EFECT OF SLAUGHTER WEIGHT AND DIET COMPOSITION OF CALVES ON MEAT AND FAT QUALITY

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Background

Many consumers in Spain and in other European countries prefer to consume meat from animals slaughtered at an early age, associating it with a healthy product, low amount of visible fat, high juiciness, high tenderness and a good smooth flavour. In fact, in the past, such meat was considered as the highest quality meat. In this sense, the use of local breeds, together with local production systems, could be a basis for establishing standards in order to improve local production and consumer confidence (Shackeldford *et al*., 2001; Dransfield *et al*., 2003).

However, in order to respond to consumer demands, it is essential to guarantee good quality meats, from a fundamental understanding of links between production factors and meat quality. Several factors, such as age, sex, breed and slaughter conditions, affect carcass and meat characteristics, but also diet is of importance. Most studies published about the effect of diet on calf performance, have been carried out using milk replacers (Beauchemin *et al*., 1990; Xiccato *et al*., 2002) and slaughtered at an early age or based on a relatively early weaning age (100-150 days), following an *ad libitum* diet of concentrate until slaughter (Hinks *et al*., 1999; Myers *et al*., 1999a, 1999b; Fluharty *et al*., 2000). However, the raising of calves on the basis of traditional systems, using whole milk, as unique feed or supplementing a concentrate diet may offer an alternative to the current systems as long as the quality of the final product could be guaranteed. On the other hand, this type of rearing system could also be used for other purpose, for example, in farms in which milk production is largely over the milk quota (Hornick *et al*., 1996). Owing to the peculiar digestive and metabolic characteristics of young calves, in which the effect of diet composition on body composition is of special importance, it may be assumed that the meat and fat from calves receiving a daily amount of milk until slaughter could show differential characteristics with respect to the meat from calves reared under intensive production systems. So, the aim of the present work was to study the effect of diet composition of calves might have on meat and fat quality.

Materials and methods

Animal Experiment

The animal experiment was conducted at the Agricultural Experimental Station of the Spanish Council for Scientific Research (CSIC) in León (Spain) while the analysis of meat quality characteristics were performed at the Meat Technological Station of Agronomic Institute (ITA) in Salamanca (Spain). Male Spanish Brown Swiss calves were used. Upon arrival, the calves were weighed and assigned to one of three groups, homogeneous in weight and age, according three experimental diets. Milk-fed (MF) calves were exclusively fed with whole milk, containing 13,8% powder milk served warm (39°C) twice daily (at 9 h and 19 h) in teat-feeder. These calves were slaughtered at 5 months of age. In the concentrate-fed (CF) treatment, after weaning at 100-kg body weight the calves received concentrate and barley straw, both available *ad libitum* until slaughter. The remaining calves, milk-concentrate group (MC), received 5 kg/d of whole milk made up the same way as for the MF group served individually once daily in buckets, and they were also fed with concentrate and barley straw, both available *ad libitum* until slaughter. The animals from last two groups were slaughtered at 7 months age. Individual weight was recorded before moving the calves to the slaughterhouse. Average slaughter weight for MF, MC and CF groups were 231.9, 346.0 and 345.5 kg respectively.

Analysis

pH was measured at 24 h post slaughter on *longissimus thoracis* muscle at 6th rib level by a penetration electrode. Dry matter, ether extract, crude protein and total collagen were determined according to official procedures (MAPA, 1979). Gross energy (GE) was determined by combustion in adiabatic calorimetric bomb. Concentration of haem pigments (mg mioglobin/g muscle) was measured by Hornsey method (1956). Labile collagen was analysed by Hill (1966) and collagen solubility was calculated as a percentage to total collagen. The fatty acid profile of subcutaneous, intermuscular and intramuscular fat from the 6th rib was obtained by gas chromatography (Perkin-Elmer Auto syst-X.L). Colorimetric parameters (L* a* b*) were obtained on *longissimus thoracis* muscle of the 6th rib, after the newly cut surface had been exposed to artificial light for 90 minutes at 10°C. Water holding capacity (WHC) was measured by four methods: drip loss (70 g aprox.) according to Honikel (1998), press loss by filter paper press method; thawing loss by thawing the sample during 4 hours in water at 18ºC (Ham, 1960) and cooking loss after cooking the sample in open polyethylene bags in water at 75°C, until the samples achieve 70ºC, measured with a thermocouple in the centre of the sample (Honikel, 1998). Water losses were expressed as a percentage of initial weight. Instrumental textural and sensory analyses were performed with the section between the 8th and 11th ribs aged through 7 days. Warner-Braztler test (Honikel, 1998) in heated meat was assessed using texture analyser TA-XT2. An eight-member trained sensory panel assessed the sensorial attributes, beef odour intensity, tenderness, juiciness; beef flavour intensity and general palatability, using a ten-point descriptive scale. Statistical analysis was performed using one-way analysis of variance (type of feeding) GLM procedure. However, in the case of fatty acid composition, in which the measurements were taken from several locations, two-way analysis of variance was used, considering the effect of diet, fat depot and the corresponding interaction. The statistical package used was SPSS 11.0.

Results and discussion

All calves shown pH values in normal range, and no differences between groups were found (5.5, 5.5 and 5.6 for MF, MC and CF respectively). The meat of calves whose diet was supplemented with milk until slaughter showed higher ether extract, lower crude protein and higher gross energy concentrations than exclusively milk-fed calves and concentrate-fed calves. Due the iron concentrate in milk and concentrate, myoglobin content was lower in exclusively milk-fed calves than in concentrate-fed calves, while calves received milk-concentrate diet provided an intermediate value (Table 1).

Table 1: Composition of *longissimus thoracis* muscle.

	Milk	Milk-Concentrate	Concentrate	P
Dry matter (%)	24.3 ± 0.78 ^{a}	25.7 ± 0.75 ^{b}	25.5 ± 0.75 ^{b}	*
Ether extract (% DM)	5.4 ± 2.23 ^{a}	8.2 ± 0.49 ^{c}	6.5 ± 1.53 ^{b}	*
Crude protein (%DM)	90.6 ± 1.33^{a}	88.0 ± 1.60 ^{b}	88.9 ± 2.46 ^{b}	***
Ash (%DM)	4.6 ± 0.25	4.3 ± 0.11	4.3 ± 0.18 ^{b}	ns
Gross energy (kcal/g)	5.4 ± 0.25 ^{a}	5.5 ± 0.07 ^{b}	5.5 ± 0.18 ^{b}	*
Myoglobin (mg/g)	2.1 ± 0.95 ^{a}	2.8 ± 1.04 ^{ab}	3.6 ± 0.62 ^{b}	*

a, b, c: values with different superscripts indicate significant differences between fat locations.
*** = p<0,001; ** = p<0,01; * = p<0,05; + = p<0,1; ns: p>0.1

The values of the colorimetric parameters obtained in *longissimus thoracis* muscle of the 6th rib are shown in table 2. As may be seen, statistically significant differences (p<0.05) were observed between the feeding strategies considered. Exclusively milk-fed calves provided the highest values of lightness and yellowness and the lowest value of redness. These results are probably related to the myoglobin content measured in *longissimus thoracis* muscle.

Whereas in the data concerning drip and thawing losses no statistically significant differences were observed between groups (p>0.05), solid feed supplemented with whole milk until slaughter led to a significant decrease (p<0.05) in press and cooking losses (table 2). This result is consistent with the findings of other authors who have observed a significant decrease in the percentage of liquid lost during cooking, parallel to the fat deposition (Gariépy *et al*., 1998; Scheeder *et al*., 1999).

Table 2: Colour, water holding capacity and Warner-Braztler for experimental groups.

	Milk	Milk-Concentrate	Concentrate	
Lightness (L*)	45.4 ±3.81 [a]	41.0 ± 1.84 [b]	40.9 ± 1.65 [b]	**
Redness (a*)	8.2 ± 2.78 [a]	12.6 ± 1.42 [b]	13.2 ± 0.64 [b]	***
Yellowness (b*)	10.6 ± 3.63 [a]	6.3 ± 0.71 [b]	7.3 ± 0.94 [c]	***
Drip loss (%)	3.0 ± 1.09	2.2 ± 0.52	2.5 ± 0.46	ns
Press loss (%)	17.4 ± 2.43 [a]	22.0 ± 2.86 [b]	24.7 ± 0.79 [b]	***
Thawing loss (%)	2.6 ± 1.13	3.1 ± 1.41	3.3 ± 1.45	ns
Cooking loss (%)	20.7 ± 3.71 [a]	22.3 ± 2.48 [ab]	26.3 ± 3.49 [b]	*
W-B shear force (kg)	6.4 ± 1.34 [a]	5.4 ± 0.19 [b]	6.5 ± 0.75 [a]	*

a, b, c: values with different superscripts indicate significant differences between fat locations.
*** = p<0,001; ** = p<0,01; * = p<0,05; + = p<0,1; ns: p>0.1

The lower value found in Warner-Bratzler test in calves receiving concentrate and milk until slaughter could be partially explained by the greater intramuscular fat content. Nishimura *et al*. (1998) have reported the important role of the fat content in shear force of cooked meat, indicating that the development of adipose tissue weakens the perimysium and hence increases the tenderness.

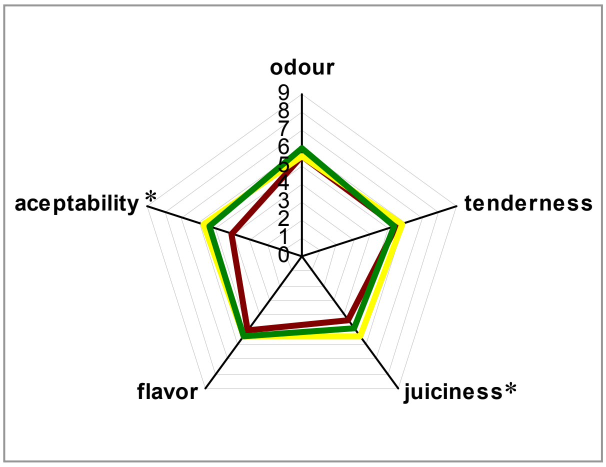

Figure 1: sensorial analysis for experimental groups

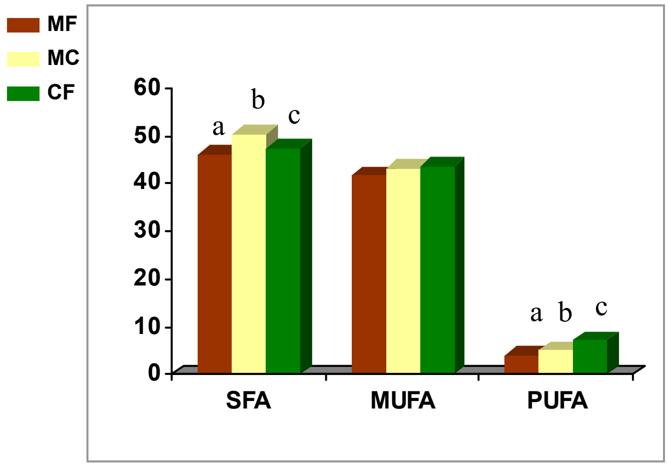

Figure 2: fatty acid composition as a function of type of feeding

The sensory analysis (figure 1) revealed statistically significant differences ($p<0.05$) for juiciness and acceptability, the lowest values corresponding to the calves received milk exclusively. These results are consistent with results obtained from water holding capacity and instrumental texture measurements.

Regarding fatty acid composition, due the absence of significant interaction between the location of fat depot and the type of feeding, both effects are described separately. The diet offered to both experimental groups provided a statistically significant effect on a large part of the fatty acids identified. Overall, the animals receiving a daily amount of whole milk until slaughter (MF and MC groups) showed a significantly higher percentage ($p<0.05$) of saturated fatty acids, which was particularly noteworthy in the case of short-chain fatty acids (figure 2).

Moreover, the calves from the CF group had a higher percentage of polyunsaturated fatty acids ($p<0.05$) and no significant differences ($p<0.05$) were found as regards the percentage of monounsaturated fatty acids. In relation with the saturation of the different fat depots, highly significant differences were found among them (date not shown). The highest proportion of polyunsaturated fatty acids corresponded to the intramuscular fat and the highest percentage of monounsaturated fatty acids to the subcutaneous depot, being the intermuscular the most saturated fraction ($p<0.01$).

Conclusions

To sum up the results of the present work, we conclude that supplementing the concentrate diet with whole milk until slaughter may be an advantageous alternative to the traditional systems based in an early weaned and after fed only with concentrate and straw or based in exclusively milk fed. However, diets including whole milk changed the fatty acid profile in the carcasses by increasing the proportion of short- and medium-chain fatty acids and reducing their degree of unsaturation.

In either case, more studies are necessary to assess the economic costs involved in this process to achieve a compromise between production expenses and carcass, meat and fat quality.

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