weight on sensory quality of goat meat and to objectively increase the amount of information to goat researchers, producers, and consumers.

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## MATERIALS AND METHODS

Carcasses were directly acquired from the Serrana National Association of Breed Producers (Mirandela, Portugal), and we did not experiment with live animals. The research project was approved by the Agro Program of the INIAP from Portuguese Agricultural Ministry.

### *Animals and Sampling*

Sixty animals (29 females and 31 males) of the Serrana breed, selected at random by the National Association of Breed Producers, and reared under normal conditions and according to the main requirements of the specifications for this Protected Origin Designation product “Cabrito Transmontano” were used. Serrana is a dual-purpose breed (milk and meat) and is the most important Portuguese goat breed. Flocks are normally reared in extensive areas of hill grazing at an altitude varying from 481 to 1,000 m, in a succession of uplands and deep valleys; the weather is often harsh and there are wide variations in food supply. The flocks are rarely given supplementary foods; some meadow hay is given only during winter. Kids were raised traditionally, suckling milk from their dams, not being weaned until slaughter at 2 to 3 mo of age, normally at the end of autumn. As described by Teixeira et al. (2005), young kids and lambs remain with their mothers during grazing.

According to the Protected Origin Designation, normal carcass weights range between 4 and 9 kg, and 3 carcass weight categories were considered: 4, 6, and 8 kg, corresponding to 7.4, 11.0, and 14.1 kg of BW, respectively. Animals were slaughtered after a 24-h fast in a commercial slaughterhouse at BW to the meet the carcass specifications given above. Carcasses were chilled for 24 h at 4°C and then transported 50 km in a refrigerated vehicle under the animal sanitary conditions and according to European Union regulations, to the Carcass and Meat Quality and Technology Laboratory of the School of Agriculture (Bragança, Portugal).

### *Sensory Analysis*

Once in the laboratory, carcasses were carefully halved and the lumbar region of the LM from the right side of the carcass was taken for sensory analysis by a trained taste panel of 11 members. Panel members were selected and trained in accordance with the Portuguese guidelines (Norma Portuguesa, 2001). Samples aged for 72 h at 4°C were vacuum packed and frozen at -21°C until taste evaluation. The day before the panel sensory session, samples were thawed at 4°C. Samples were wrapped individually in cooking bags and roasted in an oven until the internal muscle temperature reached between 70 and 80°C according to the Norma Portuguesa

(2001) and searching to reach the same temperature for all samples around 75°C.

Immediately after cooking, the LM muscle was divided in 2 cm × 2 cm × 0.5 cm samples, wrapped in aluminum foil, marked with random 3-digit codes, placed in a preheated oven at 60 to 70°C, and evaluated within 10 min. The panel members were allocated to individual randomized booths in a temperature- and light-controlled room. In all sessions the room temperature was between 20 and 22°C with 60 to 70% humidity, and the booths were illuminated with red light.

After a training period of 6 sessions evaluating, describing, and discussing goat meat quality characteristics, panelists were asked to assess each sample for the sensory attributes: toughness (the force needed to chew), juiciness (water perceived during mastication), flavor intensity (flavor of raw meat, associated with the animal species or cooked goat/kid meat), flavor quality, odor intensity (odor associated with raw meat, animal species, or cooked goat/kid meat), fiber presence (stringy, fibers perceived during mastication), sweet intensity (flavor of sugar), and overall acceptability, using a 10-cm scale with intervals but not numbered, representing at the extremes the minimum (sensation absence) and the maximum (extremely intense sensation). Panelists were asked to indicate a point on the scale corresponding to the intensity of their different feelings for each attribute, and then each one was measured using a 10-cm ruler to score it from 0 (minimum intensity) to 10 (maximum intensity).

The sensory evaluation consisted of 5 sessions. In each sensory session, samples corresponding to 6 treatments were assessed randomly and doubled in a total of 60 samples per panelist.

### *Statistical Analysis*

The model used was a completely randomized factorial design with 2 sexes (male and female) and 3 carcass weights (4, 6, and 8 kg of carcass weight) as fixed factors with no random effects. Animals were assigned to 6 groups according to their sex and carcass weight: 4-kg females (**F4**), 4-kg males (**M4**), 6-kg females (**F6**), 6-kg males (**M6**), 8-kg females (**F8**), and 8-kg males (**M8**). A sensory profile for young Serana goat meat was developed by using a generalized Procrustes analysis (**GPA**; Gower, 1975).

Generalized Procrustes analysis is a powerful multivariate technique extensively used in sensory evaluation. The analysis minimizes differences between assessors, identifies agreement between them, and summarizes the sets of 3-dimensional data (objects, characteristics, and assessors). Some graphical displays of the results were used. The data matrices of 6 (meat samples) by 8 (sensory attributes) for the 11 assessors (configurations) were matched to find a consensus using the XLSTAT version 2006, an Excel software add-in (Addinsoft, New York, NY).

**Table 1.** Residual variance, scaling factors, and percentage variation explained by the first 2 principal components for each assessor for Cabrito Transmontano sensory analysis

Assessor	Residual	Scaling factor	First dimension, %	Second dimension, %
1	7.846	1.466	70.845	1.267
2	7.456	1.402	65.635	28.580
3	3.963	0.985	92.454	3.296
4	4.305	0.920	87.376	8.936
5	14.533	1.035	53.404	37.544
6	3.457	0.895	88.370	2.988
7	5.183	0.810	93.112	1.412
8	2.233	1.120	84.440	9.849
9	12.836	0.782	63.315	28.468
10	4.861	1.485	80.465	13.169
11	5.179	0.890	72.325	14.100

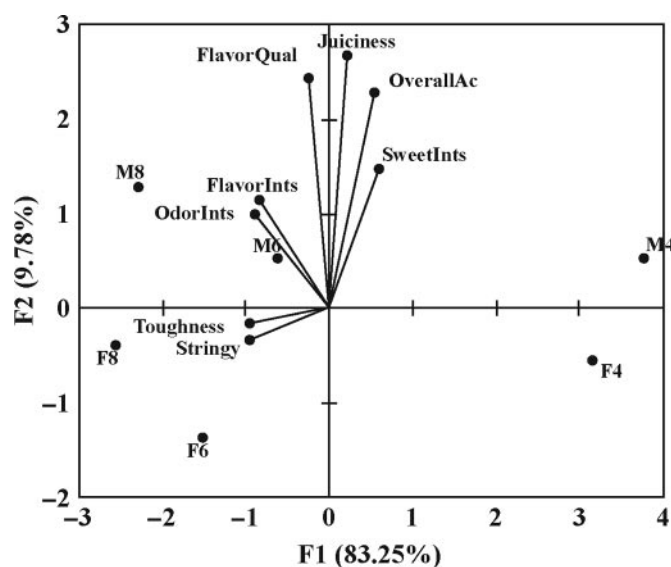
## RESULTS AND DISCUSSION

The 8 attributes described (toughness, juiciness, flavor intensity, flavor quality, odor intensity, fiber presence, sweet intensity, and overall acceptability) were used by panelists to describe differences among meat samples. The training period allowed assessors to learn the same style of the evaluation methodology, and the analysis of residuals for each assessor showed low levels of variance, confirming the reliability of the panel (Table 1). However, no training can eliminate variation among panelists (Stone and Sidel, 1985), and experts 5 and 9 showed the least consensus, having the greatest residuals and ratings not matching the consensus (Table 1). Another difficulty of sensory analysis is the tendency of some panelists to use a wide range of the

given scale, whereas others focus on a narrower part of the scale, as can be observed in the scaling factors shown in Table 1. Assessors 1, 2, 5, 8, and 10 tended to use a wider range of the scale because they presented scaling factors greater than 1. Residuals by object (Table 2) showed that M4 had the lowest value followed by F8; these meat samples, therefore, had the greatest consensus.

To minimize the differences between assessors, GPA was used to find a consensus (Figure 1). The first 2 principal axes of the consensus configuration accounted for 93% of the total variation among the samples, and each of the remaining axes explained a relatively small fraction of the remaining 7% of the total variation.

The means and standard errors of sensory traits (8 attributes) observed by panelists (11 members) for all meat categories (612 meat samples) are given in Table 3, and the correlation between sensory attributes and the factors 1 and 2 (**F1** and **F2**) indicate that toughness and stringy, as well as flavor and odor intensity, are highly and negatively correlated with F1, as their vectors direct to the negative part of the axis representing the respective factor. At the same time juiciness and flavor quality, whose vectors direct to the positive part of the axis, which represents F2, are highly and positively correlated with it. In agreement with our results, Cameron et al. (1990) working with Duroc and British Landrace pigs for meat and using a multivari-



**Figure 1.** Consensus configuration: joint representation of correlation between sensory traits and first 2 dimensions and groups of animal meat coordinates for Cabrito Transmontano sensory analysis. F1 = first principal component of generalized Procrustes analysis (GPA); F2 = second principal component of GPA; F4 = 4-kg (carcass weight) females; M4 = 4-kg males; F6 = 6-kg females; M6 = 6-kg males; F8 = 8-kg females; M8 = 8-kg males.

**Table 2.** Residual variance for each meat group (by sex and carcass weight) for Cabrito Transmontano sensory analysis

Meat group <sup>1</sup>	Residual
F4	13.384
M4	5.361
F6	13.326
M6	12.738
F8	9.793
M8	17.249

<sup>1</sup>F4 = 4-kg (carcass weight) females; M4 = 4-kg males; F6 = 6-kg females; M6 = 6-kg males; F8 = 8-kg females; M8 = 8-kg males.

**Table 3.** Correlation between sensory traits and factors produced in generalized Procrustes analysis (GPA) for Cabrito Transmontano sensory analysis and sensory scores (means  $\pm$  SEM) assessed by panelists

Sensory trait	GPA <sup>1</sup>		Meat group <sup>2</sup>					
	F1	F2	F4 (n = 92)	M4 (n = 112)	F6 (n = 102)	M6 (n = 102)	F8 (n = 102)	M8 (n = 102)
Toughness	-0.998	-0.053	1.75 $\pm$ 0.19	1.16 $\pm$ 0.11	4.64 $\pm$ 0.28	3.90 $\pm$ 0.27	5.21 $\pm$ 0.30	5.00 $\pm$ 0.30
Juiciness	0.244	0.951	4.51 $\pm$ 0.27	4.96 $\pm$ 0.23	4.04 $\pm$ 0.21	4.67 $\pm$ 0.21	4.48 $\pm$ 0.22	4.98 $\pm$ 0.25
Flavor intensity	-0.879	0.410	4.49 $\pm$ 0.20	4.56 $\pm$ 0.19	4.96 $\pm$ 0.17	5.04 $\pm$ 0.18	5.51 $\pm$ 0.18	5.84 $\pm$ 0.18
Flavor quality	-0.261	0.867	4.97 $\pm$ 0.20	5.33 $\pm$ 0.19	5.00 $\pm$ 0.18	5.09 $\pm$ 0.17	5.32 $\pm$ 0.18	5.78 $\pm$ 0.19
Overall acceptability	0.571	0.813	5.06 $\pm$ 0.21	5.42 $\pm$ 0.19	4.44 $\pm$ 0.17	5.08 $\pm$ 0.15	4.70 $\pm$ 0.19	5.34 $\pm$ 0.19
Odor intensity	-0.913	0.356	4.68 $\pm$ 0.27	4.90 $\pm$ 0.25	5.39 $\pm$ 0.24	5.61 $\pm$ 0.24	5.95 $\pm$ 0.25	6.08 $\pm$ 0.23
Stringy	-0.986	-0.116	2.60 $\pm$ 0.23	2.37 $\pm$ 0.25	4.86 $\pm$ 0.25	4.48 $\pm$ 0.26	5.23 $\pm$ 0.25	4.68 $\pm$ 0.27
Sweet intensity	0.625	0.526	5.55 $\pm$ 0.19	5.67 $\pm$ 0.16	5.37 $\pm$ 0.16	5.49 $\pm$ 0.16	5.14 $\pm$ 0.18	5.52 $\pm$ 0.19

<sup>1</sup>F1 = first principal component of GPA; F2 = second principal component of GPA.

<sup>2</sup>F4 = 4-kg (carcass weight) females; M4 = 4-kg males; F6 = 6-kg females; M6 = 6-kg males; F8 = 8-kg females; M8 = 8-kg males.

ate analysis to assess texture profiles showed that juiciness and tenderness are independent attributes. The results of work by Nute et al. (1987), in which hams were separated along a GPA dimension, indicated that tenderness and juiciness are responsible for major parts of this variation. Similarly, the work performed by Harries et al. (1972) describes “toughness-tenderness” and “juiciness” as being separated into 2 factors in a principal components analysis of 69 beef roasts, indicating that tenderness and juiciness are independent phenomena. Likewise, Risvik (1994) discussed a principal components analysis procedure to analyze a sensory profile of 36 pork samples selected from 3 breeds to obtain a maximum variation of intramuscular fat at slaughter (75 to 80 kg). The attributes juiciness and fatness fell along dimension 1, whereas hardness and chewing resistance fell along dimensions 1 and 2, opposite to juiciness and fatness. Before that, Horsfield and Taylor (1976) presented a revision regarding the relationship between sensory data and acceptability of meat and described a system of 3 independent principal components: succulence, toughness, and flavor, which contributed to the prediction of acceptability in this order.

Giving names to principal components (that is, indicating causal relationships) should only be done when results are confirmed in several studies designed for this purpose and performed by several independent groups. Taking into account the results from the above-mentioned works (Harries et al., 1972; Horsfield and Taylor, 1976; Nute et al., 1987; Cameron et al., 1990; Risvik, 1994) and our results in goat meat quality, juiciness and tenderness are the most important sensory attributes to give names to the axes plotted in Figure 1, and the abscissa represents tenderness (toughness and stringy) and the ordinate represents mainly juiciness.

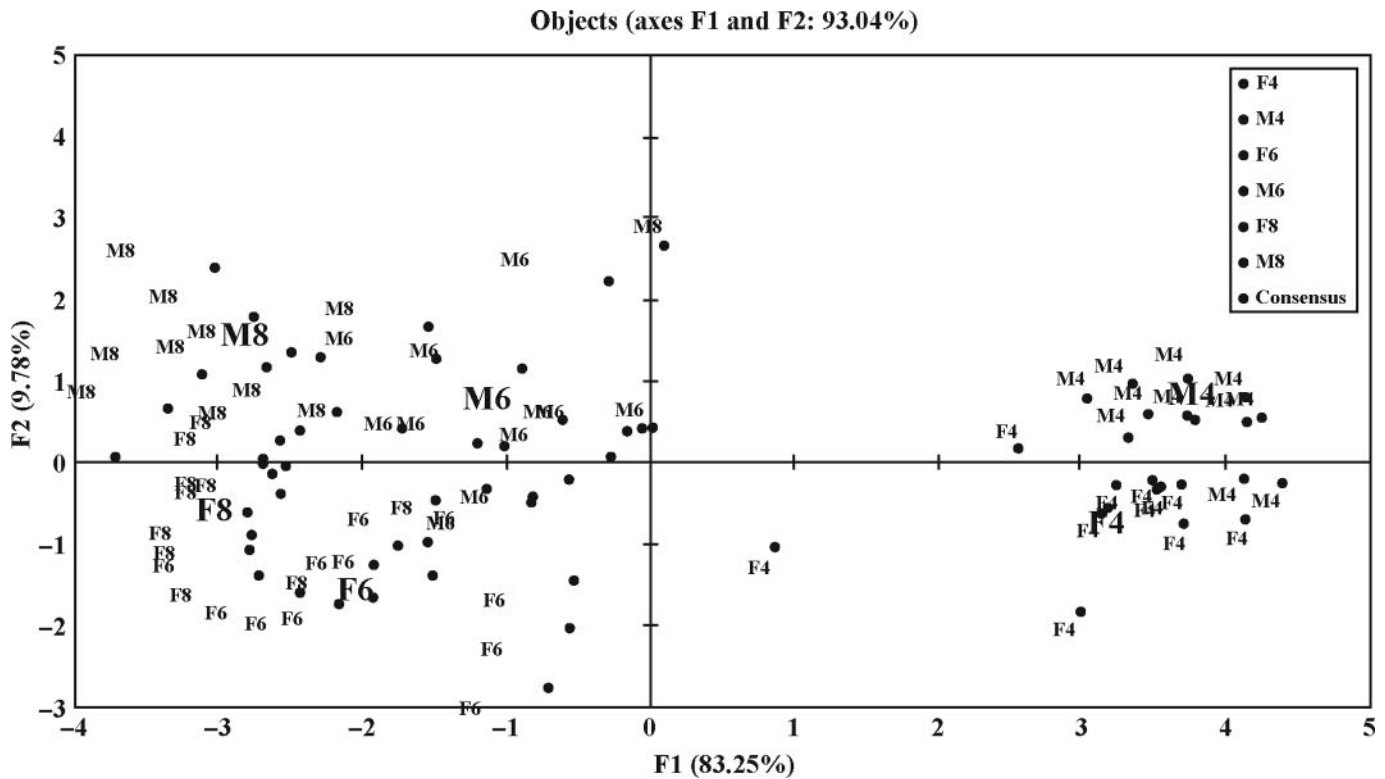
In the bi-plot of consensus configuration shown in Figure 1 can be observed the object coordinates after principal components analysis as well as the correlation between sensory attributes and the first 2 dimensions of F1 and F2 accounting for 83.25 and 9.78% of explained variance, respectively. A gradation of carcass weight groups was identified in F1, and the first group to appear was the heaviest one (8-kg carcass weight),

followed by the 6-kg group, and finally the 4-kg group. This indicates that meat from animals with different carcass weights was distinguished by toughness and aroma, and the heaviest carcasses were considered the toughest by the panelists. Whipple et al. (1990) and Koochmaraie et al. (1995), working with meat from beef and lambs, respectively, found that a smaller area of muscle fibers, which is associated with lighter BW animals, gives more tender meat. So, as in the studies by Whipple et al. (1990) and Koochmaraie et al. (1995), it was concluded that tenderness is associated with carcass weight, independent of the species.

The sex effect was evaluated by Carlucci et al. (1998) in goats and indicated a small effect on texture. Factor 2 plotted in Figure 1 indicates that males and females were separated by the sensory attributes corresponding to juiciness, flavor, and overall acceptability. Males were in the positive part of F2, whereas females were in the negative part, indicating that males were evaluated by experts as better than females. Also, Johnson et al. (1995), working with goats, found similar results and in addition concluded that castration influenced meaty odor and flavor.

A map of the different types of meat grouped by sex and carcass weight is shown in Figure 2. The points are close to the first axis as a result of 83% of the variability concentrated on this axis. Almost all types of meat sample groups were clearly recognized by panelists on the consensus configuration, particularly M4 and F4, which form individual groups and separated from the others. As in other studies with different species, GPA was an accurate method to analyze goat meat sensory quality.

Risvik (1994) suggested that tender and juicy meat is generally preferred by consumers. Therefore, this study in goats showed that lighter BW and male animals should be slaughtered. Marketing of lighter weight carcasses by producers might be advised if consumers preferred them to the same degree as the trained sensory panelists in this study. The results provide valuable information for producers and retailers but more research is needed to better understand consumer and market preferences.



**Figure 2.** Consensus configuration by object for Cabrito Transmontano sensory analysis. F1 = first principal component of generalized Procrustes analysis (GPA); F2 = second principal component of GPA; F4 = 4-kg (carcass weight) females; M4 = 4-kg males; F6 = 6-kg females; M6 = 6-kg males; F8 = 8-kg females; M8 = 8-kg males.

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