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Instrumental meat quality of veal calves reared under three management systems and color evolution of meat stored in three packaging systems

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ABSTRACT

This study evaluated the meat quality of grazing suckling calves (GR), suckling plus supplemented calves (SUP) and weaned calves finished on concentrates (FIN) and the color evolution of meat packaged in film (FILM), modified atmosphere packaging (MAP) and vacuum packaging (VAC). Intramuscular fat was quite low for all treatments and GR meat had greater percentages of PUFA and lower SFA, MUFA and n6/n3 than SUP and FIN. FIN and SUP meat had more L* and was more tender when aged than GR. GR meat was tough and dark. The packaging system was more influential on meat color than the feeding management. VAC had the lowest values of metmyoglobin when aged. MAP had the greatest L* and hue angle and the lowest redness after 13 d of aging, thus MAP was the packaging with the shortest shelf life.

1. Introduction

Identifying and producing products of distinctive quality that could have a niche market is a priority for beef producers in the Spanish dry mountains. Veal production could be a viable option because Spanish consumers like rose-colored and pale beef, which is usually associated with veal, and they are willing to pay for it (Corcoran et al., 2001). Veal production in dry mountain areas has been given little attention, although it could be an interesting alternative in suckler calf production systems for breeds with a relatively high potential milk yield (Vieira, García, Cerdeño, & Mantecón, 2005).

According to Council Regulation (EC) No 361/2008 of April 14th (EU, 2008), which regulates the marketing of meat, veal is described as the meat of bovine animals aged 8 months or less; the feed received by the animals and the meat characteristics are not regulated. Thus, several production systems could be developed in dry mountain areas to achieve the light-colored meat that veal consumers demand. However, calf management in these conditions depends on the calving season (Casasús, Sanz, Villalba, Ferrer, & Revilla, 2002). Spring-born calves remain indoors with their dams in the spring and graze on high mountain ranges until weaning at the end of the summer (8–9 months), while autumn-born calves remain indoors with their dams until weaning (5–6 months). Thus, different products could be obtained depending on the management of veal calf rearing. Besides, these products could be different regarding color and texture.

Consumers tend to make purchase decisions based on meat color, even though this is poorly related to the meat quality. It has been shown that consumers associate dull or brown colors with a loss of freshness (Hood & Riordan, 1973). Meat color is influenced by several factors within the feeding–breeding system (Alcalde & Negueruela, 2001), such as diet and age/slaughter weight. In fact, meat with an undesirable color can only be sold at a significant discount (Liu, Lanari, & Schaefer, 1995).

Fresh beef is often displayed in styrofoam trays and wrapped with oxygen permeable films. This packaging allows quick pigment oxygenation and desirable red color development, but discoloration occurs within the first 7 d (Madhavi & Carpenter, 1993) or after 6–9 d of storage in film (Albertí et al., 2005; Ripoll, Albertí, Panea, & Joy, 2007; Sanz, Ripoll, Blasco, Alvarez-Rodríguez, & Albertí, 2011). High O_2 atmospheric concentrations promote the formation of oxymyoglobin, the cherry red form of myoglobin; however, it may negatively impact on lipid oxidation and discoloration of muscle (Jeremiah, 2001). Anoxic packages keep myoglobin in its reduced form and increase the shelf life of meat (O'Keeffe & Hood, 1980); however, the purple color is less desirable for consumers than the red color of oxymyoglobin. Because consumers are less familiar with this color, meat is usually exposed to oxygen before being displayed.

The aim of this study was to analyze the color, texture and drip losses of meat from Parda de Montaña veal calves under 3 feeding management systems in dry mountain areas (GR: grazing suckling calves; SUP: suckling plus supplemented calves; FIN: weaned calves finished on concentrates). Secondly, color evolution of meat packaged

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in film (FILM), modified atmosphere packaging (MAP) and vacuum packaging (VAC) was studied.

2. Materials and methods

This experiment was conducted at the La Garcipollera Research Station, in the central Pyrenees (Spain, 42° 37′ N, 0° 30′ W; 945 m a.s.l.), using 22 single male calves from the Parda de Montaña breed. This beef breed is derived from the former Brown Swiss breed through selection for meat production, but still has a milk yield (7.5 kg/d) that allows for growth rates close to 0.9 kg/d in unsupplemented suckling calves (Villalba, Casasús, Sanz, Estany, & Revilla, 2000). All procedures were conducted according to the guidelines of the Council Directive 86/609/EEC (EU, 1986) for the protection of animals, used for experimental and other scientific purposes.

2.1. Animals and management

The animals were reared in three lots with different management systems, from birth until they reached 230 kg when they were slaughtered. Table 1 details calf performance according to the feeding management system.

– GR. This is the traditional management of spring-born calves in the Pyrenees until weaning. Eight calves, born on February 15th (±3.8 d), were loose-housed with their dams until June 15th. During the housing period, calves had access to their dams twice daily to suckle for 30 min each time, with no access to concentrates. Thereafter, dams and calves were turned out to high mountain ranges, where they remained grazing until the end of September. Afterwards, cows and calves were grazing in a valley meadow until calves reached the target slaughter weight. Then, they were transported for 3 h to a commercial abattoir (MercaZaragoza, Zaragoza, Spain).
– SUP. Seven calves born on October 10th (±4.1 d) were loose-housed with their dams. Calves had access to their dams twice daily to suckle for 30 min each time. They also had ad libitum access to a starter concentrate (11.5 MJ ME/kg DM and 16.3% CP) until they were 3 months old and to a growing concentrate (13.3 MJ ME/kg DM and 15.0% CP) until they reached the target slaughter weight. Then, calves were weaned and transported to the same abattoir as the other groups.
– FIN. Seven calves born on October 9th (±4.1 d) were loose-housed with their dams. The calves had access to their dams twice daily to suckle for 30 min each time but had no access to concentrates until the last week of lactation in order to adapt. Calves were weaned when they were 164 d old. Thereafter, they were fed with the same growing concentrate as their counterparts and barley straw on an ad libitum basis until they reached the target slaughter weight. Then, the animals were transported to the same abattoir as the other groups.

Table 1
Effect of management system on birth and slaughter weight, age at slaughter and *Longissimus thoracis* muscle chemical composition.

	GR[a]	SUP	FIN	s.e.	Sig.
Birth weight (kg)	48	43	40	2.7	ns
Slaughter weight (kg)	227	234	233	8.6	ns
Age at slaughter (d)	226[a]	164[c]	208[b]	3.9	***
Average daily gain (kg/d)	0.79[b]	1.18[a]	0.84[b]	0.037	***
Fatness score[b]	3.0	4.0	4.0	0.0	***
Ultimate pH	5.67	5.59	5.68	0.026	ns
Dry matter[c] (%)	22.50[b]	23.47[a]	23.09[a]	0.156	**
Intramuscular fat[c] (%)	0.43	0.54	0.54	0.052	ns
Crude protein[c] (%)	20.75	20.97	20.96	0.158	ns
Ash[c] (%)	1.18[a]	1.17[a]	1.14[b]	0.009	*

Ns, $P>0.05$; * $P<0.05$; ** $P<0.01$; ***, $P<0.001$.
[a] GR, grazing suckler calves; SUP, restricted suckling plus concentrate calves; FIN, grazing suckler calves finished with concentrates.
[b] Fatness score, 15-point scale (from 1 = leanest, to 15 = fattest).
[c] Expressed in percentage of fresh matter.

Average daily gain (ADG) was calculated as the increase of weight from calving to slaughter divided by age. To minimize pre-slaughter stress, calves were kept with members of their treatment group and separated from unfamiliar animals during transport and at the abattoir, and they were slaughtered after arrival. Animals were stunned using a captive bolt pistol and processed according to standard commercial practices. The carcasses were chilled for 24 h at 4 °C, then graded using the European Grading Systems (Directives (ECC) no. 1208/81 and no. 2237/91). Fatness was scored using a 15-point scale (from 1 = leanest, to 15 = fattest).

2.2. Sampling

The carcasses were weighed and the M. *longissimus thoracis* from the left half of the carcass extracted. From the 8th thoracic vertebra to the 13th thoracic vertebra, the loin was sliced into one 100 g steak for drip loss determination, 1 steak for chemical analysis, 1 steak for fatty acid determination, 3 steaks for instrumental color determination at 0 d, 5 d and 13 d in the 3 different packing systems explained below, and 3 steaks were used to determine the Warner–Bratzler shear force at different aging intervals. The steaks used for instrumental color determination were 30 mm thick and those for Warner–Bratzler shear force determination 35 mm thick. The ultimate pH was measured with a Crison pH meter (Crison Instruments, SA, Barcelona, Spain) at the 10th vertebra level.

2.3. Chemical and fatty acid determination

To prepare meat for compositional analyses, the steak 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. Crude protein was determined following the Dumas procedure (A.O.A.C., 2000) using a nitrogen and protein analyzer (Model NA 2100, CE Instruments, Thermoquest SA, Barcelona, Spain) and expressed as a percentage of fresh meat. 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. 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 a percentage of fresh meat. Analyses were run in duplicate.

Fatty acid profiles were obtained as described by Tor, Estany, Francesch, and Cubiló (2005), modified for beef meat, fatty acids were quantified by incorporating an internal standard, 1,2,3-tritridecanoylglycerol (tritridecanoin c13:0), into each sample. Proportions of poly-unsaturated (PUFA), mono-unsaturated (MUFA) and saturated (SFA), n6, n3 fatty acids and the n6/n3 ratio were obtained from individual fatty acid percentages (Table 2).

2.4. Instrumental color measured in 3 packing systems

2.4.1. Modified atmosphere package (MAP)

Each steak was split into 3 pieces (1 piece for each display time) randomly allocated in trays with a modified atmosphere (70% 0_2; 20% CO_2; 10% N_2) (Praxair España, Spain) for each storage time. In each tray, pieces from 4 different animals were allocated keeping a 2:1, gas to meat, headspace. The cover film (Cryovac 1825–50, Cryovac Europe, Barcelona, Spain) had an oxygen permeability of 14.8 $cm^3 \cdot m^{-2} \cdot 24\ h^{-1}$ at 1 atm and a water vapor permeability of 16 $g \cdot m^{-2} \cdot 24\ h^{-1}$. The trays were kept at 4 °C and illuminated 24 h per day (410 lx) until the color was