Beef cattle performance, carcass and meat quality traits to discriminate between pasture-based and concentrate diets

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Abstract. The aim of this work was to identify general relationships between the fattening diet and weight gains, carcass and meat quality across experiments, using data from bulls (n = 90) and steers (n = 56) of Parda de Montaña and Pirenaica breeds collected in 7 experiments. The different factors considered were diet (1. pasture+supplement; 2. pasture+supplement and indoor finishing for <3 months; 3. concentrates), breed and sex. Dietary energy and protein, forage:concentrate ratio, animal performance (weight gain, dry matter intake, age at slaughter), carcass (weight, conformation and fat scores, fat colour) and meat quality (intramuscular fat, colour and texture) were registered. The relationships between variables were studied with a Principal Component Analysis. Three factors explained 50% of the total variability: Factor 1 (21% of variability) was associated positively with fat yellowness and colour intensity, and negatively with daily gains during fattening; Factor 2 (15%) with meat yellowness, lightness and tenderness; and Factor 3 (14%) with meat redness and colour intensity. These factors were influenced by diet, sex and/or weight or age at slaughter, but not by breed. A discriminant analysis classified animals by fattening diet, with total accuracy for concentrate-fed diets (100%), intermediate for pasture+supplement (97%) and lower for cattle finished after grazing (91%), probably because of their intermediate meat and carcass characteristics.

Keywords. Attening diets – Cattle performance – Product quality – Discriminant analysis.

Utilisation des performances, de la qualité de la carcasse et de la viande pour discriminer entre les régimes à base de fourrages ou de concentres dans les des bovins à viande

Résumé. *Le but de ce travail était d'identifier des relations générales entre le régime d'engraissement et les performances, la qualité de la carcasse et de la viande des bovins, en utilisant données de males entiers (n = 90) et bouvillons (n = 56) de deux races, recueillis dans 7 expériences. On a considéré le régime (1. pâturages+supplément; 2. pâturages+supplément et finition à l'intérieure pendant <3 mois; 3. concentrés), la race et le sexe. On a enregistré la quantité et qualité des aliments ingérés, les performances, la qualité de la carcasse (conformation, engraissement, couleur du gras) et de la viande (graisse intramusculaire, couleur et tendreté). Les relations entre eux ont été étudiées avec une analyse de composantes principales. Trois facteurs expliquaient 50% de la variabilité: Facteur 1 (21%) associée avec l'intensité du couleur jaune de la graisse, et négativement avec des gains; Facteur 2 (15%) avec le couleur jaune de la viande, sa luminosité et tendreté; et Facteur 3 (14%) avec l'intensité de rouge de la viande. Ils étaient influencés par le régime alimentaire, le sexe et/ou le poids ou l'âge à l'abattage, mais pas par la race. Une analyse discriminante a classé les animaux selon leur régime alimentaire, avec précision totale pour les régimes de concentré (100%), intermédiaire pour le pâturage+supplément (97%) et inférieure pour les bovins finis après pâturage (91%), peut-être parce qu'ils avaient des caractéristiques intermédiaires entre les autres.*

Mots-clés. *Régimes d'engraissement des bovins – Performance – Qualité – Analyse discriminante.*

I – Introduction

Beef cattle performance and product quality are greatly dependant on the animal type or the feeding management. Forage feeding is currently given increasing interest as compared to concentrate fattening diets, due both to economic efficiency and consumer demands. These requests are based on perceptions of animal well-being, environmental sustainability and meat nutritional quality (leaner and with a more healthful fatty acid profile) (Van Elswyk and McNeill, 2014), and have led to the development of different methods to authenticate meat produced with forage-rich diets (Blanco *et al.*, 2011). The aim of this work was to identify relationships between the fattening diets of cattle and weight gains, carcass and meat quality.

II – Materials and methods

1. Animals and diets

This study was conducted using existing data from seven experiments conducted at the facilities of CITA research stations (2003-2010). Performance and carcass and meat quality data were obtained from 90 bulls and 56 steers, of Parda de Montaña and Pirenaica beef cattle breeds, raised during their fattening period (5-13 months in the different studies) after weaning on several feeding strategies. They were classified into three fattening diets: (i) Concentrates: animals received *ad libitum* concentrates throughout the fattening phase (n = 62); (ii) Pasture+Supplement: animals grazed on pastures (alfalfa pastures or mountain meadows) with supplementation (maize, barley or concentrates) (n = 62); and (iii) Pasture+Finishing: animals grazed on pastures with supplements and finished indoors for less than three months, on diets with 40 to 90% concentrates (n = 22).

2. Measurements

The animals were weighed fortnightly throughout the fattening phase, and daily gains were calculated for the whole fattening period (ADG) and for the last 3 months (ADG3). Forage and concentrate intake was determined or estimated; the forage:concentrate ratio (F:C) was calculated for the whole fattening period and for the last 3 months. The chemical composition of the different feedstuffs was determined to estimate the dietary energy and protein intake.

The animals were slaughtered in a commercial abattoir when they reached the target age (SA) or weight (SW) for each experiment (Table 1). Carcasses were visually graded for conformation (CONF, SEUROP system transformed into an 18-point scale) and fatness score (FS in a 15-point scale, from 1 for 1- to 15 for 5+). Subcutaneous fat colour (CIE lightness: L*fat, redness: a*fat, yellowness: b*fat, Chroma: C*fat and Hue angle: h*fat) was measured at the loin area with a spectrophotometer.

The *Longissimus thoracis* muscle was removed for meat analyses. Meat colour was determined with a spectrophotometer after 7 days of air exposure (L*meat, a*meat, b*meat, C*meat, H*meat). For instrumental texture analysis, steaks were aged for 7 days at 4ºC for Warner-Bratzler shear force determination (maximum stress, STRESS) using an Instron machine. Intramuscular fat content (IMF) was quantified with an XT10 Ankom extractor.

Table 1. Mean (± s.d) of slaughter weight (SW), slaughter age (SA), carcass conformation (CONF), fatness score (FS) and subcutaneous fat colour, and meat colour, intramuscular fat (IMF) and toughness (STRESS) (n = 146)

		Carcass					Meat				
SW, kg	SA, months	CONF	FS	L*fat	a*fat	b*fat	L*meat	a*meat	b*meat	IMF, %	STRESS, N/cm^2
483 ± 47	14.8 ± 4	9.2 ± 2.3	4.4 ± 1.4	72.6 ± 4	2.6 ± 1.7	13.5 ± 3.9	40.3 ± 3.4	13.3 ± 2.4	13 ± 2.8	1.6 ± 0.8	70.4 ± 20.7

3. Statistical analyses

All the analyses were conducted with SAS (SAS 9.4, Cary, NC, USA). The relationships between the variables of performance (gains), carcass (dressing percentage, conformation, fatness score, subcutaneous fat colour) and meat quality (intramuscular fat content, meat colour and maximum stress) were studied with a Principal Component Analysis (PCA). New groups of variables (factors) that retained as much variance as possible were defined. These factors were analysed with a GLM procedure, using Diet, Breed and Sex as fixed effects, and SA and SW as covariates. The correlations between the factors obtained in the PCA and diet traits (F:C, energy and protein content) were performed using the CORR procedure. A discriminant analysis was performed using the DISCRIM procedure, to predict the dietary treatment a given observation belonged to, considering all response variables. Cross-validation was run by omitting each observation one at a time, recalculating the classification function with the rest and classifying the omitted observation.

III – Results and discussion

Three factors explained 50% of the total variability of the selected variables (Table 2). **Factor 1** was associated positively with fat colour intensity (C*fat), especially yellowness, and negatively with gains during the fattening phase. It was affected by Diet (Pasture+Supplement had the highest values and Concentrates the lowest) and Sex (higher values in steers than in bulls) but not by Breed. Higher SW led to higher values of Factor 1 ($p<0.01$). **Factor 2** was related with meat yellowness, lightness and toughness. It was influenced by Diet (Pasture+Finishing and Concentrates had higher values than Pasture+Supplement) and Sex (higher in steers than in bulls) but not by Breed; and animals with higher SA had lower values of Factor 2 ($p<0.001$). **Factor 3** was related with meat

Table 2. Contribution of response variables to the main factors in the PCA. Influence of diet, sex, breed, age and liveweight at slaughter on these factors

	Factor 1 (fat colour and gains)	Factor 2 (meat yellowness & toughness)	Factor 3 (meat redness)
% Variability explained	21%	15%	14%
Correlation[†] with response variables			
a*fat	**0.65**	-0.03	0.01
b*fat	**0.99**	0.08	-0.06
C*fat	**0.99**	0.07	-0.06
a*meat	0.14	-0.31	**0.94**
b*meat	-0.05	**0.80**	**0.60**
H*meat	-0.14	**0.97**	-0.15
C*meat	0.05	0.34	**0.93**
L* meat	-0.33	**0.47**	0.00
ADG	**-0.65**	0.06	-0.09
STRESS	0.24	**-0.41**	-0.08
ADG3	**-0.58**	0.32	0.01
Effects			
Diet	*<0.001*	*<0.001*	0.14
Sex	*<0.001*	*<0.001*	0.11
Breed	0.36	0.46	0.30
SA (covariate)	0.07	*<0.001*	0.06
SW (covariate)	*0.01*	0.17	*0.02*

[†] Only variables with correlation >|0.4| (absolute value, in bold) with at least one factor are presented.

colour intensity and particularly redness. It was not influenced by any of the fixed effects, but animals with higher SA had lower values of Factor 3 ($p<0.05$). The lack of breed differences agrees with results of Albertí *et al.* (2005), who classified them together as "medium meat producers" when compared with other Spanish beef breeds.

Diet composition and quality were correlated with the response variables and therefore with the factors obtained from the PCA. Focusing on forage-based diets, Factor 1 was highly correlated ($r>0.60$) with the amount and proportion of forage in the diet, the energy and protein content of forage, and negatively ($r<-0.60$) with the amount and protein content of concentrate. These relationships indicate that diets with higher forage content led to more yellow subcutaneous carcass fat and lower gains. The fact that lower performances were achieved despite high forage nutritional quality may be due to a higher energy expenditure associated to these diets or a suboptimal nutrient synchrony (carbohydrate and protein fractions), which could be improved with specific supplements or timing supplement delivery (Hersom, 2008). Factors 2 and 3 were less related to diet characteristics.

The discriminant analysis based on the three factors classified animals into their actual fattening diets with a 4.1% error rate (up to 7.7% with cross-validation). The accuracy was 100% for concentrate-fed diets (all animals correctly classified), intermediate for animals fattened on pasture with supplements (97%) and lower for cattle finished indoors after grazing (91%) (Fig. 1), probably because the finishing diets of the latter group resulted in carcass and meat traits intermediate between the other two categories, as Blanco *et al.* (2011) described.

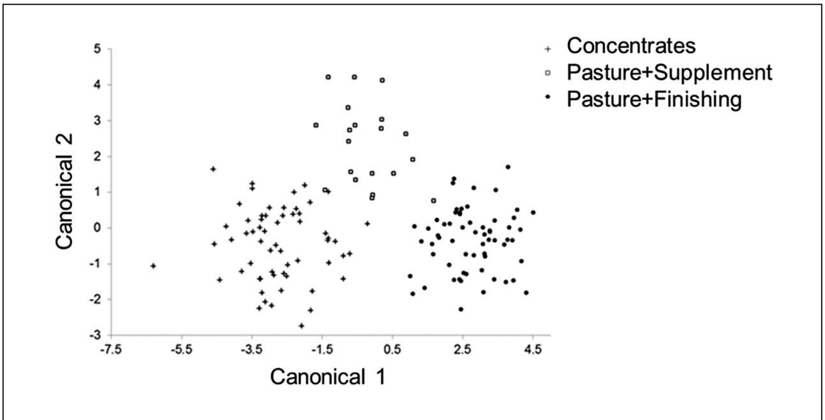

Fig. 1. Representation of animals fattened with the different diets in the canonical space obtained from the response variables.

IV – Conclusions

The fattening diets influenced cattle gains, fat colour and meat quality attributes. Therefore, these traits can be used to discriminate among feeding strategies based on pasture or concentrates, although accuracy will depend on the diet type.

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References

Albertí P., Ripoll G., Goyache F., Lahoz F., Olleta J.L., Panea B. and Sañudo C., 2005. Carcass characterisation of seven Spanish beef breeds slaughtered at two commercial weights. *Meat Science,* 71, 514-521.

Blanco M., Casasús I., Ripoll G., Sauerwein H. and Joy M., 2011. Grazing lucerne as fattening management for young bulls: technical and economic performance and diet authentication. *Animal,* 5, 113-122.

Hersom M.J., 2008. Opportunities to enhance performance and efficiency through nutrient synchrony in forage-fed ruminants. *Journal of Animal Science,* 86, E306-317.

Van Elswyk M.E. and McNeill S.H., 2014. Impact of grass/forage feeding versus grain finishing on beef nutrients and sensory quality: The U.S. experience. *Meat Science,* 96, 535-540.