Does forage type (grazing vs. hay) fed to ewes before and after lambing affect suckling lambs performance, meat quality and consumer purchase intention?


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A B S T R A C T

The aim of the study was evaluate the use of forage diets (grazing pasture vs. hay) around ewe parturition on the performance and meat quality of suckling lambs (10–12 kg body-weight). Forty-eight multiparous single bearing ewes from the Churra Tensina breed were used. The experimental treatments were conducted during the last 5 weeks of pregnancy (pre-partum period) and the 5 weeks of lactation (post-partum period) in a 2 × 2 factorial design. Ewes were fed ad libitum on mountain pastures or pasture hay. Hay was made in late spring from the same pasture paddocks to those grazed in autumn. Results showed that ewes body-weight (BW) and body condition score (BCS) were not affected by forage type feed around ewe parturition. The week post-partum had a more determinant effect on milk production and composition than forage type pre- and post-partum. The energy-corrected milk yield peaked on first week of lactation (1.39 l/day, P < 0.05), and decreased significantly from week 3 post-partum onwards (1.29 l/day vs. 1.02 l/day, P < 0.05). Forage type supplied to ewes during the pre-partum period did not affect any of the studied variables on lambs. During post-partum period forage type had effect on lamb ADG, which was higher in grazing system than in hay feed (259 g/day vs. 220 g/day). Consequently, age at slaughter was greater in lambs raised by ewes receiving hay post-partum compared to grazing ewes (36 days vs. 32 days, P < 0.05). Caudal fat colour was affected only by post-partum forage type, showing grazing group greater redness, yellowness and absolute value of the integral of the translated spectrum (SUM) than that forage type (P < 0.05). Carcasses from lambs raised by post-partum grazing ewes led to a muscle with lower lightness and yellowness and greater redness than hay forage type (P < 0.05). Lambs whose dams grazed presented a higher visual appraisal score at cutting time, however these differences disappeared as time advanced. Grazing forage had a positive effect on consumer purchasing decision (P < 0.10). In conclusion, forage type in pre-partum period did not affect the studied parameters whereas ewes grazing on mountain pastures after autumn-lambing improved lamb performance without any detrimental effect on carcass and instrumental meat quality.

1. Introduction

In the European Mediterranean countries, light lambs production (lighter than 24 kg BW) represents the largest share of lamb market (Sañudo et al., 1998). Consumers from Southern Europe show a preference for pale-pink colour of meat and white fat light lambs (Sañudo et al., 2007). To
obtain this kind of meat, the production system is mainly in confinement, based on concentrate feed after 45–55 days of age (light lambs) and on dam’s milk (suckling lambs).

Nowadays, there are increasing numbers of consumers demanding safe, healthy meat and clear information about production systems, especially animal feeding and management (Zervas et al., 1999). This stimulates the market interest in pasture-based production systems, which are considered to be of higher quality compared to those based on concentrates (Adnoy et al., 2005). Grass feeding produces more healthy meat, with higher contents of conjugated linoleic acid (CLA) and n-3 polyunsaturated fatty acids (PUFA) (Enser et al., 1998; Demirel et al., 2006; Scollan et al., 2006).

In earlier works, it was demonstrated that light lambs could be raised by their dams on mountain pastures during the spring season (Álvarez-Rodríguez et al., 2007; Joy et al., 2008a; Carrasco et al., 2009b) or on alfalfa pastures during late spring, summer and early autumn seasons (Álvarez-Rodríguez et al., 2010) with minimum or even no detrimental effects on lamb and carcass performance. These studies were carried out in periods of high forage mass availability, which can meet maintenance and production requirements. In some harsh environments, such as Mediterranean or Nordic conditions, there are several months with a lack of herbage mass due to drought or snow. During this period, ewes usually receive conserved forage, as hay or silage, around parturition. However, the influence of forage type fed to ewes before and after lambing on carcass and meat quality of sucking lambs is not widely studied. The aim of the study was to evaluate the use of two different forage types (grazed pasture vs. hay) fed to ewes around parturition on sucking performance, meat quality and consumer purchase intention.

2. Material and methods

2.1. Experimental site

The experiment was conducted in La Garrpicolla Research Station, in the Pyrenees (North-eastern Spain, 42°37‘N. 0°30‘W, 945 m above sea level, a.s.l.), during autumn 2008. The average annual rainfall is bimodally distributed with peaks in spring and autumn, with dry summers and some precipitation in form of snow in winter. The mean temperature during September, October, November and December was 16.2, 11.6, 5.0 and 3.0 °C, while precipitation in these months was 31.8, 120.8, 94.0 and 59.2 mm, respectively.

2.2. Animal management and experimental design

Forty-eight multiparous single-bearig ewes from the Churra Tensina breed were used in this study (46.5 ± 0.66 kg body weight, BW, and body condition score, BCS, of 3.0 ± 0.03 at breeding). Ewes were mated during spring (5 May to 15 June) to produce suckling lambs for the autumn-lambing period. Ewes were kept on mountain pastures (920–1500 m above see level) during the mating period (April–June) and the pre-partum, post-partum period (August–October). Ewes were slaughtered at 16.2, 11.6, 5.0 and 3.0 °C, while precipitation during these months was 31.8, 120.8, 94.0 and 59.2 mm, respectively.

2.3. Slaughter, carcass measurements and muscle sampling procedures

When lambs reached 10–12 kg BW they were weighed at farm and then transported to the experimental abattoir of the Research Institute in Zaragoza, which is located 180 km away from the farm. Immediately after arrival, lambs were slaughtered according to EU laws (European Union Directive and No. 86/609/CEE, 1986) and hot carcass weight (HCW) was recorded.

Carcasses were chilled at 4 °C for 24 h, cold carcass was weighed (CCW) and dressing percentage was calculated as the ratio of cold carcass weight to BW at slaughter (BWS). Fatness degree classification was carried out following the Community Scale for Classification of Carcasses of Ovine Animals (DOCE, 1994) for light carcasses (<13 kg). Every degree of fat cover of the scale 1 (low), 2 (slight), 3 (average), 4 (high) were expanded to three points: 1, 1+ , 2, 2+ , 3, 3+, 4, 4+. Hence, the fatness degree was scored from 1 to 12.

Thereafter, carcasses were split and M. Longissimus thoracis et lumbrorum from the left side were removed, and sampled as follows: samples from 6th to 10th thoracic vertebrae were taken for chemical analysis, vacuum-packed and frozen (−20 °C) until analysis. Samples from 11th to 13th thoracic vertebrae were taken to measure colour index, and from 1st to 6th lumbar vertebrae for visual appraisal and consumer purchase intention.
2.4. Instrumental measurements

Colour was measured in the CIELAB space (CIE, 1986). The lightness (L*), redness (a*) and yellowness (b*) were recorded. In caudal subcutaneous fat, besides of trichromatic coordinates, the proportion of reflected light each 10 nm between 450 and 510 nm was collected and the absolute value of the integral of the translated spectrum (SUM) was calculated according to Priolo et al. (2002). This variable is used to estimate the carotenoid pigments content of fat. All instrumental colour was measured with a white surface below the samples.

Carcass fat and Rectus abdominis muscle colour were measured 24 h post-mortem using a Minolta CM-2600d spectrophotometer (Konica Minolta Holdings, Inc., Osaka, Japan). R. abdominis muscle colour was measured at two locations of the internal face of the muscle randomly selected to obtain a mean value of a representative reading of the surface colour, after having removed the covering fascia (Ripoll et al., 2008). A white tile behind the muscle was used to standardize the measurements. Caudal subcutaneous fat colour was measured in the tail root, from three locations randomly selected but avoiding blood blots, discolorations and less covered areas (Díaz et al., 2002).

Muscle ultimate pH was measured at the 4th vertebral region with pH-meter equipped with a Crison 507 penetrating electrode (Crison Instruments S.A., Barcelona, Spain). Muscle samples for colour measurements were cut with a minimum thickness of 2 cm and placed in a polystyrene tray, wrapped with an oxygen permeable film and kept in the dark at 4°C. M. Longissimus colour was measured immediately after cutting on the cranial side of 11th thoracic vertebra and at 1 and 2 days after cutting.

2.5. Chemical analysis

Milk samples were analysed in a CombiFoss 5000 (Foss, Hillerød, Denmark) device comprising a Fossomatic 5000 somatic cell counter (based on the flow cytometry principle) and a MilkoScan 4000 compo- nent for protein and fat analysis. Meat samples were minced to determine the percentage of crude protein (Dumas procedure) and intramuscular fat (A.O.A.C., 2000).

2.6. Visual appraisal and consumer purchase intention

Loin portion was sliced at minimum thickness of 2 cm. A random sampling was carried out and 33 samples were evaluated. Individual samples were placed in polystyrene trays, wrapped with an oxygen permeable film and kept in a refrigerated display case. Trays were identified with a randomly written three – figure number. Samples were kept 6 days in the refrigerated glass case and identification and location of samples were exchanged every day to avoid that consumers recognized the sample. Twenty-five consumers (gender and age balanced) assessed the visual appraisal of meat at 0, 1, 2, 3, 4 and 5 days post-slicing, using a scale from 1 (very bad) to 10 (very good). Additionally, consumers were asked daily about their purchase intention for each sample (yes vs. no).

2.7. Statistical analyses

Data were analysed with the SAS statistical software (SAS v.9.1). Ewe milk data were analysed through analysis of variance with a mixed model (MIXED procedure) with pre- and post-partum forage type and week post-partum as fixed effects and ewe as a random effect. Body-weight, BCS and ADG from ewes were analysed through analysis of variance with a general linear model (GLM procedure) with pre- and post-partum forage type as fixed effects. Lamb data were analysed through the same model but adding lamb sex as fixed effect.

Visual appraisal of meat was analysed through analysis of variance with a mixed model (MIXED procedure) with pre- and post-partum forage type, lamb sex and display time as fixed effects and lamb as random effect. Consumer intention purchase data was analysed using LIFETEST procedure to evaluate the effects of pre- and post-partum forage type and lamb sex on the purchase intention. The Kaplan–Meier curves were drawn and the Wilcoxon and log-rank tests were used to examine the differences between the survival curves. Correlation between purchase intention and visual appraisal was tested with Spearman correlation coefficient.

Results were reported as least square means and their associated standard errors (SE). Multiple comparisons among treatments were performed by the Tukey’s method. Interaction effects were removed progressively from the model when non significant. Interactions are commented in the text only when they were significant (P<0.05).

3. Results

3.1. Productive performance of ewes

Forage type did not affect BW, ADG or BCS of ewes during late pregnancy and lactation. However, BW decreased during the experimental period, from 52.5 kg at the first week of the experimental period (week –5 pre-partum) to 47.7 kg at lambing and to 44.2 kg at week 5 post-partum (P<0.001). Ewes ADG during the late pregnancy period and lactation was not affected by forage type (average 0.12 ± 0.01 kg/day and –0.07 ± 0.02 kg/day, respectively; P>0.05). The body reserves coupled BW trend and BCS decreased steadily during the same periods (from 3.24 to 2.68, and to 2.41, respectively; P<0.001).

The effect of forage type on milk yield and composition is reported in Table 1. Pre- and post-partum forage type did not affect either milk or milk nutrient yields (P>0.05), except crude protein content, which was affected by the forage type during the pre-partum period (P<0.05). In contrast, week post-partum had large effect on milk and milk nutrients yields (Table 1; P<0.001). The changes of milk and nutrient yields according to week of lactation are shown in Table 2. The energy-corrected milk milk peaked on the first week of lactation (1.39 l/day, P<0.05), and decreased significantly from week 3 post-partum onwards (1.29 l/day vs. 1.02 l/day, respectively; P<0.05). The somatic cell count (SCC) in milk was not affected by treatment (P>0.05), but their log-values were greater at weeks 1 and 5 of lactation than in the rest (P<0.05).

3.2. Lamb growth performance and carcass characteristics

Forage type supplied to ewes during the pre-partum period did not affect most of the growth variables and carcass traits of lambs (Table 3; P>0.05). In the same way, forage type during the post-partum period did not have an effect either on BW or on weight losses during transport, but it had an effect on lamb ADG (P<0.01), which was higher in grazing than in hay feed system. Consequently, age at slaughter was greater in lambs raised by ewes receiving hay post-partum compared to grazing ewes (36 days vs. 32 days, P<0.05). Sex did not affect either BW at birth (3.6 kg vs. 3.7 kg for female and male lambs, respectively, P>0.05), or ADG during the rearing period (230 g/day vs. 249 g/day, respectively, P>0.05).

Neither pre- nor post-partum dam’s feeding system have significant effect on dressing percentage and fatness degree (Table 3; P>0.05). In addition, lamb gender did not affect any carcass trait either (P>0.05). Lightness of subcutaneous caudal fat was not affected by pre- or post-partum forage type fed to dams or by sex (Table 4). However, post-partum feeding affected redness (a*) (P<0.001) and yellowness (b*) indexes and SUM (P<0.05) of subcutaneous caudal fat, having greater a* and b* the carcasses...
of lambs from grazing dams. A significant interaction (P < 0.05) between sex and pre-partum forage type was detected in yellowness and SUM. Females from pre-partum grazing dams had greater values of yellowness and SUM than males, and conversely females raised by dams fed hay had lower values of yellowness and SUM than their counterpart males (Fig. 1).

Forage type fed to dams affected the lightness and redness index of M. r. abdominis in both evaluated periods (P < 0.05), whereas the yellowness index was affected

<table>
<thead>
<tr>
<th>Week</th>
<th>Milk yield (kg/day)</th>
<th>Yield (g/day)</th>
<th>Contents (%)</th>
<th>Log SCC (**<em>)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard (l/day)</td>
<td>Fat</td>
<td>Protein</td>
<td>Fat</td>
</tr>
<tr>
<td>1</td>
<td>1.26a</td>
<td>1.39a</td>
<td>115a</td>
<td>70a</td>
</tr>
<tr>
<td>2</td>
<td>1.19ab</td>
<td>1.19b</td>
<td>96b</td>
<td>60b</td>
</tr>
<tr>
<td>3</td>
<td>1.14ab</td>
<td>1.09bc</td>
<td>85bc</td>
<td>56bc</td>
</tr>
<tr>
<td>4</td>
<td>1.08bc</td>
<td>1.05bc</td>
<td>83c</td>
<td>54bc</td>
</tr>
<tr>
<td>5</td>
<td>0.93c</td>
<td>0.91c</td>
<td>70c</td>
<td>48c</td>
</tr>
</tbody>
</table>

1 Within each parameter, different letters (a, b and c) means significant differences between weeks post-partum (Tukey’s method; P < 0.05).
2 Standard production according to the equation of Bocquier et al. (1993); (milk production (l/day) × ((0.071 × SCP × 1.036 × 10) + (0.0043 × %CP × 1.036 × 10) + 0.2224).
3 Somatic cells count.

<table>
<thead>
<tr>
<th>Pre-partum</th>
<th>Post-partum</th>
<th>SE*</th>
<th>P-Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay</td>
<td>Grazing</td>
<td>Hay</td>
<td>Grazing</td>
</tr>
<tr>
<td>BW (kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At birth</td>
<td>3.6</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>At farm</td>
<td>11.6</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>At slaughter</td>
<td>11.2</td>
<td>11.1</td>
<td>11.2</td>
</tr>
<tr>
<td>Weight losses (%)b</td>
<td>3.31</td>
<td>3.79</td>
<td>2.99</td>
</tr>
<tr>
<td>ADG (g/day)</td>
<td>245</td>
<td>234</td>
<td>220b</td>
</tr>
<tr>
<td>Age at slaughter (d)</td>
<td>34</td>
<td>34</td>
<td>36a</td>
</tr>
<tr>
<td>HCW (kg)</td>
<td>5.98</td>
<td>5.89</td>
<td>5.89</td>
</tr>
<tr>
<td>CCW (kg)</td>
<td>5.88</td>
<td>5.77</td>
<td>5.77</td>
</tr>
<tr>
<td>DP (%)</td>
<td>52.37</td>
<td>52.10</td>
<td>51.69</td>
</tr>
<tr>
<td>Fatness degreec</td>
<td>3–</td>
<td>2+</td>
<td>2+</td>
</tr>
</tbody>
</table>

NS = P > 0.05.
* P < 0.05.
** P < 0.01.
† Interactions were not significant (P > 0.05); within a row, different letters (a and b) denote statistical differences between groups (P < 0.05).
‡ Standard error.
§ Weight recorded before suckling lambs were transported to the slaughterhouse (180 km far).
© Average daily gain.
° Hot carcass weight.
ρ Dressing percentage = (CCW × 100)/BWS.
γ Every degree of fat cover of the scale 1 (low), 2 (slight), 3 (average), 4 (high) were expanded to three points (1−, 1+; 2−, 2+; 3−, 3+; 4−, 4+).
Table 4
Influence of pre-partum (PRE) and post-partum (POST) forage type supplied to dams on the instrumental colour of subcutaneous caudal fat and of Rectus abdominis muscle of suckling lambs.

<table>
<thead>
<tr>
<th></th>
<th>Pre-partum</th>
<th>Post-partum</th>
<th>SEa</th>
<th>P-Values1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hay</td>
<td>Grazing</td>
<td>Hay</td>
<td>Grazing</td>
</tr>
<tr>
<td>Subcutaneous caudal fat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>71.4</td>
<td>70.3</td>
<td>71.2</td>
<td>69.6</td>
</tr>
<tr>
<td>a*</td>
<td>3.1</td>
<td>3.9</td>
<td>2.6a</td>
<td>3.7b</td>
</tr>
<tr>
<td>b*</td>
<td>11.5</td>
<td>11.8</td>
<td>10.5a</td>
<td>12.4b</td>
</tr>
<tr>
<td>SUMa</td>
<td>190.8</td>
<td>196.4</td>
<td>180a</td>
<td>201b</td>
</tr>
<tr>
<td>Rectus abdominis muscle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>51.78a</td>
<td>48.91b</td>
<td>52.36a</td>
<td>48.33b</td>
</tr>
<tr>
<td>a*</td>
<td>9.12b</td>
<td>10.46a</td>
<td>8.89b</td>
<td>10.70a</td>
</tr>
<tr>
<td>b*</td>
<td>13.14</td>
<td>11.69</td>
<td>13.42a</td>
<td>11.42b</td>
</tr>
</tbody>
</table>

NS – P > 0.05.
* P < 0.05.
** P < 0.01.
*** P < 0.001.
1 Interactions were not significant (P > 0.05), within a row except for b* and SUM of caudal fat. Different letters (a and b) denotes statistical differences between groups (P < 0.05).
2 Standard error.
3 Absolute value of the integral of the translated spectrum between 450 nm and 510 nm.

only by forage type during post-partum period (P < 0.05; Table 4). Grazing forage led to muscle less bright, yellowness, and more redness than hay forage type.

3.3. Chemical composition and instrumental measurement of M. Longissimus thoracis

Values of pH were not affected by any factor studied (P > 0.05). Only forage type supplied during the ewe post-partum period had effect on moisture and crude protein contents of lamb meat (Table 5; P < 0.01). Meat from suckling lambs whose dams grazed during the post-partum period presented greater crude protein content than those raised by ewes fed hay during lactation (P < 0.05). The crude fat content was not affected by forage type fed to dams in any period studied (P > 0.05). An interaction between pre-partum ewe feeding and lamb sex affected crude protein content of meat (P < 0.05), which was greater in females than in males when dams were fed hay pre-partum (20.86% vs. 19.84%, respectively, P < 0.05). Nevertheless, this difference between lamb gender was not significant in lambs from pre-partum grazing dams (20.44% vs. 20.20% in females and males, respectively; P > 0.05).

M. L. thoracis muscle colour was affected by forage type in the same way than R. abdominis (Table 6), although the effect was more noticeable. Loin from lambs whose dams grazed presented lower lightness (L*) and yellowness (b*), and greater redness (a*) (P < 0.05). The storage time affected significantly all indexes studied (P < 0.001), with significantly lower values at 0 h than at days 1 and 2 (P < 0.05), which did not differ between them.

3.4. Visual appraisal and consumer purchase intention

Visual appraisal score (Fig. 2) was not affected by pre-partum forage type and sex (P > 0.05) but a significant interaction (P < 0.001) was found between days of display and post-partum forage type. Scores ranged from 6.9 and 6.3 at cutting time (grazing and hay, respectively) to 2.1 and 2.6 at day 6 of display (grazing and hay, respectively). Scores from lamb’s meat from grazing ewes were significantly higher than those from hay fed dams at cutting time (P < 0.05). However, these differences disappeared from day 1 to day 5 (P > 0.05). At day 6 of storage the score from hay forage type had a tendency to be higher than grazing forage type (P < 0.1), in contrast of that observed in day 0.

Consumer purchase intention expressed as survival probability curves is shown in Fig. 3. Around 10% of consumers rejected the lamb meat at day 0 indicating that certain people would not buy suckling lamb meat anyway.
Table 5
Effect of pre-partum (PRE) and post-partum (POST) forage type on meat composition of suckling lambs.

<table>
<thead>
<tr>
<th>Ewes' feeding</th>
<th>Pre-partum</th>
<th>Post-partum</th>
<th>SE*</th>
<th>P-Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hay</td>
<td>Grazing</td>
<td>Hay</td>
<td>Grazing</td>
</tr>
<tr>
<td>pH 24 h</td>
<td>5.64</td>
<td>5.67</td>
<td>5.65</td>
<td>5.65</td>
</tr>
<tr>
<td>Dry matter (%)</td>
<td>24.63</td>
<td>24.58</td>
<td>24.29</td>
<td>24.92ab</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>20.36</td>
<td>20.33</td>
<td>19.94</td>
<td>20.74a</td>
</tr>
<tr>
<td>Crude fat %</td>
<td>2.04</td>
<td>2.06</td>
<td>2.08</td>
<td>2.02</td>
</tr>
</tbody>
</table>

NS = P > 0.05. Within a row, different superscript letters (a and b) denote statistical differences between groups (P < 0.05).
** P < 0.01
† Sex had no effect. Interactions were not significant (P > 0.05), except for crude protein pre-partum × sex: P = 0.02.
* Standard error.

Table 6
Influence of forage type in pre-partum (PRE) and post-partum (POST) on the instrumental colour of Longissimus thoracis muscle of suckling lambs.

<table>
<thead>
<tr>
<th>Time</th>
<th>Pre-partum</th>
<th>Post-partum</th>
<th>SE*</th>
<th>P-values†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hay</td>
<td>Grazing</td>
<td>Hay</td>
<td>Grazing</td>
</tr>
<tr>
<td>0 h</td>
<td>42.42a</td>
<td>40.18a</td>
<td>42.78a</td>
<td>39.82a</td>
</tr>
<tr>
<td>1 day</td>
<td>48.94b</td>
<td>46.70b</td>
<td>48.53b</td>
<td>47.12b</td>
</tr>
<tr>
<td>2 days</td>
<td>48.70b</td>
<td>46.22b</td>
<td>48.72b</td>
<td>46.21b</td>
</tr>
<tr>
<td>0 h</td>
<td>7.96a</td>
<td>9.23a</td>
<td>7.56a</td>
<td>9.63a</td>
</tr>
<tr>
<td>1 day</td>
<td>8.97ab</td>
<td>10.29ab</td>
<td>9.18ab</td>
<td>10.09ab</td>
</tr>
<tr>
<td>2 days</td>
<td>9.83b</td>
<td>10.88b</td>
<td>9.83b</td>
<td>10.88b</td>
</tr>
<tr>
<td>0 h</td>
<td>5.70a</td>
<td>4.81a</td>
<td>6.01a</td>
<td>4.49a</td>
</tr>
<tr>
<td>1 day</td>
<td>9.33b</td>
<td>9.46b</td>
<td>10.05b</td>
<td>8.75b</td>
</tr>
<tr>
<td>2 days</td>
<td>10.19b</td>
<td>9.80b</td>
<td>10.27b</td>
<td>9.73b</td>
</tr>
</tbody>
</table>

NS = P > 0.05.
† Sex had no effect on colour indexes. Within each variable, different superscript letters (a and b) means significant differences between rows (P < 0.05).
** P < 0.01.
*** P < 0.001.
* Standard error.

Purchase intention decreased quickly from day 0 to day 2 of storage. At day 2, 60% of consumer would purchase the meat, whereas at day 6 the consumer purchase intention decreased to 50%. There were no differences between curves according to pre-partum forage type (P > 0.05). However, a tendency to different purchase intention over time was observed between lamb’s meat from grazing ewes and hay fed dams during the post-partum period (P < 0.1). Purchase intention was higher for lamb’s meat from post-partum grazing ewes than for post-partum hay fed dams between 2 and 6 days of storage. Consumers purchase intention was significantly correlated with visual appraisal evaluation (r = 0.80; P < 0.001).

4. Discussion

4.1. Productive performance of ewes

The body reserve dynamics in terms of BW and BCS evolution were similar, regardless of forage type. Ewes lost body condition steadily from week –5 to week 5 of lactation to couple with mammary gland development and milk yield nutrient demand, respectively. The lack of effect of forage type during the last month of pregnancy on milk yield agrees with Goodchild et al. (1999), who found that feeding system in late pregnancy did not affect post-partum productive parameters of ewes bearing single lambs. In the present study, the estimated dietary metabolizable energy (ME) content, according to Cannas et al. (2004) was 10.2 and 9.1 MJ ME/kg DM for hay and pasture, respectively. In addition, the alfalfa pellets supplied 10.2 MJ ME/kg DM to grazing ewes when snow did not allow pasture grazing (16% of the whole experimental period). Thus, the lack of differences in milk yield suggests that the dietary energy content in both treatments was enough to meet the nutrient requirements of dams in order to achieve their milk production potential.

Milk fat content was not affected by forage type fed to ewes prior or after lambing. The relationship between milk
fat concentration and energy balance varies depending on the range of milk yield considered, being stronger at high milk production (Pulina et al., 2006). According to them, the negative association between milk fat content and milk yield is either weak or not significant in low milk production, as in the case of the present study. Unexpectedly milk protein content was greater in dams which were fed hay during the pre-partum period. In contrast, the forage type during post-partum period did not affect milk protein content despite of the greater crude protein of pasture compared to hay.

Although ewes rearing lambs are found to have a milk yield peak at 20–30 days post-partum (Cardellino and Benson, 2002), the decline of milk yield was observed herein from the beginning until the end of the study. Similar results were found by Joy et al. (2008b) and Atti et al. (2006), using local breeds. The differences between studies can be due to the genotypes used. In addition, the decrease of milk fat and protein contents from the beginning of lactation was unexpected as there was no increase in milk production. The higher concentration of fat and protein found in the first week of lactation (involving from 3 to 7 days of lambing) could be a consequence of the presence of colostrum.

4.2. Lamb performance, carcass characteristics and meat quality

Lamb performance was similar to that observed in suckling lambs (10–12 kg BW) under autumn grazing system (Sanz et al., 2008). The greater ADG observed in lambs from grazing dams might be related to some bioactive compounds of ewe’s milk fed fresh forages (Sampelayo et al., 2007; Cuchillo et al., 2010) and/or improved health by enhanced in vivo cellular immune response in lambs reared at pasture compared to indoors management system (Braghieri et al., 2007). However, we did not detect any sign of clinical disease neither in grazing nor hay treatments. Grass-based systems can be better alternative than a hay-based system in autumn conditions for suckling lamb production in order to use natural resources and to provide the meat required by tendency of consumers for the Christmas period. Regarding carcasses characteristics, both forage type supplied to ewes before and after lambing allowed producing comparable suckling lamb carcass. The similar carcass fatness degree highlights the similar milk yield and composition observed in all ewes, which did not limit adipose tissue accretion. Likewise, the greater meat protein in lambs reared by grazing ewes may have been induced by direct grass intake, since milk protein yields were similar in both forage type diets. The supply of green or hay forage to dams are both feasible feeding strategies to produce suckling lambs. However, according to the present results, feeding grazing pasture to ewes after lambing improves the growth of lambs until 12 kg BW.

The forage type supplied to dams affected carcass fat and meat colour, regardless of the period relative to parturition. Nevertheless, forage type exerted a more important effect during the post-partum compared to the pre-partum period. The effect of forage type during the pre-partum period on meat colour of suckling lambs was not expected. This effect could be related to the possible depots of lipid soluble pigments, as carotenoids, in intramuscular fat of foetal tissues. However, this issue deserves further studies.

As expected, subcutaneous cœdinal fat from suckling lambs whose dams grazed had greater yellowness and redness indexes and SUM than when dams were fed hay forage. Field wilting of cut forage to make hay resulted in major losses of carotenoids (Kalac, 2011), maximum responsible of yellowness index and SUM. The concentration of carotenoids in milk is highly dependent on the concentration of carotenoids in the diet (Nozière et al., 2006). The influence of grass-based feedstuffs on carcass fat colour of heavy lambs is well known (Schroeder et al., 1980; Chestnutt, 1994; Prache and Theriez, 1999). In contrast, in suckling lambs this influence is not widely studied. Studying the CIE L’*a”∗b∗ colour of milk ewes, Priolo et al. (2003) observed that milk from grass-fed animals showed higher b∗ values than the milk from control ewes eating silage and concentrate. However, Nozière et al. (2006) conclude that the carotenoid transfer from diet to milk is relatively low. The same authors, from an overview of their results, observed a weak relationship between milk carotenoids and its yellow milk colouration. Therefore, the greater yellowness, redness and SUM of cœdinal fat might be again due to the direct grass intake (although minimal quantity;
Álvarez-Rodríguez et al., 2007) instead of milk carotenoids content (Raynal-Ljutovac et al., 2008).

The lack of effect of forage type, period and sex on pH value of meat from suckling lambs rejects any stress factors influencing negatively the pH value. In relation to that, Carrasco et al. (2009b) observed that the cortisol concentrations before slaughter were not high enough to affect pH value when four feeding systems were studied (from high forage to high concentrate diets).

Ripoll et al. (2005) and Carrasco et al. (2009a) reported that colour differences between treatments disappeared as time of oxygen exposure increased (3 and 6 days after cutting time) regardless of the feeding system used. In the present study, during first day of blooming all parameters increased due to the myoglobin oxygenation, and then it became stable. Usually, grazing lambs presents high yellowness value (b’), which is associated with the presence of carotenoids, flavonoids and α-tocopherol concentration in their diet (Lynch et al., 2000). In suckling lambs the intake of these compounds via maternal milk was not enough to modify b’ in either R. abdominis or L. thoracis muscles. The lack of effect of sex on fat and meat colour might be explained by the similar growth physiology of lambs at short age.

M. R. abdominis from lambs raised at pasture also showed greater redness index but in contrast to fat colour they showed lower yellowness index. These results followed a similar pattern to those observed in light lambs of 22–24 kg BW (Ripoll et al., 2008; Carrasco et al., 2009a). The effect of diet on meat colour is not consistent. (Renerre, 1986) observed that the meat of lambs raised on pasture is darker in relation to stall-fed lambs due to greater concentration of haem pigments in muscles as a result of exercise. In contrast, Colomer-Rocher et al. (1988) reported, in light lamb carcasses that muscle R. abdominis colour was influenced by diet and age, but not by physical activity. In the present study, the differences in meat colour among treatments were not due to the final meat pH. As the main feed of suckling lambs is milk, the differences on colour parameters might be due to the differences in the ewes milk composition and their pigments contents.

4.3. Visual appraisal and consumer purchase intention

Colour is the single most important sensory attribute affecting consumer purchasing decisions of red meats (Eikelenboom et al., 2000). Consumer purchase intention was lower than the maximum score at initial time, with 10% of consumers rejecting the samples at first time. A similar consumer purchase intention pattern was detected by Kennedy et al. (2004) in Irish panelists and Panea et al. (2005) in Spanish consumers. It was expected that at the beginning of study (day 0) the consumer purchase intention would be 100%. This result supports that the shelf-life of food also depends on the interaction between consumer and food (Garitta et al., 2005). A large number of non-sensory factors, as convenience, price, production technology, health, contextual influences and others, determine the decisions of people (Jaeger, 2005). A slight influence of post-partum forage type was detected, with positive effect of grazing on purchase intention. Although instrumental muscle and fat colour in grazing lambs was not completely in line with the pale-pink meat and white fat type demanded by Spanish consumers, the visual assessment did not penalise such traits.

5. Conclusions

In ewes rearing single lambs, the week of post-partum had a more determinant effect on milk production and composition than forage type supply around parturition (hay vs. grazing pasture). Post-partum grazing had a positive effect on lamb growth. Suckling lambs meat from raised by grazing ewes led to greater crude protein content, lesser muscle lightness and yellowness and more redness compared to those from dams fed hay. Grazing forage had a positive effect on consumer purchasing intention. Therefore, in dry mountain conditions, ewes can be fed hay forage or grazing around parturition to produce suckling lambs in autumn. However, in post-partum period grazing pasture is recommended, instead of hay, because improved lamb performance without any detrimental effect on carcass and instrumental meat quality, besides of its positive effect on consumer purchasing intention.

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