Body composition in mature Parda de Montaña and Pirenaica suckler cows

J. Álvarez-Rodríguez*, M. Blanco, G. Ripoll, A. Sanz and I. Casasús

Centro de Investigación y Tecnología Agroalimentaria (CITA), Gobierno de Aragón.
Av. Montañana 930. 50059 Zaragoza (Spain).

Abstract

Two experiments were conducted to study the body composition of mature females from two breeds of suckler cattle (Parda de Montaña and Pirenaica) with different origin and purpose. In Exp. 1, body condition score (BCS) and subcutaneous fat thickness (SFT) were measured in 64 cows in a 2x2 factorial arrangement (Parda de Montaña *vs.* Pirenaica breed and dry *vs.* lactating cows). SFT was similar across genotypes (P>0.05) but physiological stage affected this trait (P<0.05). SFT values were concomitant with BCS, allowing moderately good predictions of the former parameter from the latter. In Exp. 2, 16 mature dry cows, 8 per breed, were slaughtered and some fat depots, together with carcass and non-carcass characteristics were evaluated. No differences were found in any of the *in vivo* (SFT) or *post-mortem* (omental, kidney knob and channel fat) measured fat depots (P>0.05). Carcass weights (hot and cold) and dressing percentages (slaughter and commercial) as well as the weight of some metabolically active organs (liver, spleen and kidney) and hide were similar across breeds (P>0.05). The previous traits revealed no differences in the body composition of Parda de Montaña and Pirenaica cattle breeds, highlighting the parallel trajectory of selection for meat production in both genotypes over the last years.

Additional key words: carcass, cull cows, offals, omental fat, subcutaneous fat thickness.

Resumen

Composición corporal en vacas nodrizas de raza Parda de Montaña y Pirenaica

Se realizaron dos experimentos para estudiar la composición corporal de dos razas de vacas nodrizas (Parda de Montaña y Pirenaica) con distinto origen y aptitud. En el Exp.1 se midió la condición corporal (BCS) y el espesor de grasa subcutánea (SFT) en 64 vacas según un diseño 2x2 factorial (raza Parda de Montaña *vs.* Pirenaica y vacas secas *vs.* lactantes). La SFT fue similar entre genotipos (P>0,05), pero no entre estados fisiológicos (P<0,05). Los valores de SFT fueron concomitantes con los de BCS, permitiendo moderadamente buenas predicciones del primer carácter a partir del segundo. En el Exp. 2 se sacrificaron 16 vacas secas adultas, 8 por raza, para evaluar varios de sus depósitos adiposos, junto con algunas características de la canal y del quinto cuarto. No se observaron diferencias en ninguno de los depósitos adiposos medidos *in vivo* (SFT) o *post-mortem* (grasa omental y pélvico-renal) (P>0,05). Los pesos de la canal (caliente y frío) y sus rendimientos (matadero y comercial), además del peso de algunos órganos metabólicamente activos (hígado, bazo y riñón) y la piel, fueron similares entre razas (P>0,05). Los caracteres previos no revelaron diferencias en la composición corporal de las razas Parda de Montaña y Pirenaica, reflejando la paralela trayectoria de selección hacia la producción de carne en ambos genotipos a lo largo de los últimos años.

Palabras claves adicionales: canal, espesor de grasa subcutánea, grasa omental, quinto cuarto, vacas de deshecho.

Introduction

Parda de Montaña (PA) and Pirenaica (PI) are two suckler cattle breeds widely spread throughout northern Spain (between 25-30 and 20-23 thousand heads, respectively). The former comes from the selection for beef and mothering abilities from the old Brown Swiss, which was introduced in the country two centuries ago as a dual-purpose breed (milk-beef). The latter is an autochthonous hardy breed from the mountain area of Pyrenees, which was utilized in the past as a triple-purpose breed (work-milk-beef) and is currently used for beef production.

Even though PA and PI have relatively similar mature weight (around 575 kg at calving) their live-weight evolution during the grazing season is different (Casasús *et al.*, 2002), mainly due to lower gains of PA compared to PI cows. Furthermore, milk potential and intake capacity throughout the post-partum period are greater in PA cows so that their higher milk yield can be supported (Casasús *et al.*, 2004). Such differences lead to suggest that body composition would also differ across both breeds, especially if we consider that there is large evidence that extreme dairy-type breeds deposit a higher proportion of their total fat internally (as kidney knob and channel fat) and a lower proportion subcutaneously than traditional beef breeds (Kempster *et al.*, 1982).

The body condition scoring system has been proved extremely useful in quantifying relationships between body condition and certain parameters within the production cycle (Lowman *et al.*, 1976). The development of specific prediction equations for body fat depots based on body condition score (BCS) should take into account the afore-mentioned lipogenic diversity in each breed. As BCS scale only assesses subcutaneous fat cover, variation in the partition of fat among the main adipose tissue depots might be expected.

We hypothesized that for a similar moderate to high BCS, PA cows may have higher omental fat content than their PI counterparts, affecting such differences to carcass and non-carcass yields. Thus, the aim of this experiment was to compare the body composition of mature females from two breeds of suckler cattle with different origin and purpose.

Material and methods

Two experiments were conducted to prove the earlier hypothesis. In Experiment 1 we aimed to measure subcutaneous fat thickness in PA and PI cows at two physiological stages and the ability of prediction of BCS on subcutaneous fat thickness. In Experiment 2 we performed a serial of measurements *in vivo* and *post-mortem* in clinically healthy culled cows from both breeds to study some body composition traits related with energy partitioning.

Experiment 1 (*In vivo* study)

Sixty-four mature beef cows were selected from the herd of La Garcipollera Research Station, in the mountain area of the southern Pyrenees (North-eastern Spain, 42°37 N, 0°30 W, 945 m above sea level).

Cows were distributed in a 2x2 factorial arrangement: two breeds (PA *vs.* PI) x two physiological stages (dry cows *vs.* mid lactating cows). Lactating cows were on day 105±3.1 *post-partum*. On the day of measurements all cows were in mid breeding period, which lasted 65 days.

Cows were group fed according to breed and physiological stage a total dry mixed ration (9 MJ ME kg^{-1}, 85 g CP kg^{-1}, on DM basis), to meet 100% their energy requirements for maintenance and, in case of lactating cows, milk production (ARC, 1990).

The BCS was assessed according to Lowman *et al.* (1976) (0 to 5 scale). At the same time, subcutaneous fat thickness (with and without skin) was measured by ultrasound scanning with a multifrequence probe (7.5 MHz; Aloka SSD-900, Aloka Co., Ltd., UK) as the mean of two consecutive recordings by a single technician. Skin contact with the transducer was achieved using vaseline. The transducer was positioned vertically to an imaginary line between the tuber coxae (hooks) and tuber ischia (pins). The examination site was located in the sacral region between the caudal one-quarter and one-fifth connection line going from the dorsal part of pins to hooks (Schröder and Staufenbiel, 2006).

Experiment 2 (*In vivo* and *post-mortem* study)

Sixteen mature dry non-pregnant cows (aged 12.5±1.1 years), 8 per breed, were culled from the afore-mentioned herd. Cows were clinically healthy at the time of the experiment and all of them had calved in the previous year. Cows were group fed a total dry mixed ration, which aimed to meet 100% their energy requirements for maintenance (7 MJ ME kg^{-1}, 80 g CP kg^{-1}, on DM basis).

Live-weight was registered on two consecutive weeks prior to *in vivo* measurements. The day prior to slaughter,

live-weight, BCS, body measurements and subcutaneous fat thickness by ultrasound were recorded before morning feeding with the same procedure than in Experiment 1. Body measurements were wither height (measured from the highest point of the shoulder blade to the ground) and body length (measured from humerus breastbone articulation to the ischium tuberosity). In addition, blood samples were collected by tail vessel puncture into vacuum tubes containing EDTA-k_3. Blood was centrifuged at 3000 x g during 15 min and plasma was harvested and frozen at -20ºC until blood metabolites analyses.

Plasma non-esterified fatty acids (NEFA) were analysed in duplicate using an enzymatic commercial kit (Randox Laboratories Ltd., Co. Antrim, UK). Plasma β-hydroxybutyrate (enzymatic method), total protein (Biuret method) and urea (Glutamate-dehydrogenase method) were assayed using an automatic analyser (Olympus AU400, Germany). Accuracy of all quantification methods was implemented with control serum from respective manufacturers. Reagent manufacturers were Randox Laboratories Ltd. (Crumlin, Co. Antrim, UK) for NEFA and β-hydroxybutyrate and Olympus System Reagent (Olympus®, Ireland) for total protein and urea.

Cows were transported to an EU-licensed commercial slaughterhouse 6 km away from the Research Station facilities. Immediately after arrival, they were slaughtered by captive bolt pistol and exsanguinated. There was no fasting period. Carcass dressing followed a standardised protocol, without use of electrical stimulation, and with the removal of the remaining subcutaneous fat cover. Fatty tissue surrounding the forestomachs (omental fat) was separated, along with any associated ligaments and connective tissue and weighed. The weight of liver, spleen and hide was also recorded to characterise some non-carcass components. Additionally, hide thickness was measured on two randomly located points on the neck region with a digital calliper.

Carcasses were split into two sides with tail on the right side of carcass and chilled at 4±1ºC for 48 h. Hot carcass weight was measured immediately after slaughter and cold carcass weight was determined after 48 h of refrigeration. Conformation and fatness score were graded on the hot carcass according to the UE classification (EEC, 1991). Carcass conformation was based on a visual assessment (SEUROP classification) with a 6-point scale (from P=poorest, to S=best). Fatness score was evaluated with a 5-point scale (from 1=leanest, to 5=fattest). Dressing percentages were calculated as (hot carcass weight /pre-slaughter live-weight) x 100 and (cold carcass weight /pre-slaughter live-weight) x 100.

Kidney knob and channel fat (KKCF) depot and the kidney were collected in left half carcass after the refrigeration period. Weight of KKCF was calculated as twice the weight of the left side.

Statistical analyses

Results were analysed with SAS statistical software (SAS Institute Inc., Cary, NC, USA). In Exp. 1, BCS and subcutaneous fat measurements were analysed with the GLM procedure with the following model:

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

Where: y_{ijk} = dependent variable, μ = overall mean, α_i = breed effect, β_j = physiological stage effect, $(\alpha\beta)_{ij}$ = breed x physiological stage interaction and ε_{ijk} = residual error.

In addition, regression analyses were performed with the GLM procedure of SAS to evaluate the ability of prediction of subcutaneous fat thickness (without skin) from BCS measurement within breed and physiological stage. The accuracy of the obtained equations was measured with their coefficient of determination (R^2) and coefficient of variation (CV).

In Exp. 2, *in vivo* and *post-mortem* continuous variables were analysed according to the model:

$$y_{ij} = \mu + \alpha_i + \varepsilon_{ijk}$$

Where: y_{ij} = dependent variable, μ = overall mean, α_i = breed effect and ε_{ijk} = residual error.

Blood metabolites were tested for normality before further analysis with the Shapiro-Wilk test. In the case of total protein, normal distribution was not verified and this variable was analysed with the Kruskal-Wallis nonparametric test of NPAR1WAY procedure. Differences between proportions of carcasses in each conformation and fatness score were analysed using the Fisher exact test of FREQ procedure. For all tests, the level of significance was set at 0.05.

Results

Experiment 1 (*In vivo* study)

The results of BCS and SFT with and without skin are reported in Table 1. No differences were detected

Table 1. Experiment 1. Body condition score (BCS) and subcutaneous fat thickness (SFT) in dry and lactating Parda de Montaña (PA) and Pirenaica (PI) cows

	PA		PI		SE[1]	P-value[2]		
	Dry	Lactating	Dry	Lactating		B	PS	B x PS
n	16	16	16	16				
BCS	2.92	2.58	2.91	2.68	0.08	NS	***	NS
SFT including skin (mm)	39	33	42	34	1.7	NS	***	NS
SFT (mm)	35	28	36	29	1.7	NS	***	NS

[1] SE=Standard error. [2] B=Breed. PS=Physiological stage. ***=$P<0.001$. NS=Non-significant ($P>0.05$).

across breeds either in BCS or SFT ($P>0.05$) whereas dry cows displayed greater BCS and SFT than lactating cows, regardless of breed ($P<0.001$). Figure 1 shows an example of SFT measured with and without the inclusion of skin. Figure 2 depicts selected results of SFT (including skin) in thin and fat cows.

Although breed effect was not significant, the regression equations predicting SFT from BCS in dry and lactating cows showed slightly higher accuracy when they were estimated within breed (Table 2).

Experiment 2 (*In vivo* and *post-mortem* study)

Body condition score, subcutaneous fat thickness, body measurements (Table 3) as well as selected blood metabolites (Table 4) were similar across breeds ($P>0.05$).

After slaughter, no differences were observed either on carcass (Table 5), non-carcass characteristics or internal fat depots (Table 6) ($P>0.05$). The subjective

conformation grade according to the SEUROP scale (PA: 25%-R and 75%-O *vs.* PI: 50%-R and 50%-O) and fatness score (PA: 75%-2 and 25%-3 *vs.* PI: 87.5%-2 and 12.5%-3) were also similar across breeds ($P>0.05$).

Discussion

Live animal traits (Experiments 1 and 2)

Subcutaneous fat thickness did not differ between breeds and it was concomitant with body condition scoring. Although other examination sites have been used to measure SFT in beef cattle (12-13th rib bones, Perkins *et al.*, 1992; 13th rib bone-4th lumbar bone; Delfa *et al.*, 2007), the sacral region was chosen in the current experiment, according to the evaluation methods of body fat reserves in dairy cattle reviewed by Schröder and Staufenbiel (2006). These authors examined the whole back region from the thoracic spine to the tail and pointed out that the sacral region site was the
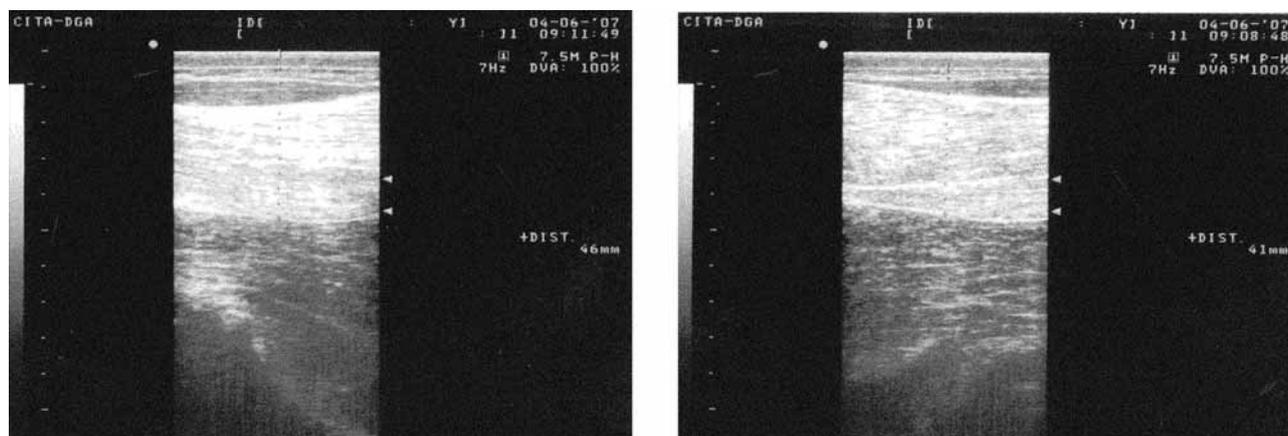

Figure 1. Measures of subcutaneous fat thickness by ultrasound including skin (left side) or not (right side) (cow no. 6).
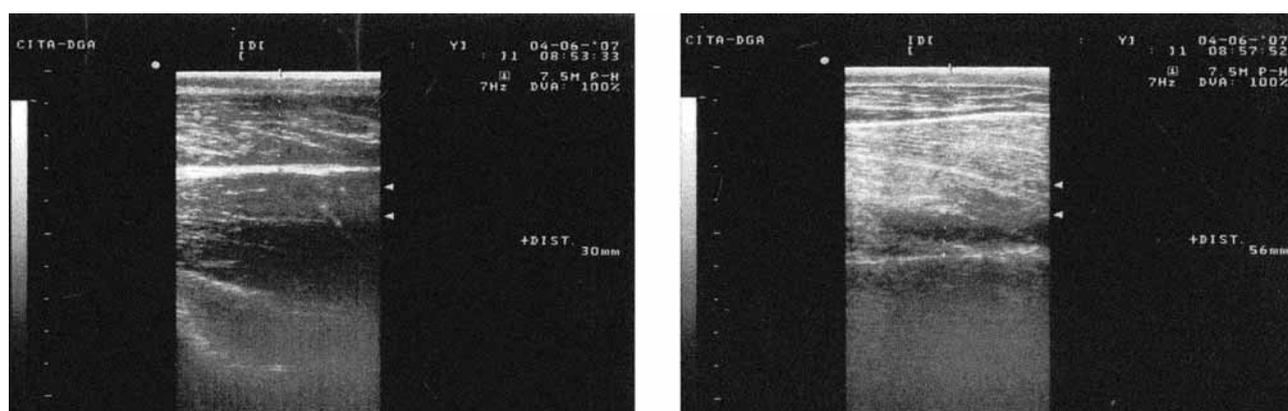
Figure 2. Measures of subcutaneous fat thickness (including skin) by ultrasound in a thin cow (left side: cow no. 7000) and a fat cow (right side: cow no. 2465).

most suitable area for assessing backfat thickness in mature cows, as judged by its correlation with total body fat content (r=0.90). In addition, sacral region has the largest amount of adipose tissue in the back, it is easy to locate and its subcutaneous fat only changes slightly in a range of several square-centimetres.

The within breed equations for dry cows obtained in Exp. 1 were used to predict SFT in cows of Exp. 2. The predicted values were accurate (4±4% lower and 1±5% higher than actual values in PA and PI cows, respectively). In this regard, BCS has been proved the best predictor of total amount of body subcutaneous fat when measured after slaughter in beef (R^2=0.77) (Bullock *et al.*, 1991) and dairy cows (R^2=0.36-0.65) (Domecq *et al.,* 1995).

Body measurements and the metabolic status were also similar across breeds. Wither height in PI cows was close to the value reported by Blasco *et al.* (1992)

for multiparous cows in this breed (130.3 cm) whereas no references are available concerning PA cows, because this genotype has reached rather recently its independent breed status (BOE, 2004). Accordingly, wither height in the latter was in agreement with Brown Swiss standards (133.7 cm) (Heinrichs and Hargrove, 1994).

The analysed blood metabolites were in both breeds within the reference ranges for adequately nourished adult cows (0.18-1.32 mmol L^{-1} NEFA, 0.12-0.61 mmol L^{-1} β-hydroxybutirate, 59.2-87.5 g L^{-1} total protein, 1.88-7.00 mmol L^{-1} urea; Agenäs *et al.*, 2006).

Carcass traits (Experiment 2)

Carcass characteristics did not differ between breeds; therefore *post-mortem* measurements did not support

Table 2. Experiment 1. Prediction equations of subcutaneous fat thickness (without skin, mm) (*Y*) on body condition score (*X*, 1-5 score) according to breed (PA, Parda de Montaña, and PI, Pirenaica) and physiological stage (dry and lactating)

	Equations[1]		R^2	CV (%)
	Slope (*a*)	**Intercept (*b*)**		
Dry	13.47 ± 2.19	-2.80 ± 6.51	0.57***	14.4
Lactating	20.58 ± 3.35	-26.17 ± 9.03	0.57***	12.7
PA-Dry	12.40 ± 1.94	-1.54 ± 5.71	0.72***	10.5
PA-Lactating		-4.19 ± 7.03		
PI-Dry	16.51 ± 2.80	-11.64 ± 8.25	0.63***	16.4
PI-Lactating		-15.26 ± 10.25		

[1] *Y=aX+b, a*=Slope, *b*=Intercept, ***=P<0.001

Table 3. Experiment 2. Body condition score (BCS), subcutaneous fat thickness (SFT) and body measurements in Parda de Montaña (PA) and Pirenaica cows (PI) prior to slaughter

	PA	PI	SE[1]	P-value[2]
n	8	8		
Live-weight (kg)	599	564	18.1	NS
BCS	2.69	2.63	0.18	NS
SFT including skin (mm)	39	37	2.9	NS
SFT (mm)	34	31	3.0	NS
Wither height (cm)	131.9	129.6	1.8	NS
Body length (cm)	157.5	160.1	2.2	NS
Body length/Wither height	1.19	1.24	0.02	NS
Compact index[3]	4.54	4.29	0.11	NS

[1] SE= Standard error. [2] NS= Non-significant (P>0.05). [3] Compact index= Pre-slaughter live-weight/Wither height.

the initial hypothesis either. To our knowledge, this is the first study reporting these traits in culled adult PA and PI cows. In north-western Spain, Carballo and Moreno (2006) did not detect a significant breed effect on carcass yields when comparing Rubia Gallega and Holstein Friesian cattle breeds slaughtered at similar live-weights and body condition. Slaughter dressing percentage in culled cows of the present experiment was within the range reported by the latter authors for R-O carcass conformation grade (47.3-51.7%, corresponding to cows with 569-660 kg live-weight and 2.67-3.38 BCS) and 2-3 fatness degree score (47.0-50.0%, corresponding to cows with 576-633 kg live-weight and 2.78-3.14 BCS).

If we compare the current data with those of entire males of Bruna dels Pirineus (a very close population to PA also selected from Brown Swiss and located in eastern Pyrenees) and PI breed, indeed no differences were observed across their dressing percentage (60.7% *vs.* 60.5%). However, Bruna dels Pirineus calves showed a

Table 4. Experiment 2. Blood metabolite concentration in Parda de Montaña (PA) and Pirenaica (PI) cows prior to slaughter

	PA	PI	SE[1]	P-value[2]
NEFA (mmol L^{-1}) [3]	0.34	0.44	0.08	NS
β-hydroxybutirate (mmol L^{-1})	0.21	0.17	0.02	NS
Total protein (g L^{-1})	82.2	85.7	3.5	NS
Urea (mmol L^{-1})	5.52	6.63	0.53	NS

[1] SE= Standard error. [2] NS= Non-significant (P>0.05). [3] NEFA=Non-esterified fatty acids.

Table 5. Experiment 2. Carcass weights and associated dressing yields in Parda de Montaña (PA) and Pirenaica (PI) cows

	PA	PI	SE[1]	P-value[2]
Hot carcass (kg)	299	283	11.7	NS
Cold carcass (kg)	289	274	11.1	NS
Slaughter dressing (%)[3]	49.9	50.6	1.4	NS
Commercial dressing (%)[4]	48.1	48.7	1.3	NS

[1] SE= Standard error. [2] NS=Non-significant (P>0.05). [3] Slaughter dressing = (hot carcass weight /pre-slaughter live-weight) x 100. [4] Commercial dressing = (cold carcass weight /pre-slaughter live-weight) x 100

slightly higher carcass conformation (O+ *vs.* O) and fatness score (3- *vs.* 2+) than PI calves (Piedrafita *et al.*, 2003). Although young bulls with similar live-weight (around 550 kg) but younger age (382 days old) than these culled cows displayed a slightly greater conformation and fatness cover, the carcass performance of the present adult females was not a constraint to market them, even considering that they were not fattened on a concentrate-based diet. Nevertheless, it was proved that commercial dressing differed between ages and genders. This could be likely a result of the major importance of the weight of digestive tract and its engaged fat content in mature cows which in addition were not fasted prior to slaughter.

Intramuscular fat is the largest depot in beef cattle, followed by subcutaneous and internal fat (Dolezal *et al.*, 1993). Even though the intramuscular fat depot was not measured, another recent study in bull calves of PA and PI cattle breeds slaughtered at 450 kg do not support a potential difference in this trait (1.9% *vs.* 1.7%, respectively; Blanco, 2007).

Table 6. Experiment 2. Non-carcass organs and internal fat depots in Parda de Montaña (PA) and Pirenaica (PI) cows

	PA	PI	SE[1]	P-value[2]
Liver (kg)[3]	6.4	6.1	0.3	NS
Spleen (kg)	1.3	1.2	0.1	NS
Left kidney (kg)	0.64	0.59	0.04	NS
Omental fat (kg)	5.4	6.7	1.1	NS
KKCF (kg)[4]	2.6	3.4	0.6	NS
Hide (kg)[5]	34.9	34.3	1.5	NS
Hide thickness (mm)	5	5	0.4	NS

[1] SE= Standard error. [2] NS=Non-significant (P>0.05). [3] includes gall bladder. [4] KKCF = Kidney knob and channel fat. [5] includes udder

Non-carcass traits and internal fat depots (Exp. 2)

Omental fat and KKCF weights were rather similar in both breeds. Although there were no statistical differences, the former dual purpose breed (PA) displayed slightly lesser contents of these fat depots than the hardy breed (PI). A similar trend was observed in young bulls of these breeds fed on a concentrate-based diet and slaughtered at 540 kg (5.4 *vs*. 5.5 kg for omental fat, 3.5 *vs*. 3.5 kg for KKCF, in PA and PI, respectively) (Alzón *et al.*, 2007).

In the current work, the weight of the omental fat was two-fold the weight of KKCF depot in both breeds, suggesting an important role of the abdominal fat on the total internal fat in mature cows. In fact, Wright and Russel (1984) pointed out that the sum of omental and mesenteric fat weights was two to three-fold the weight of the KKCF depot in different beef and dairy genotypes.

In the above-quoted study of Piedrafita *et al.* (2003) the weight of KKCF depot was higher in Bruna dels Pirineus than in PI bulls fed on a concentrate-based diet (7.9 kg *vs*. 5.4 kg), but this breed difference was not found here in these mature females (2.6 vs. 3.4 kg, in PA and PI, respectively; P>0.05). Moreover, their values were also substantially greater than the ones registered in the forage-fed cows of the present experiment.

A possible limitation in our study was the lack of measure of the weight of the mesenteric fat and thus the sum of total internal fat depots. In a comparative study of body composition between Churra (milk-meat purpose) and Merino (wool-meat purpose) sheep breeds, the gross weight of omental and mesenteric fat depots were similar across them but not their proportion with respect to total internal fat (Frutos *et al.*, 1995). In fact, total internal fat in relation to empty body weight was greater in the dairy breed.

We might consider that according to Kempster *et al.* (1982) the dairy-beef difference in body fat deposition should be mainly observed between extreme dairy-type breeds and traditional beef breeds. Even though PA and PI genotypes come from different origin (*Bos taurus brachyceros vs. Bos taurus turdetanus*, respectively) and were selected for different purpose in the past, they have been managed similarly over the last decades, thereby being minimized their body differences at present.

Likewise, the weight of the measured internal organs did not differ across breeds. Taylor and Murray (1991) observed that dairy breeds (British Friesian and Jersey) had greater liver and spleen than their beef counterparts (Hereford and Aberdeen Angus), possibly as consequence of the higher rate of metabolic activity in cows with a genetically established greater milking potential. Although the weights of liver, spleen and kidney in PA cows were similar to those reported for Brown Swiss cows (6.1, 0.9 and 0.65 kg, respectively) (Jenkins *et al.*, 1986), there were no differences in the weight of these organs across the ancient dual purpose breed (PA) and the traditional beef breed (PI).

The hide weight and thickness did not differ across breeds either. This organ is the most important for abattoirs, as it represents even half of the non-carcass commercial value (Carballo *et al.*, 2006). In the current study, hide weight accounted for 5.8% and 6.1% of their live-weight in PA and PI cows, respectively. These values were close to those reported for Rubia Gallega culled cows (6.2%; Carballo *et al.*, 2006), especially in Pirenaica breed.

Skin thickness estimated by ultrasound was in line with hide thickness measurement *post-mortem*. Accordingly, Schröder and Staufenbiel (2006) provided skin values of 5 to 6 mm, and recommended to include skin thickness within the measure of subcutaneous fat, bearing in mind its contribution on that amount. Indeed, they suggested that ultrasound machines with linear transducer and frequency between 5 to 7.5 MHz (within the range of our probe), allows measuring the layer of subcutaneous fat to the nearest 1 mm.

In conclusion, the initial hypothesis did not hold true. The measured internal fat depots (subcutaneous, omental and kidney knob and channel fat), together with carcass and non-carcass yields, revealed no differences in the body composition of Parda de Montaña and Pirenaica cattle breeds. This outcome possibly highlights the parallel trajectory of selection for meat production in both genotypes over the last years.

Acknowledgements

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