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Assessment of Sensory Quality of Calf Chops with Different Fat Cover by a Trained Panel using a Specific Sensory Method

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Abstract

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Carcass fat cover is used in many countries as a predictor of meat quality, although studies relating this parameter to sensory quality of meat are scarce and are mainly based on acceptability or palatability evaluation. The samples of calf chops with three different degrees of carcass fat cover were analysed according to a specific method for sensory quality assessment. A trained panel evaluated the samples and scored the sensory quality related to odour, texture, flavour, and persistence. Samples with higher carcass fat cover presented significantly better scores for texture, flavour, and persistence, although not for odour. When calculating global sensory quality by integrating the cited parameters, significant differences were found between the three fat cover groups. Texture, flavour, and persistence were also correlated with fat cover and marbling degree. Specific sensory characteristics (medium tenderness, slightly tough, rancid odour, cooked meat aroma, equal or higher than fat aroma, very low aroma intensity, dominance of fat aroma, obvious liver aroma and milky aroma) contributed to explaining the quality differences observed among the groups.

Keywords: beef meat; meat quality; quality categorisation; sensory description; meat texture

Carcass fat cover degree or fat thickness is one of the main criteria used to classify carcasses commercially (Commission of the European Communities 2008; United States Department of Agriculture 1997; Canadian Beef Grading Agency 2009; Meat and Livestock Australia 2011). With respect to sensory characteristics, in some studies the relation of fat cover degree to palatability or overall mouthfeel has been evaluated by trained or semi-trained panels (Tatum *et al.* 1982; Jeremiah 1996; Miller *et al.* 1997). Marbling is another fat-related aspect that has been associated with sensory characteristics, especially with texture (Jeremiah 1996; Brewer *et al.* 2001). Although the opinions of trained panels on desirability, acceptability and palatability can be influenced to a great extent by personal preference, such opinions are not based on previous definitions of sensory quality. The same is true for studies using consumers to measure the acceptability or desirability of meat samples with different degrees of marbling (Fernandez *et al.* 1999b; Font-i-Furnols *et al.* 2012). In this sense, the method developed to evaluate the sensory quality of calf chops with PGI Euskal okela (Basque meat) that we described previously in Etaio *et al.* (2013) is a unique method to assess meat samples. The method is based on previous definitions of desirable characteristics in this product and employs a specifically-trained panel.

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The objective of the present work was to use this method to study how different degrees of carcass fat cover influence the sensory quality of calf chops.

MATERIAL AND METHODS

Assessors. Panel candidates (*n* = 66) underwent a selection process and basic training in sensory analysis, as described by Pérez Elortondo *et al.* (2007). Among the 51 candidates passing the tests, 18 were selected on the basis of interest and availability. After being trained in the method described by Etaio *et al.* (2013), qualification tests were run in two sessions to check the ability of each candidate (Supplementary Table S1). Validation tests were also carried out to check the reliability of the panel (Supplementary Table S2). All the assessors passed qualification tests. All validation criteria were fulfilled at the first attempt. The final panel consisted of 17 assessors: nine women and eight men, with ages of 25–60.

Sampling and sample preparation. Samples were collected from carcasses classified at the abattoir according to the amount of fat on the outside of the carcass and in the thoracic cavity (Commission of the European Communities 2008) (Table 1). An amount of 38, 52, and 37 samples came from carcasses with a fat cover degree of 1 (G1), 2 (G2), and 3 or more (G3), respectively. Samples consisted of calf chops between the 7^{th} and 11^{th} ribs of carcasses, matured for seven days at a temperature ≤ 7°C. The protocol for preparing and cooking the samples is described in Etaio *et al.* (2013).

Sensory evaluation. Samples were evaluated throughout 17 sessions of 80–90 minutes. The eight assessors attending each session evaluated eight samples each. The presentation procedure as well as the procedure for sensory evaluation is described in Etaio *et al*. (2013). Assessors marked in the score card the sensory situations perceived for odour, texture, flavour, and persistence and scored in a 1 to 5 point ordinal scale (1-very low, 5-very high/optimum) the sensory quality related to these four parameters by using decision trees.

Statistical analysis. Analysis of variance (ANOVA) and correlation analysis were applied using IBM SPSS Statistics v. 22 (IBM Corporation, USA). A general linear model of ANOVA was used to determine the presence or absence of significant differences ($P \leq 0.05$) among sensory parameters considering fat cover, session and assessor as fixed factors. The used model was the following:

$$Y = \mu + \text{fat cover} + \text{session} + \text{assessor (session)} + \text{fat cover} \times \text{session} + \text{error}$$

Pairwise comparisons using the estimated marginal means for the fat cover groups were carried out using Fisher's Least Significant Difference (LSD) test ($P \leq 0.05$). To study bivariate correlations between parameters, Pearson's correlation coefficient was used.

The citation frequency of each sensory attribute describing the samples (CF, percentage of assessors citing it) was calculated for each sample in order to plot graphs. CF values for the fat cover groups did not show a normal probability distribution for many sensory attributes, so the Kruskal-Wallis test was applied to establish the presence or absence of statistically significant differences ($P \leq 0.05$) among the groups. Next, the Mann-Whitney test was performed for multiple comparison analysis ($P \leq 0.05$).

RESULTS AND DISCUSSION

Sensory description and differentiation of samples according to scores. The distribution of mean scores for odour, texture, flavour, persistence, and global quality in samples from the three groups of fat cover is shown in Figure 1. Descriptive statistics and the *F*- and *P*-values for each sensory parameter and fat cover group, as well as the inter-group differences from the pairwise comparison test, are shown in Table 2. Significant differences ($P \leq 0.05$) were found for texture, flavour, persistence, and global quality.

With regards to odour quality (Figure 1A), only one sample presented an evidently defective odour (mean score of 1.71). The other samples ranged from 2.80 to 5.00.

Texture (Figure 1B) scores ranged from 1.38 to 4.75, thus covering the entire scale. Since these samples were not previously a differentiated (10.2% of the samples) this characteristic was clearly defective, with a mean score ≤ 2. Samples from G3 presented a slightly higher distribution in the upper values. As shown in Table 2, G1, G2, and G3 groups showed significantly different values for texture quality, indicating that increasing fat cover corresponded with higher textural quality.

The distribution for flavour quality (Figure 1C) ranged from 1.83 to 4.75. There were significant differences for G3 compared with G1 and G2 (Table 2), that is, calf chops with higher fat cover exhibited better flavour. However, this effect would only be appreciated once a sufficient level of fat cover is reached.

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Table 1. Main characteristics of the samples and the corresponding carcasses and calves

Fat cover	n	Calves characteristics			Carcass measurements				Chop measurements			
										colour measurement		
		age (months)§	sex	live weight (kg)§	conformation (n)	fat cover (n)	pH§	temperature (°C)§	Marbling degree (n)	L^* (D65)§	a^* (D65)§	b^* (D65)§
					$O^{\#}$ (1)	$1^{\#}$ (3)			$A^{\#}$ (1)			
					R^{-} (1)				A^{+} (3)			
					$R^{\#}$ (1)				AA^{-} (12)			
					R^{+} (11)				$AA^{\#}$ (9)			
G1	38	13.3 ± 2.1 (9.2–18.1)	7 female 31 male	280.5 ± 53.7 (151.0–367.5)	U^{-} (5)		5.71 ± 0.10 (5.60–5.90)	4.3 ± 1.7 (1.5–7.0)	AA^{+} (7)	36.2 ± 3.9 (28.4–43.4)	13.5 ± 2.1 (9.5–19.5)	12.5 ± 1.6 (10.3–16.4)
					$U^{\#}$ (8)	1^{+} (35)			AAA^{-} (3)			
					U^{+} (7)							
					E^{-} (1)				$AAA^{\#}$ (3)			
					$E^{\#}$ (3)							
					$O^{\#}$ (1)	2^{-} (16)			A^{+} (1)			
					O^{+} (1)	$2^{\#}$ (21)			AA^{-} (2)			
					R^{-} (1)	2^{+} (15)			$AA^{\#}$ (17)			
					$R^{\#}$ (5)				AA^{+} (10)			
G2	52	13.1 ± 2.3 (9.1–21.1)	23 female 29 male	282.4 ± 45.9 (183.2–362.6)	R^{+} (14)		5.69 ± 0.11 (5.42–5.90)	5.5 ± 1.8 (1.6–10.0)	AAA^{-} (4)	36.2 ± 4.3 (28.5–45.5)	13.1 ± 1.7 (9.6–17.3)	12.1 ± 1.6 (8.7–16.4)
					U^{-} (12)				$AAA^{\#}$ (8)			
					$U^{\#}$ (11)							
					U^{+} (6)				AAA^{+} (10)			
					E^{-} (1)							
					R^{-} (1)	3^{-} (9)			AA^{-} (1)			
					$R^{\#}$ (5)	3 (15)			$AA^{\#}$ (3)			
					R^{+} (16)	3^{+} (7)			AA^{+} (2)			
G3	37	13.9 ± 2.5 (10.2–18.3)	32 female 5 male	281.9 ± 31.7 (232.7–354.8)	U^{-} (12)	4^{-} (4)	5.71 ± 0.10 (5.50–5.89)	6.1 ± 1.9 (2.7–10.0)	AAA^{-} (2)	36.3 ± 4.0 (28.5–43.4)	13.8 ± 2.0 (10.1–17.1)	12.2 ± 1.6 (8.5–15.3)
									$AAA^{\#}$ (5)			
					$U^{\#}$ (3)	4 (2)			AAA^{+} (13)			
									prime$^{\#}$ (11)			

§mean, mean standard deviation, extreme values; *P* – poor, *O* – fair, *R* – good, *U* – very good, *E* – excellent, *S* – superior – SEUROP scale; $^{-}$low; $^{\#}$medium, $^{+}$high; *A*, *AA*, *AAA*, and prime – Canada Grade standards; L^*, a^*, b^* – CIELAB colour dimensions

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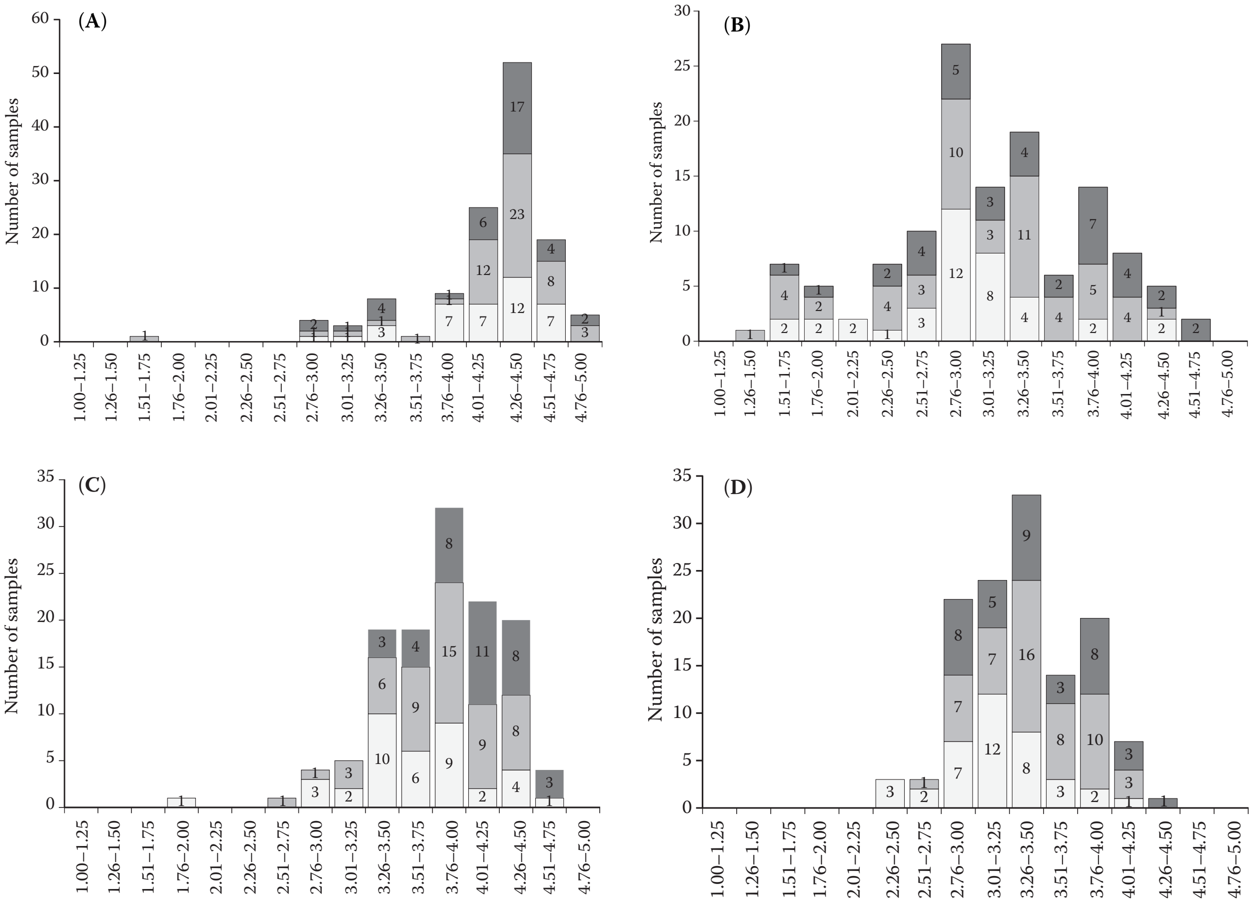

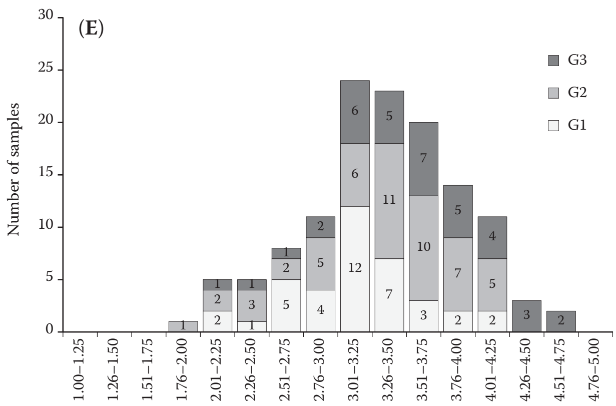

Figure 1. Distribution of samples in the three fat cover groups (G1, G2 and G3) according to their scores for odour quality (**A**), texture quality (**B**), flavour quality (**C**), persistence quality (**D**), and global quality (**E**)

For persistence (Figure 1D), the scale use ranged from 2.38 to 4.29, without any clearly defective samples. Thus, scores were almost entirely related to the duration of aroma after the swallowing of the sample. The quality of persistence related was significantly increased ($P \leq 0.05$) in G2 and G3 compared to G1 (Table 2), showing that aroma persistence was decreased in samples with lower fat content.

Application of weighting factors to calculate a global quality score for each sample (5% for odour, 70% for texture, 15% for flavour, and 10% for persistence) resulted in the distribution shown in Figure 1E. Global quality scores ranged from 1.98–4.61. To a certain extent, distribution of global quality matched the texture quality distribution, although the former was shifted slightly to the upper part of the scale, due to higher odour, persistence and mainly, flavour scores. The ANOVA for global quality scores (Table 2) showed that the scores increased with fat cover, with significant ($P \leq 0.05$) differences between the three groups. Thus, increasing fat cover corresponded to higher sensory global quality.

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Table 2. Descriptive statistics and results of ANOVA analysis of sensory data from samples with different degrees of fat cover (G1, G2 and G3)

	Odour			Texture			Flavour			Persistence			Global quality		
	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
Minimum score	2.83	1.71	3.00	1.57	1.38	1.63	1.83	2.75	3.43	2.38	2.67	2.83	2.14	1.98	2.21
Maximum score	4.75	5.00	4.86	4.5	4.29	4.75	4.57	4.5	4.75	4.14	4.17	4.29	4.23	4.17	4.61
Interval width	1.92	3.17	1.86	2.93	2.91	3.12	2.74	1.75	1.32	2.38	2.67	2.83	2.09	2.19	2.40
Mean ± SD	3.93 ± 1.13	4.04 ± 1.11	4.00 ± 1.07	2.98 ± 1.13^{a}	3.12 ± 1.10^{b}	3.40 ± 1.11^{c}	3.57 ± 1.02^{a}	3.75 ± 0.99^{a}	3.91 ± 1.00^{b}	3.20 ± 0.87^{a}	3.42 ± 0.89^{b}	3.51 ± 0.94^{b}	3.14 ± 0.85^{a}	3.29 ± 084^{b}	3.52 ± 0.88^{c}
F		0.297			14.708			4.681			5.614			17.029	
P		0.743			**0.000**			**0.010**			**0.004**			**0.000**	

Pairwise comparisons of estimated marginal means were carried out using Fisher's LSD test; $P \leq 0.05$ was indicative of significant differences (marked in bold for sensory parameters and with different superscript letters for sample group)

Correlation analysis was run for average panel values for each sample to investigate relationships between sensory parameters. Although the aim of the present work was not to study the effect of non-sensory parameters on sensory quality, correlation analysis was also run among sensory and the non-sensory parameters described in Table 1 to discover the most important relationships. Bivariate correlations found between parameters were in all cases positive (Table 3). In addition to the expected high correlation with texture, global quality was also significantly correlated ($P \leq 0.05$) with flavour and persistence, but not with odour ($P > 0.05$).

Texture quality and global sensory quality were highly correlated ($P \leq 0.05$) with fat cover and marbling degree. Several authors have reported a relationship between subcutaneous fat thickness and acceptability (Tatum *et al.* 1982; Jeremiah 1996), and between marbling degree or intramuscular fat and higher palatability or acceptability of meat samples (Tatum *et al.* 1982; Jeremiah 1996; Fernandez *et al.* 1999b). In any case, it should be noted that the approaches adopted by studies on palatability or acceptability are different from the present approach in which sensory quality was evaluated by a trained panel, which followed a specific procedure and criteria about quality concept.

Fat cover and marbling degree were also correlated ($P \leq 0.05$) with persistence and, especially, with flavour, showing that these two parameters are very relevant for sensory quality. The contribution of fat

Table 3. Pearson bivariate correlation (*r*) between sensory parameters and between sensory and non-sensory parameters

Sensory parameter	Sensory parameter	*r*	Non-sensory parameter	*r*
Odour	flavour	0.244**		
	persistence	0.192*		
Texture	flavour	0.321***	fat cover	0.287**
	persistence	0.285**	marbling	0.336***
	global quality	0.984***		
Flavour	odour	0.244**	fat cover	0.348***
	texture	0.321***	temperature	0.204*
	persistence	0.556***	marbling	0.372***
	global quality	0.470***		
Persistence	odour	0.192*	fat cover	0.227*
	texture	0.285**	marbling	0.281**
	flavour	0.556***	b* (D65 colour dimension)	0.202*
	global quality	0.414***		
Global quality	texture	0.984***	fat cover	0.324***
	flavour	0.470***	marbling	0.381***
	persistence	0.414***		

Only significant correlations are shown; ***$P \leq 0.001$, **$P \leq 0.01$, *$P \leq 0.05$

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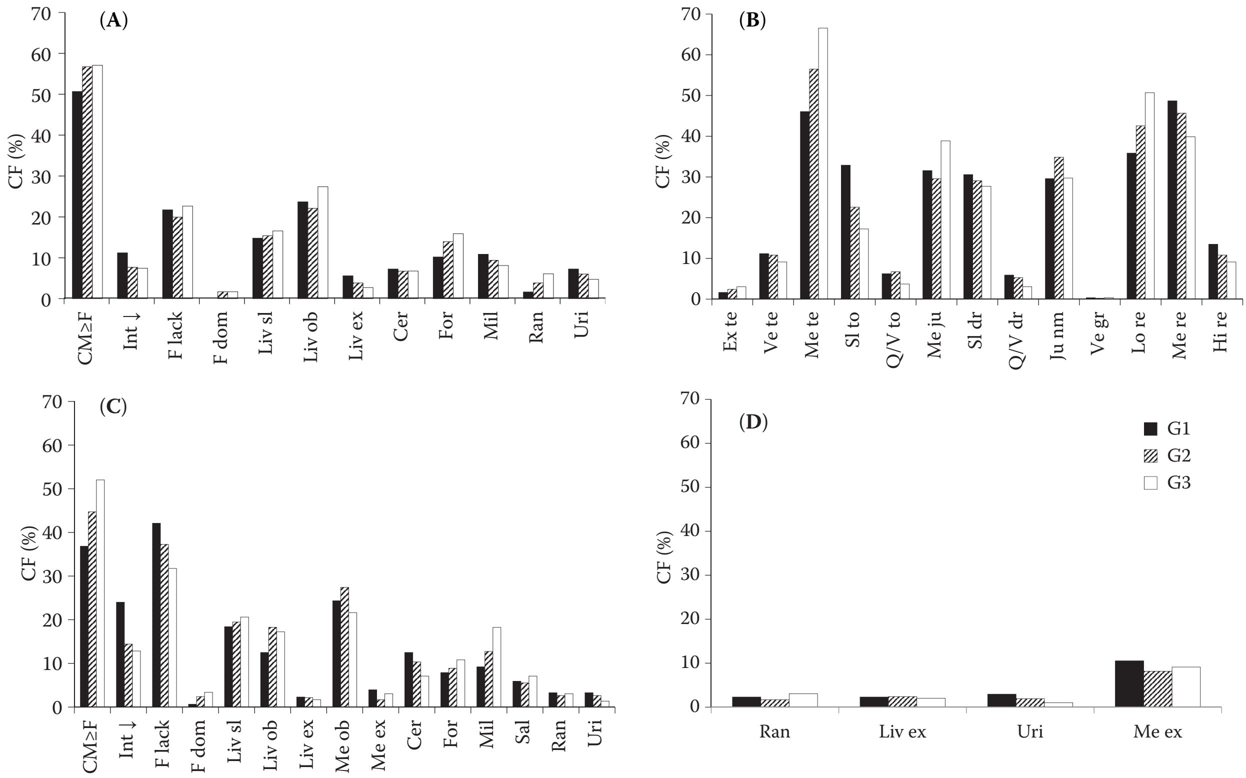

Figure 2. Citation frequency (CF expressed as % of the total possible citations) for the three fat cover groups (G1, G2, and G3) for sensory characteristics of odour (**A**), texture (**B**), flavour (**C**), and persistence (**D**)

Abbreviations for sensory situations of odour, flavour and persistence: CM ≥ F: cooked meat ≥ fat; Int↓: low intensity; F lack: fat lack; F dom: fat dominance; Liv sl: liver slight; Liv ob: liver obvious (not excessive); Liv ex: liver excessive; Cer: cereal; For: forage; Mil: milky; Ran: rancid; Uri: urine; Me ob: metallic sensation obvious (not excessive); Me ex: metallic sensation excessive; Sal: salty
Abbreviations for texture situations: Ex te: extremely tender; Ve te: very tender; Me te: medium tenderness; Sl to: slightly tough; Q/V to: quite/very tough; Me ju: medium juiciness; Sl dr: slightly dry; Q/V dr: quite/very dry; Ju nm: juiciness not maintained; Ve gr: very greasy; Lo re: low residue; Me re: medium residue; Hi re: high residue

content to the odour and flavour of meat has been exhaustively described (Mottram 1998), and the relationship between intramuscular fat content and flavour intensity has been reported in several studies (Fernandez *et al.* 1999a; Brewer *et al.* 2001).

Sensory description and differentiation of samples according to sensory attributes. Citation frequency (CF) of the different sensory characteristics is shown in Figure 2, and descriptive statistics for each fat cover group, and *P*-values of the eight sensory attributes with significant differences ($P \leq 0.05$) among groups are shown in Table 4. With respect to odour (Figure 2A), the most cited attribute was the ideal one (cooked meat ≥ fat odour), followed by liver odour (encompassing obvious, slight and excessive) and lack of fat odour, with values of 50.7–57.1, 41.4–46.6 and 20.00–22.6%, respectively. Only rancid odour was statistically different ($P \leq 0.05$) among the groups with different fat cover (Table 4), with CF higher in G3 (6.1%) than in G1 (1.6%). The higher frequency of this attribute in G3 than in G1 could be explained by the higher fat content, since most compounds responsible for rancid odours are generated by lipid oxidation (Ladikos & Lougovois 1990).

Regarding texture, among tenderness/toughness related situations, medium tenderness was the most cited attribute (CF 46.1–66.6%), followed by slightly tough (17.2–32.9%) (Figure 2B). There were significant differences ($P \leq 0.05$) in medium tenderness among the three groups (Table 4), with CF increasing from G1 (46.1%) to G2 (56.5%), and from G2 to G3 (66.6%). The slightly tough category also revealed differences, with CF higher in G1 (32.9%) than in the groups with higher fat cover (G2 22.6% and G3 17.2%). Regarding juiciness, three categories exhibited similar CF: medium-high juiciness maintained

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Table 4. Descriptive statistics and P-values for citation frequency (CF) of sensory characteristics with significant differences ($P \leq 0.05$) among groups of calf chops with different degrees of fat cover (G1, G2, and G3) in the Kruskal-Wallis test

	P	Mean and standard deviation of CF (%)		
		G1	G2	G3
Odour situations				
Rancid odour	0.036	1.6 ± 4.3^{a}	3.9 ± 7.7^{ab}	6.1 ± 8.7^{b}
Texture situations				
Medium tenderness	0.001	46.1 ± 22.7^{a}	56.5 ± 23.8^{b}	66.6 ± 23.8^{c}
Slightly tough	0.003	32.9 ± 21.8^{a}	22.6 ± 18.5^{b}	17.2 ± 19.8^{b}
Aroma situations				
Cooked meat ≥ fat	0.001	36.8 ± 18.4^{a}	44.7 ± 17.0^{b}	52.0 ± 17.1^{c}
Very low aroma intensity	0.003	24.0 ± 16.0^{a}	14.4 ± 11.2^{b}	12.8 ± 9.5^{b}
Dominance of fat aroma	0.042	0.7 ± 2.8^{a}	2.4 ± 5.6^{ab}	3.4 ± 5.6^{b}
Liver obvious	0.029	12.5 ± 12.3^{a}	18.3 ± 11.5^{b}	17.2 ± 11.2^{b}
Milky	0.021	9.2 ± 11.1^{a}	12.7 ± 11.5^{ab}	18.2 ± 15.5^{b}

Different superscript letters indicate significant differences ($P \leq 0.05$) among groups according to the Mann-Whitney test

over time (29.6–38.9%), slightly dry (27.7–30.6%), and juiciness not maintained over time (29.6–34.9%). No significant differences ($P > 0.05$) were found for juiciness characteristics.

With respect to residue, two categories with similar CF accounted for the majority of citations: low residue (35.9–50.7%) and medium residue (39.9–48.7%). No significant differences ($P > 0.05$) were found in residue characteristics. Therefore, the observed significant differences ($P \leq 0.05$) in texture quality scoring among the three groups (Table 2) were explained mainly by tenderness/toughness. Tenderness has been reported as the main trait affecting the eating quality of beef meat (Boleman *et al.* 1997; Miller *et al.* 2001; Shackelford *et al.* 2001).

Regarding flavour (Figure 2C), the optimal category was the most cited one (36.8–52.0%), although with a notable CF for lack of fat aroma (31.8–42.1%), while very low aroma intensity (12.8–24.0%) was also important. CF of attributes related to liver aroma ranged from 33.2 to 39.9% and those categories related to metallic sensations from 24.7% to 29.1%, showing that these two categories were also important for describing the samples.

As shown in Table 4, there were five aroma characteristics that discriminated among the groups, indicating that aroma was more discriminative than odour. The frequency of the optimal aroma category was significantly different ($P \leq 0.05$) among the three groups, with higher CF for G3 (52.0%), then G2 (44.7%) and G3 (36.8%), whereas CF for very low aroma intensity was significantly higher ($P \leq 0.05$) in G1 (24.0%) than in G2 (14.4%) and G3 (12.8%). These results regarding aroma contribute to explaining the mentioned higher scores for flavour quality in G3 (Table 2), and corroborate the important contribution of fat content to flavour, as described by different authors (Mottram 1985, 1998; Calkins & Hodgen 2007; Resconi *et al.* 2013). Although cooked without subcutaneous fat, the intramuscular triglycerides and phospholipids of meat lead to the formation of lipid-derived volatiles, which would be some of the main compounds responsible for meat odour/aroma, especially when meat is not cooked under severe conditions and compounds derived from the Maillard reaction do not have a predominant effect (Mottram 1985). Regarding dominance of fat aroma, CF was significantly higher ($P \leq 0.05$) in G3 (3.4%) than in G1 (0.7%), although the CF for this characteristic was very low in the three groups.

With regard to liver-related characteristics, liver aroma obvious (not excessive) presented a CF that was significantly higher ($P \leq 0.05$) in G2 and G3 (18.3 and 17.2%, respectively) than in G1 (12.5%). The origin of this attribute, usually described as off-flavour, is not totally understood and the results of different studies are not always consistent. Peptides from protein degradation might be mainly responsible for liver flavour (Alder-Nissen 1986; Miller *et al.* 1988). Yancey *et al.* (2006) found that total iron content, myoglobin and, to a certain extent, some unsaturated fatty acids may be related to liver flavour, whereas Camfield *et al.* (1997) and Calkins and Hogen (2007) found that some

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unsaturated fatty acids and several compounds from lipid oxidation could play an important role in the development of this flavour. So, factors other than fat cover could explain the significant higher CF for liver aroma obvious found in G2 and G3.

Regarding milky aroma, significantly higher values ($P \leq 0.05$) were found in G3 (18.2%) than in G1 (9.2%). The origin of this aroma is not completely understood. Some authors have related this characteristic to the fatty acid composition resulting from the forage feeding of animals (Priolo *et al.* 2001). Other authors (Brennand *et al.* 1989; Prescott *et al.* 2001; Young *et al.* 2003) included the milky/dairy aroma in the broader concept of pastoral flavour and linked it to several compounds such as skatole and branched-chain fatty acids in lamb meat (which has a much higher content in these fatty acids than beef meat). Although we cannot provide an explanation for the higher milky aroma in G3 compared to G1, we hypothesise that the potentially higher content of these compounds in samples with higher fat content may contribute.

Despite the importance of metallic sensation in describing the samples (mainly as obvious (not excessive); CF of 21.6–27.4%), no significant differences ($P > 0.05$) among the groups were found. With regard to undesirable categories of persistence (Figure 2D), metallic sensation excessive was the most cited (CF of 8.2–10.5%), whereas the other defects presented a very low CF (CF ≤ 3.0%). There were no significant differences ($P > 0.05$) for persistence defects. Thus, the significant differences founded for persistence quality in G1 in comparison with G2 and G3 (Table 2) would not be explained by defective characteristics but by differences in aroma duration after swallowing the sample.

CONCLUSIONS

A new method to assess the sensory quality of calf chops was applied by a specifically trained panel to investigate differences in sensory quality according to three levels of carcass fat cover. In addition to providing an exhaustive description of the sensory characteristics of each sample, the results indicated that sensory quality related to texture, flavour and flavour persistence, as well as global sensory quality, increased significantly with higher fat cover levels. The absence of any effects of fat cover on odour quality suggests the possibility of limiting odour evaluation to checking that samples do not present off-odours.

With respect to the citation frequency of odour characteristics, only rancid odour showed statistically significant differences among different levels of fat cover, lending further support to the idea of reducing odour evaluation to off-odour checking. For texture, medium tenderness and slightly tough showed statistically significant differences among groups (with higher citation frequencies for samples with higher and lower fat cover, respectively). Regarding flavour, fat cover level had a significant effect on the citation of very low aroma intensity (with higher citation frequencies for samples with lower fat cover), cooked meat aroma equal or higher than fat aroma, dominance of fat aroma, obvious liver aroma, and milky aroma (all of them related to samples with higher fat cover).

The results of the application of this novel method to assess the sensory quality of calf chops highlights the importance of a high fat cover in achieving higher sensory quality in these products.

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