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SUMMARY - The precision of the use of cold carcass weight, fat thickness, C measurement and longissimus dorsi depth for predicting the carcass composition were determined in 52 adult Rasa Aragonesa ewes aged 10 (s.d. 2) years and ranging in body condition score (BCS) from 1.5 to 4.5. The cold carcass weight is the best predictor of intermuscular fat (r^2=0.94) and the inclusion of the C measurement in multiple regression with the cold carcass weight estimates with accuracy the subcutaneous fat (r^2=0.91). The pelvic and kidney fat can be predicted with the same precision by cold carcass weight in multiple regression with fat thickness or BCS (r^2=0.86). 95% of the variation in total carcass fat was accounted for by variation in cold carcass weight and fat thickness. The best muscle carcass predictors were cold carcass weight in multiple regression with fat thickness or C measurement (r^2=0.91).

RESUME - 52 brebis adultes de race Rasa Aragonesa vides et taries d'état corporel compris entre 1,5 et 4,5, ont été utilisées pour prédire la composition de la carcasse à partir du poids de la carcasse froide (PCF), état corporel (EC), mesure de l'épaisseur du gras sous-cutané au niveau lombaire (EGL), mesure C et profondeur du m. *longissimus dorsi*. Le PCF est le meilleur prédicteur du gras intermusculaire de la carcasse (r^2= 0,94) et lorsqu'il est introduit en équation de régression multiple avec la mesure C et l'EC ils sont les meilleurs prédicteurs respectivement du muscle et de la graisse sous-cutanée de la carcasse (r^2= 0,91) et graisse pelvienne-rénale (r^2= 0,86). Lorsqu'il est introduit en équation de régression multiple avec l'EGL ils sont les meilleurs prédicteurs du gras total (r^2= 0,95) gras pelvico-rénal (r^2= 0,86) et muscle total (r^2= 0,91) de la carcasse.

Introduction

The fat thickness and depth muscle measurements have been used for predicting the carcass composition in several species by different authors and in cattle by Johnson and Vidyadaran (1981).

In sheep, Hirzel (1939) used the B and C measurements as principal characters in order to classify carcasses. At the same time Palsson (1939) showed that the m. *Longissimus dorsi* depth (measurement B) was an indicator of total carcass muscle and the fat thickness (measurement C) was highly correlated with subcutaneous fat. Nevertheless Starke and Joubert (1961) suggested that the B measurement was better predictor of m. *Longissimus dorsi* weight than total carcass muscle and the J measurement was better than C measurement to estimate the total carcass fat. The results from Kempster *et al.* (1982) showed that a visual assessment of external fat cover and kidney knob and channel fat development and fat thickness (measurement C)

provided good precision of carcass composition estimates and that the sample joints are the most precise predictors. In this way Bruwer *et al.* (1987) found that the inclusion of fat thickness measurements as independent variables in a multiple regression with carcass weight improved the precision of carcass composition prediction, in agreement with Timon and Bichard (1965), Kirton and Johnson (1979), Thompson and Atkins (1980) and Wood and McFie (1980).

These prediction equations are useful to avoid the difficult and expensive work of carcass dissections. Nevertheless the use of weights as independent variables, presents problems of interpretation, because the breeds will differ in relative proportions of fat and other carcass tissues (Kempster and Cuthbertson, 1977; Kempster, 1980).

Therefore the principal objective of the present study was to evaluate the precision of the use of fat thickness, C measurement and *Longissimus dorsi* depth for predicting the carcass composition of Rasa Aragonesa ewes with different body condition score. Part of the results have been presented elsewhere (Teixeira *et al,* 1989; Delfa *et al.* 1989).

Material and methods

52 adult Rasa Aragonesa ewes from the experimental flock of Servicio de Investigación Agraria de la Diputación General de Aragón were scored using the Russel technique (1 to 5 score range intervals of 0.25 units) The body condition score (BCS) of each ewe was assessed to the nearest 0.25 score by three experienced people.

The ewes were slaughtered in the experimental slaughter house of S.I.A. - D.G.A., after 24 hours fasting. The carcasses were cooled at 6°C during 24 hours, before fat thickness was calibre-measured at the 4th lumbar vertebrae site.

The carcasses were halved carefully and the left side was dissected into muscle, bone, subcutaneous, intermuscular, kidney and pelvic fat. The B measurement, m. *Longissimus dorsi* depth and C measurement (Palsson, 1939) were assessed on a joint taken from the lumbar region described by Delfa *et al.* (1989).

The relationships between the measurements assessed on carcass (fat thickness, C measurement and *Longissimus dorsi* depth) and carcass composition were analyzed using correlation and regression analyses (Steel and Torrie, 1980).

Results and discussion

The means and s.d.s of all parameters measured, grouped according to condition score, are showed in Tables 1 and 2. All parameters showed substantial variation between condition score categories. The determination coefficients between fat depots and carcass cold weight, BCS and measurements assessed on carcass are given in Tables 3, 4, 5 and 6. The best fat carcass predictors are fat carcass measurements in multiple regression with carcass weight, which agrees with Timon and Bichard (1965), Kirton and Johnson (1979), Thompson and Atkins (1980) and Wood and McFie (1980) Kirton *et al.* (1986) and Bruwer *et al.* (1987).

Nevertheless the cold carcass weight is the best predictor of intermuscular fat (r^2=0.94) and pelvic plus kidney fat can be predicted with the same precision by cold carcass weight and fat thickness or cold carcass weight and BCS (r^2=0.86).

95% of the variation in total carcass fat was accounted for by variation in cold carcass weight and fat thickness. Delfa *et al.* (1990) found that the same variables in multiple regression only account 79% of the variation in total carcass fat. This difference can be explained because the present study involve 52 ewes with great range of condition score, whereas the mentioned work only had 14 ewes with same BCS.

These equations only can be used for adult ewes Rasa Aragonesa because the breeds will differ in relative proportions of fat, and the accuracy of measures of subcutaneous fat development (subjective scores or fat thickness measurements) as predictors of total carcass fat content depends on the constancy of fat distribution and if the breed differ in their ratio of subcutaneous fat to total fat and common regression relationship is applied across breeds, the predicted values for the breeds will be biased to some extent (Kempster and Cuthbertson, 1977)

The determination coefficients between total carcass muscle and carcass cold weight, BCS and measurements assessed on carcass are given in Table 7. The best muscle carcass predictor is the cold carcass weight in multiple regression with fat thickness or C measurement (r^2=0.91). The inclusion of carcass weight as an independent variable in a multiple regression with lumbar fat thickness and fat kidney weight in order to estimate the lean content has also been reported by Judge and Martin (1963). The use of fat carcass measurements, like "C" fat thickness assessed on carcass or measured on live animal with ultrasonic machine are the best predictors of lean content which have been demonstrated by Field *et al.* (1963); Timon and Bichard (1966); Kempster *et al.* (1976) and Wood and MacFie (1980). The smallest determination coefficient between total carcass muscle and *m. longissimus dorsi* depth (r^2=0.62) has also been reported by Starke and Joubert (1961) and Flamant and Boccard (1966).

These results suggest that 90 % of the variation in total muscle weight was accounted for by variation in cold carcass weight and lumbar fat thickness. So the inclusion of cold carcass weight as independent variable in a multiple regression with lumbar fat thickness improve the precision of muscle carcass weight prediction, which again agrees with Delfa *et al.* (1990).

Conclusions

From the results obtained, we could conclude:

- The cold carcass weight is the best predictor of total carcass intermuscular fat in carcass;

- The inclusion of cold carcass weight as an independent variable in a multiple regression with: "C" measurement, body condition score (BCS) and lumbar fat thickness, improve the precision of muscle and subcutaneous fat, kidney and pelvic fat, total carcass fat and total muscle predictions, respectively.

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Table 1. Composition of the corrected half carcass weights grouped according to body condition score (BCS) (TEIXEIRA *et al.*, 1989).

	COLD CARCASS WEIGHT (Kg)		CORRECTED HALF CARCASS WEIGHT (g)		MUSCLE (g)		BONE (g)		SUBCUTANCOUS FAT (g)		INTERMUSCULAR FAT (g)		KIDNEY AND PELVIC FAT (g)		BONE AND REMAINDER (g)	
BCS group	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
1,5 to 1,75 (n = 8)	12,0^{a}	1,5	5686^{a}	728	3680^{a}	517	1373^{A}	149	79^{a}	48	300^{a}	138	58^{a}	30	1562^{AB}	199
2,0 to 2,25 (n = 8)	13,1^{a}	1,4	6172^{a}	718	3854^{a}	505	1291^{A}	190	163^{b}	82	535^{b}	135	137^{b}	54	1469^{A}	208
2,5 to 2,75 (n = 8)	17,5^{b}	1,2	8521^{b}	627	4869^{b}	542	1535^{B}	213	666^{c}	234	862^{c}	288	352^{a}	98	1725^{B}	175
3,0 to 3,25 (n = 8)	19,3^{b}	3,5	9310^{b}	1739	5421^{b}	987	1527^{B}	176	685^{c}	243	967^{c}	267	489^{c}	247	1653^{AB}	195
3,5 to 3,75 (n = 8)	23,6^{c}	2,9	11465^{c}	1623	5945^{Ac}	737	1595^{B}	187	1489^{d}	667	1386^{d}	353	839^{d}	343	1719^{AB}	281
4,0 to 4,50 (n = 12)	30,9^{d}	4,3	14983^{d}	2389	6828^{Bc}	973	1571^{B}	207	2793^{c}	993	2183^{c}	522	1314^{c}	235	1738^{AB}	295

Means with different superscripts in the same columns differ significantly at $P < 0,05$ (lower case) and at $P < 0,01$ (upper case).

Table 2. Measurements and composition of lumbar joint in ewes of different body condition score (BCS) (DELFA *et al.*, 1989).

	LENGHT (mm)		A† (mm)		B† (mm)		C† (mm)		WEIGHT (g)		MUSCLE (g)		BONE (g)		SUBCUTANEOUS FAT (g)		INTERMUSCULAR FAT (g)	
BCS group	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
1,5 to 1,75 (n = 8)	112^{A}	6	60^{AB}	12	18^{A}	5	0,3^{a}	0,5	220^{a}	52,4	164^{A}	40,8	42^{AB}	12,5	3^{a}	2,3	7^{a}	4,1
2,0 to 2,25 (n = 8)	106^{A}	8	53^{B}	6	17^{A}	3	1,7^{a}	2,3	226^{b}	39,3	166^{A}	35,5	36^{B}	5,0	7^{a}	4,7	14^{b}	4,0
2,5 to 2,75 (n = 8)	112^{A}	4	66^{A}	7	23^{B}	2	3,8^{b}	2,5	342^{b}	38,7	211^{B}	27,9	54^{AC}	19,7	43^{b}	14,2	29^{Ac}	8,6
3,0 to 3,25 (n = 8)	110^{A}	3	68^{A}	5	30^{C}	3	3,6^{b}	1,5	367^{b}	56,8	236^{BC}	30,9	56^{AC}	12,9	44^{b}	17,3	25^{Ac}	11,8
3,5 to 3,75 (n = 8)	114^{A}	6	69^{A}	9	30^{C}	5	7,3^{c}	2,5	459^{Ac}	82,9	255^{CD}	48,2	59^{AC}	26,5	100^{c}	45,4	40^{Bc}	13,9
4,0 to 4,50 (n = 12)	112^{A}	5	66^{A}	6	31^{C}	3	14,4^{d}	5,1	575^{Bc}	103,1	287^{D}	40,6	49^{AC}	19,5	186^{d}	54,1	50^{d}	19,0

$^{a, b, c}$ Means with different superscripts in the same columns differ significantly at $P < 0,05$ (lower case) and at $P < 0,01$ (upper case).

† A = width of muscle *m. longissimus dorsi*; B = depth of muscle *m. longissimus dorsi*; C = fat thickness above B.

Table 3. Determination coefficients (r^2) of correlations between total carcass fat and cold carcass weight, measurements obtained on carcass and body condition score.

	TOTAL CARCASS FAT
LFTh	0.75**
BCS	0.80**
C measurement	0.86**
CCW	0.93**
CCW + LFTh	0.95**

** P< 0.01
Lumbar fat thickness measured on carcass (LFTh)
Body condition score (BCS)
C measurement (C)
Cold carcass weight (CCW)

Total carcass fat = 301.18 CCW - 3296.57
(r^2=0.93, P< 0.01; s_b= 11.64)

Total carcass fat = 241.5 CCW + 125.05 LFTh - 2683.9
(r^2=0.95, P< 0.01; s_{b1}= 17.61; s_{b2}= 30.19)

Table 4. Determination coefficients (r^2) of correlations between total subcutaneous fat and cold carcass weight, measurements obtained on carcass and body condition score.

	TOTAL SUBCUTANEOUS FAT
LFTh	0.72**
BCS	0.72**
C measurement	0.85**
CCW	0.87**
CCW + LFTh	0.89**
CCW + C measurement	0.91**

** P< 0.01
Lumbar fat thickness measured on carcass (LFTh)
Body condition score (BCS)
C measurement (C)
Cold carcass weight (CCW)

Total subcutaneous fat = 108.29 CCW + 68.16 LFTh - 1444.2
(r^2=0.89, P< 0.01; s_{b1}= 12.39; s_{b2}= 21.24)

Total subcutaneous fat = 79.84 CCW + 85.9 C - 1043.8
(r^2=0.91, P< 0.01; s_{b1}= 14.68; s_{b2}= 18.42)

Table 5. Determination coefficients (r^2) of correlations between total intermuscular fat and cold carcass weight, measurements obtained on carcass and body condition score.

	TOTAL INTERMUSCULAR FAT
LFTh	0.72**
BCS	0.80**
C measurement	0.84**
CCW	0.94**

** P< 0.01
Lumbar fat thickness measured on carcass (LFTh)
Body condition score (BCS)
C measurement (C)
Cold carcass weight (CCW)

Total intermuscular fat = 96.9 CCW - 831.1
(r^2=0.94, P< 0.0001; s_b= 3.6)

Table 6. Determination coefficients (r^2) of correlations between kidney and pelvic fat and cold carcass weight, measurements obtained on carcass and body condition score.

	TOTAL KIDNEY AND PELVIC FAT
LFTh	0.68**
BCS	0.81**
C measurement	0.72**
CCW	0.84**
CCW + LFTh	0.86**
CCW + BCS	0.86**

** P< 0.01
Lumbar fat thickness measured on carcass (LFTh)
Body condition score (BCS)
C measurement (C)
Cold carcass weight (CCW)

Total kidney and pelvic fat = 63.4 CCW - 687.2
(r^2=0.84, P< 0.0001; s_b= 3.9)

Total kidney and pelvic fat = 195.8 BCS + 40.4 CCW - 809.5
(r^2=0.86, P< 0.0001; s_{b1}= 76.71; s_{b2}= 9.75)

Table 7. Determination coefficients (r^2) of correlations between total carcass muscle and cold carcass weight, measurements obtained on carcass and body condition score.

	TOTAL CARCASS MUSCLE
LFTh	0.45**
BCS	0.76**
C measurement	0.58**
B measurement	0.62**
CCW	0.88**
CCW + LFTh	0.91**
CCW + C measurement	0.91**

** P< 0.01
Lumbar fat thickness measured on carcass (LFTh)
Body condition score (BCS)
C measurement (C)
B measurement (B)
Cold carcass weight (CCW)

Total carcass muscle = 217.1 CCW + 90.0 LFTh + 1287.9
(r^2=0.91, P< 0.0001; s_{b1}= 14.14; s_{b2}= 24.25)

Total carcass muscle = 243.1 C.C.W. - 96.6 C + 852.7
(r^2=0.91, P< 0.0001; s_{b1}= 17.56; s_{b2}= 22.03)