Journal of Animal and Feed Sciences, 15, 2006, 17–24

Effect of production system on performance traits, carcass and meat quality in Brown Swiss young cattle

A. Cerdeño[1,3], C. Vieira[2], E. Serrano[1] and A.R. Mantecón[1]

[1]*Estación Agrícola Experimental, CSIC*
Apdo, 788, 24080 León, Spain
[2]*Estación Tecnológica de la Carne, ITACyL*
Apdo, 58, 37770 Guijuelo-Salamanca, Spain

(Received 21 July 2005; revised version 13 October 2005; accepted 6 January 2006)

ABSTRACT

Performance, carcass and meat quality were assessed in 3 groups of Brown Swiss male calves, all of them suckled by their dams: groups M200 and M250 were exclusively milk-fed and slaughtered at 200 or 250 kg, respectively, and G400 group was supplemented with grain and slaughtered at 400 kg after a short finishing period. Increasing weight in milk-fed animals led to an increase in dressing percentage and conformation score, and a decrease in muscle content with an increase in dissectible fat in the rib, with no repercussions on meat quality. G400 group showed higher values in compactness index, percentage of high-priced cuts and dissectible fat content than the lighter milk-fed groups. Regarding meat quality, the only remarkable difference in grain-fed animals was a higher a* index, with no detectable differences in sensory traits.

KEY WORDS: milk feeding, Brown Swiss cattle, performance, carcass quality, meat quality

INTRODUCTION

Production systems based on dual-purpose breeds, like the European Brown Swiss breed, located mainly in mountanious areas, in which the natural constraints from the climate and the geography seem to be unfavourable to mass meat production at low cost, are characterized by small- to medium-sized herds and

[3] Corresponding author: e-mail: anacerdeno@yahoo.es

difficulties in selling the milk (Serrano et al., 2005). A way to make a profitable use of the milk produced could be to feed it to their calves. This production can represent an optimal complementary income, producing either exclusively milk-fed calves - veal calves - or suckled animals receiving a short finishing period and slaughtered at 9 or 10 months of age-finished suckled bulls.

Furthermore, this alternative has the advantages of the reduction of costs of milk replacer and solid feeds (Vieira et al., 2005) and the production of valuable high-quality products.

The production of this type of young animals is in line with the market demands in several countries in the Mediterranean basin, where an important part of beef consumers demands light-coloured beef from young animals, in contrast with the demand of red beef from older animals in the northern European countries. This way, in Spain, 77% of beef consumption corresponds to meat from animals under one year old, 17% to yearlings and 6% to meat from older animals (MAPA, 2004).

Colour is, therefore, an important issue in this production. Differences in colour between veal calves and young bulls meat are expectable and accepted by consumer provided that meat colour remains being pale and not red. Thus, the effect of production system on meat colour, together with other quality traits, require a deeper knowledge in this type of products.

For these reasons, this study was designed to study the performance and the quality characteristics of carcass and meat of Brown Swiss animals reared exclusively with milk or supplemented with concentrate, and slaughtered at different weights.

MATERIAL AND METHODS

Animals and experimental design

A total of 18 Brown Swiss male calves were distributed, at birth, in three experimental groups. Animals in M200 group were milk-fed by their dams twice a day until slaughter, at a target liveweight of 215 kg. Calves in M250 group were equally reared than M200 group but slaughtered at about 250 kg liveweight. In the G400 group, animals were also suckled by their dams and were weaned at 150 days of age, having free access to growing concentrate (DM 88.7%; g/kg DM: CP 186.7; NDF 166.0; ash 81.8) during this rearing period. After weaning, animals received *ad libitum* finishing concentrate (DM 88.2%; g/kg DM: CP 164.8; NDF 185.8; ash 67.3) until slaughter, at 400 kg liveweight. All animals had free access to straw. Animals were allocated by group on straw bedding pens and were weighed every 21 days, average daily gain being calculated by linear regression.

Measurements, analytical methods and statistics

Empty body weight (EBW) was calculated as the difference between liveweight (LW) and the weight of gut content. Internal fat (kidney-channel, ommental and mesenteric fat) and the empty parts of the digestive tract were weighed. Dressing percentage was calculated as EBW relative to hot carcass weight. Carcasses were graded visually for conformation and fatness, according to EUROP beef carcass grading system. Morphological measurements were recorded on the left carcass side (De Boer et al., 1974). Compactness index was expressed as the ratio between hot carcass weight and carcass length. Subcutaneous fat depth and *longissimus* muscle area were recorded at the level of the 6th rib. Percentage of the sum of high-priced cuts (tenderloin, loin, thick flank, topside, silverside, rump, eye of round, chuck, shoulder and chuck tenderloin) was assessed. The sixth rib was dissected into bone, muscle, fat (subcutaneous and intermuscular) and other tissues.

pH was measured at 24 h *post mortem* in the *M. longissimus thoracis* (LT) at the 5th rib level, using a pH meter Metrohm 704 (Metrohm®, Herislau, Switzerland). Colorimetric parameters (CIE L*a*b*) were measured at the surface of the LT muscle corresponding to the 6th rib section, at 24 h *post mortem* and after a 90-min blooming period, using a Minolta CM-2002 spectrophotometer (Minolta®, Osaka, Japan). To evaluate the other measures of meat quality, a sample cut of *M. longissimus thoracis*, from 7th to 11th ribs, was taken from the left carcass side. Chemical analysis (dry matter, ash, crude protein and ether extract) were carried out according to official procedures. Drip loss and cooking loss were assessed according to Honikel (1998). Press loss was determined using the filter paper method. Warner-Bratzler shear force (WBSF) test was performed on the cooked samples using a Texture Analyser TA-XT2$_i$ (Stable Micro Systems®, Surrey, UK).

In order to evaluate the eating quality of the meat, a group of 8 trained panellists scored from 1 to 10 the intensity of the following characteristics: beef odour, tenderness, juiciness, beef flavour and overall acceptability. Sample used was aged for 7 days, vacuum-packed and frozen at -20ºC until analysis, being then thawed at 4ºC for 24 h. Sample was cut into 2 cm-thick steaks, which were cooked at 220ºC in an electric oven to an internal temperature of 70ºC. Two subsamples of 1.5 × 2 cm from each animal were offered to each panelist who judged meat from 4-5 animals per session within a total of four sessions. Each sample was maintained at 60ºC during the session which was carried out under red light to avoid that colour could influence panelists' judgements on the rest of the traits. Colour itself was excluded as a sensory trait because it is not relevant in cooked beef during consumption while being an important trait for purchase decision.

Statistical analysis was performed using one-way analysis of variance (SPSS 10.0). Significant differences between means were detected using Duncan test.

RESULTS

As shown in Table 1, average daily gain (ADG) was not significantly different between groups (P=0.160). For G400 group, ADG was 1.19±0.056 kg/d for the period from birth to weaning and 1.49±0.078 kg/d from weaning to slaughter. As expected, LW and EBW were significantly different between groups (P<0.001). The weight of body fat depots was higher (P<0.01) in the G400 group, though when this weight was expressed as a percentage of EBW this difference became non significant. Regarding the different parts of the gastrointestinal tract, we found the greatest development of reticulorumen and

Table 1. Animal performance, non-carcass parts and carcass characteristics

Indices	M200	M250	G400	S.E.M.	Sign.
Age, d	166.8[a]	179.2[a]	267.2[b]	12.25	***
ADG[1], kg/d	1.13	1.26	1.28	0.031	n.s.
LW[1], kg	219.5[a]	243.1[b]	407.0[c]	20.41	***
EBW[1], kg	204.5[a]	229.0[b]	375.0[c]	18.44	***
Non-carcass parts					
internal fat, kg	6.5[a]	9.3[a]	14.7[b]	1.16	**
% EBW					
internal fat	3.2	4.1	4.0	0.25	n.s.
GI[1] tract	5.0[a]	4.1[a]	5.8[b]	1.49	**
reticulo-rumen	1.6[a]	1.1[a]	2.5[b]	0.83	***
omasum	0.4[a]	0.3[a]	0.7[b]	0.24	**
abomasum	0.5[a]	0.4[b]	0.4[b]	0.08	**
small intestine	2.0[a]	1.6[a]	1.5[b]	0.25	**
large intestine	0.6	0.7	0.7	0.18	n.s.
Carcass characteristics					
hot carcass weight, kg	127.0[a]	150.5[b]	229.5[c]	10.73	***
dressing percentage, %	62.1[a]	63.9[b]	61.2[a]	0.36	***
cooling shrinkage, %	1.3[a]	1.6[ab]	2.6[b]	0.22	*
conformation score[2]	6.5[a]	9.0[b]	7.7[ab]	0.39	*
fatness score[3]	2.0	1.5	2.2	0.14	n.s.
carcass length, cm	100.8[a]	97.8[a]	119.4[b]	2.46	***
hind-limb length (L), cm	69.3[a]	70.1[a]	79.9[b]	1.67	**
hind-limb width (W), cm	18.9[a]	20.8[b]	24.6[c]	0.62	***
hind-limb perimeter, cm	90.5[a]	93.3[a]	106.0[b]	1.77	***
W/L	0.27[a]	0.30[ab]	0.31[b]	0.006	*
compactness index, kg/cm	1.26[a]	1.55[b]	1.92[c]	0.069	***
rib fat depth, mm	5.3	8.2	7.7	0.95	n.s.
high-priced cuts, %	59.2[ab]	57.1[a]	61.1[b]	0.68	*
LT[1] area, cm[2]	35.0[a]	43.8[b]	42.7[b]	1.65	*

*** P<0.001; ** P<0.01; n.s. P>0.05

[1]ADG: average daily gain; LW: liveweight; EBW: empty body weight; GI: gastrointestinal; LT: *longissimus thoracis* muscle

[2] 15 point scale: 15=E+ (very good conformation), 1=P- (very poor conformation)

[3] 5 point scale: 5= very fat, 1= very lean

omasum in G400 group and the lowest proportion of small intestine in this group, while the proportion of abomasum was the highest (P<0.01) in M200 group.

Dressing percentage was the highest (P<0.001) in M250 group (Table 1). Conformation score was also higher in this group and lower in M200 group, with G400 presenting an intermediate value. Fatness score and rib fat depth did not differ in a significant way between groups (P>0.05), probably related to high variability within groups. The proportion of high-priced cuts was higher in G400 group and LT area was lowest in M200 group (P<0.05).

Percentages of the different tissues obtained from the sixth rib dissection are shown in Table 2. We found that the M200 group presented the greatest proportion of muscle and the lowest proportion of intermuscular fat (P<0.05), while subcutaneous fat proportion was highest in G400 group.

Table 2. Tissue composition of the 6th rib

Tissue, %	M200	M250	G400	S.E.M.	Sign.
Bone	20.6	23.0	21.0	0.92	n.s.
Muscle	67.1^{a}	61.8^{b}	62.3^{b}	0.90	*
Subcutaneous fat	1.8^{a}	2.5^{a}	3.8^{b}	0.32	*
Intermuscular fat	7.5^{a}	9.9^{b}	10.8^{b}	0.53	*
Other tissues	3.1	2.8	2.1	0.18	n.s.

*** P<0.001; * P<0.05; n.s. P>0.05

Table 3. Meat quality traits

Indices	M200	M250	G400	S.E.M.	Sign.
pH LT	5.61	5.66	5.65	0.031	n.s.
Meat colour					
L*	41.5	38.4	39.5	0.78	n.s.
a*	8.9^{a}	8.5^{a}	11.7^{b}	0.46	*
b*	10.9	9.0	12.1	0.50	n.s.
Chemical composition					
DM, %	25.5	25.6	26.3	0.24	n.s.
ash, % of DM	4.8^{a}	4.7^{a}	4.2^{b}	0.11	*
crude protein, % of DM	90.1	91.3	89.8	0.46	n.s.
ether extract, % of DM	5.2	7.0	8.2	0.56	+
Drip loss, %	1.6	1.2	1.5	0.08	n.s.
Press loss, %	13.0^{a}	14.3^{a}	16.5^{b}	0.47	**
Cooking loss, %	20.1	19.1	21.7	1.00	n.s.
Sensory traits[1]					
beef odour intensity	5.7	5.5	5.0	0.17	n.s.
tenderness	5.7	6.6	5.2	0.31	n.s.
juiciness	4.3	4.8	4.5	0.19	n.s.
chewiness	4.1	4.9	4.4	0.32	n.s.
beef flavour intensity	5.1	5.1	5.0	0.09	n.s.
overall acceptability	4.3	5.0	4.5	0.24	n.s.

*** P<0.001; ** P<0.01; * P<0.05; n.s. P>0.05; + P<0.10

[1] all measured on a 10-point scale (1= the lowest intensity, 10= the highest intensity)

Regarding meat quality (Table 3), few differences were found between groups. The most remarkable one is the higher a* index found in the heavier grain-fed group ($P<0.05$). Ether extract content tended ($P=0.080$) to be higher and press loss was significantly higher ($P<0.01$) in this same group. No significant differences were found in sensory traits between groups.

DISCUSSION

Values concerning average daily gain are comparable to those reported by Bergström and Dijkstra (1991) with calves fed only milk (1.088 g/d) or supplemented with a silage/concentrate mix (1.309 g/d), but were superior to those found by Casasús et al. (2001) for Brown Swiss calves during the suckling period, unsupplemented (0.783 g/d) or supplemented with concentrate (1.109 g/d).

The higher internal fat content in the G400 group as compared to that in M200 and M250 groups was more likely derived from the increase in slaughter weight than from the feeding strategy, as evidenced by the absence of differences when this content was expressed as a proportion of EBW.

The observed variations in the proportion of the different parts of the digestive tract reflects the transition from the pre-ruminant to the ruminant state, characterized by a decrease in abomasum and small intestine along with an increase in rumen and omasum. Thus, the decrease of dressing percentage in this group basically reflects differences in digestive tract weight, as supported by the correlation found between these traits ($r=-0.68$, $P=0.002$) and the coinciding results of Beauchemin et al. (1990).

Conformation score in the grain-fed group was expected to be higher, corresponding to its higher carcass weight and the superiority in the morphological measurements and compactness index. The scores obtained by the milk-fed groups are similar to those reported by Vieira et al. (2005) in Brown Swiss veal calves.

Regarding the tissue composition, the highest muscle proportion found in the lighter milk-fed group is in agreement with other authors who pointed out the early development of muscle which growth slows down as fatty tissue growth increases (Berg and Butterfield, 1968). This way, the heavier slaughter weight and the grain feeding led to a significantly higher fat content in rib in G400 group. Results obtained with respect to intermuscular and subcutaneous fat are reflecting the differences in the relative growth of these depots reported by Robelin (1986), with an earlier development of intermuscular fat.

The colour is the main trait determining marketability of veal meat. The higher redness index (a*) found in the grain-fed group compared to the milk-fed groups was expected, according to previous observations (Bergström and Dijkstra, 1991;

Scheeder et al., 1999; Vieira et al., 2004), suggesting these differences could be attributed to the different iron and pigment concentration. However, the a* value found in the young bulls from G400 group (11.7) is still quite lower to that shown by Brown Swiss bulls under usual fattening systems and slaughtered at higher weights, e.g., 15.9 reported by Sañudo et al. (1998) or 21.3 reported by Serra et al. (2004).

The chemical composition of meat in milk-fed groups was comparable to that obtained by Vieira et al. (2005) with animals of similar characteristics. Though ether extract content showed a numerical increase with slaughter weight and with grain feeding, differences between groups were not statistically significant (P=0.080). Notwithstanding this, intramuscular fat content showed a strong correlation with carcass weight (r=0.90; P=0.011).

Production system had no significant effect on sensory properties of meat, in agreement with observations of Bergström and Dijkstra (1991), Johnson et al. (1992), Cozzi et al. (2002) and Xiccato et al. (2002), who compared exclusively milk-fed calves with alternatively fed calves. Vieira et al. (2004) reported differences in juiciness and acceptability, relating them to variations in intramuscular fat content. Thus, the high variability in the ether extract content in our groups could be at least partly responsible for the lack of significant effects on sensory traits in M250, together with some other unknown factors which require further investigation.

CONCLUSIONS

Within milk-fed animals, the higher slaughter weight would be recommended, since colour and other meat quality traits remained unaffected and the increase in carcass weight favour the profitability of the production system. The production of suckled and grain-fed young bulls provide heavier carcasses with "redder" meat colour, which will be recognized by consumers as a different but also accepted product, therefore, the election of this system will depend on farms conditions, market prices and local consumer demands.

REFERENCES

Beauchemin K.A., Lachance B., St.-Laurent G., 1990. Effects of concentrate diets on performance and carcass characteristics of veal calves. J. Anim. Sci. 68, 35-44

Berg R.T., Butterfield R.M., 1968. Growth patterns of bovine muscle, fat and bone. J. Anim. Sci. 27, 611-619

Bergström P.L., Dijkstra M., 1991. Veal production with less milk replacer in the ration supplemented with concentrates and maize silage. In: J.H.M. Metz, C.M. Groenestein (Editors). New Trends in Veal Calf Production. EAAP Publication No. 52, Wageningen, pp. 23-31

Casasús I.S., Bernués A., Sanz A., Revilla R., 2001. Feeding cow and calves during lactation and fattening period under mountanious extensive systems: (I) Performance of herd during lactation (in Spanish). ITEA Extra 22, 433-435

Cozzi G., Gottardo F., Mattiello S., Canali E., Scanziani E., Verga M., Andriguetto I., 2002. The provision of solid feeds to veal calves: I. Growth performance, forestomach development, and carcass and meat quality. J. Anim. Sci. 80, 357-366

De Boer H., Dumont B.L., Pomeroy R.W., Weniger J.H., 1974. Manual on E.A.A.P. reference methods for the assessment of carcass characteristics in cattle. Livest. Prod. Sci. 1, 151-164

Honikel K.O., 1998. Reference methods for the assestment of physical characteristics of meat. Meat Sci. 49, 447-457

Johnson D.D., Van Horn H.H., West R.L., Harris Jr. B., 1992. Effect of calf management on carcass characteristics and palatability traits of veal calves. J. Dairy Sci. 75, 2799-2804

MAPA, 2004. Food Consumption Panel 2004 (in Spanish). Ministry of Agriculture, Fisheries and Food. Madrid (Spain)

Robelin J., 1986. Growth of adipose tissues in cattle; partitioning between depots, chemical composition and cellularity. A review. Livest. Prod. Sci. 14, 349-364

Sañudo C., Albertí P., Campo M.M., Olleta J.L., Panea B., 1998. Instrumental quality of beef meat from seven Spanish breeds (in Spanish). Arch. Zootec. 48, 397-402

Scheeder M.R.L., Becker B., Kreuzer M., 1999. Veal colour and other meat quality characteristics in calves fattened on maize silage and concentrate. Arch. Tierzucht 42, 535-553

Serra X., Gil M., Gispert M., Guerrero L., Oliver M.A., Sañudo C., Campo M.M., Panea B., Olleta J.L., Quintanilla R., Piedrafita J., 2004. Characterisation of young bulls of the Bruna dels Pirineus cattle breed (selected from old Brown Swiss) in relation to carcass, meat quality and biochemical traits. Meat Sci. 66, 425-436

Serrano E., Cerdeño A., Lavín P., Giráldez F.J., Ruiz-Mantecón A., 2005. Characteristics of cattle farm systems in Montaña de Riaño (León) region (in Spanish). ITEA 101, 3-24

Vieira C., García M.D., Cerdeño A., Mantecón A.R., 2005. Effect of diet composition and slaughter weight on animal performance, carcass and meat quality, and fatty acid composition in veal calves. Livest. Prod. Sci. 93, 263-275

Vieira C., García-Cachán M.D., Martínez B., Cerdeño A., Mantecón, A.R., 2004. Effect of slaughter weight and diet composition of calves on meat and fat quality. In: Proceedings of the 50th International Congress of Meat Science and Technology. Helsinki (Finland), pp. 1354-1357

Xiccato G., Trocino A., Queaque P.I., Carazzolo A., 2002. Rearing veal calves with respect to animal welfare: effects of group housing and solid feed supplementation on growth performance and meat quality. Livest. Prod. Sci. 75, 269-280