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SUMMARY – An experiment was carried out to study the effect of sex and rearing system on growth performance and carcass quality of milk-fed Assaf lambs. A total of 24 lambs, 12 males and 12 females were used. They were slaughtered at 10 kg of body weight. Half of them remained with their mothers throughout the experiment (NR: suckling lambs). The other twelve (AR: artificially reared lambs) were removed from the ewes within 24-36 hours of birth, housed in individual pens and fed *ad libitum* twice daily (09:00 and 19:00 h) with reconstituted cow's milk (18% of dry matter). There was no significant effect ($P > 0.05$) of sex on growth rate and carcass quality, except for perirenal-retroperitoneal fat (91 vs 63 g for male and female lambs, respectively). Concerning the effects of the rearing system, NR lambs showed a significant higher growth rate (307 vs 253 g/day) and consequently a lower age at slaughter (19 vs 24 days) than AR lambs ($P < 0.05$). NR lambs also showed higher values of fatness score (2.9 vs 2.5 points) as well as subcutaneous (7.2 vs 5.7%) and intermuscular fat (7.0 vs 5.6%) in the shoulder. Nevertheless, the rearing system did not affect ($P > 0.05$) either carcass weight or dressing proportion. Regardless of sex or rearing system effects, carcasses quality was in general suitable for Spanish market.

Key words: Assaf, milk-fed lambs, carcass quality.

RESUME – *"Croissance et qualité de la carcasse de l'agneau Assaf recevant le lait reconstitué". Cette expérience avait pour l'objectif d'étudier l'effet du sexe et du système d'élevage sur la croissance et la qualité de la carcasse des agneaux de race Assaf. On a utilisé 24 agneaux, 12 de chaque sexe, qui ont été abattus lorsqu'ils ont atteint 10 kg de poids corporel. La moitié des agneaux sont restés avec leur mère pendant toute l'expérience (NR : agneaux avec allaitement naturel). Le reste (12 ; AR : agneaux avec allaitement artificiel) a été séparé de leur mère entre les 24 et les 36 heures après leur naissance, placés dans des cages individuelles et nourris avec du lait reconstitué (18% de matière sèche). Le lait s'administrait* ad libitum *2 fois par jour. Le sexe n'a pas montré une influence statistiquement significative ($P > 0,05$) sur la vitesse de croissance ni sur les caractéristiques de la carcasse, sauf sur le gras périrénal-retropéritonéal (91 vs 63 g pour les femelles et les mâles, respectivement). En ce qui concerne le système d'élevage, les NR ont eu un gain de poids quotidien supérieur (307 vs 253 g/jour) et en conséquence un âge inférieur à l'abattage (19 vs 24 jours). Les NR ont présenté aussi des valeurs supérieures de gras de couverture (2,9 vs 2,5 points) et de gras interne (7,2 vs 5,7%) et intermusculaire (7,0 vs 5,6%) au niveau dorsal. Le système d'élevage, cependant, n'a pas affecté le poids de la carcasse ni la productivité. Indépendamment de l'effet du sexe et du système d'élevage, la qualité des carcasses d'agneaux Assaf peut être considérée appropriée pour le marché espagnol. Les différences en comparaison avec les carcasses d'agneaux de races espagnoles sont aussi commentées.*

Mots-clés : *Assaf, agneaux de lait, qualité de la carcasse.*

Introduction

In Spain, most milk production sheep systems produce lambs, which are slaughtered unweaned at approximately 10 kg live body weight (LBW). This type of lamb is a very valuable product due to its appreciated organoleptic qualities (Sañudo *et al*., 1997; Beriain *et al*., 2000). Several studies have been carried out to study the carcass and meat quality of this type of lamb from different Spanish native breeds but there is little available information on Assaf lambs. However, this breed is becoming the most important milk sheep breed in a number of Spanish regions (Ugarte *et al*., 2001).

This experiment was carried out to study the effect of sex and rearing system (natural vs artificial) on animal performance and carcass quality of Assaf lambs.

Material and methods

Animals and experimental procedure

Twenty-four Assaf lambs (12 males and 12 females) were used. Half of them remained with their mothers throughout the experiment (NR: suckling lambs). The other twelve (AR: artificially reared lambs) were removed from the ewes within 24-36 hours of birth, housed in individual pens and fed *ad libitum* twice daily (09:00 and 19:00 h) with milk-replacer [reconstituted cow's milk containing 18.5% of dry matter (DM), 4 MJ of gross energy (GE)/kg, 45 g of crude protein (CP)/kg and 47 g of ether extract (EE)/kg]. Milk was prepared immediately before its distribution and supplemented with NaCl (0.5 g/kg), Ca_2PO_4 (1 g/kg) and vitamins A (500 µg/g), D_3 (7.5 µg/g) and E (600 µg/kg). Feed refusals were weighed to determine the actual intake. All lambs were weighed immediately after birth and then three times per week before the morning feeding throughout the experiment. During the suckling period ewes were offered lucerne hay [148 g of CP/kg DM and 477 g of neutral detergent fibre (NDF)/kg DM] *ad libitum* and a concentrate mixture (194 g CP/kg DM and 264 g NDF/kg DM) at a rate of 1600 g per ewe per day.

Slaughter procedure and carcass measurements

Animals were slaughtered when they reached the aimed body weight (10 ± 0.150 kg). Lambs were anaesthetised with sodium pentobarbitone and then slaughtered by exsanguination from the jugular vein, eviscerated and skinned. The whole body of each lamb was dissected into carcass, which included thymus, testicles, kidney and perirenal-retroperitoneal fat, and "non-carcass", the weights of the different components being recorded. Carcasses were chilled at 4°C for 24 h and then weighed again (cold carcass weight, CCW). Dressing proportion was calculated as the CCW expressed as a proportion of slaughter weight. Carcasses were graded from 1 to 4, according to visual fatness (1 = very low fat cover; 4 = high fat cover). Linear measurements described by Pálsson and Vergés (1952) and Boccard *et al.* (1958) were taken on the whole and left half carcass to determine carcass morphology. These measurements were carcass external (K) and internal length (L), pelvic limb length (F) and buttock width (G) and perimeter (B). Left half carcass was cut into the following commercial joints as described by Colomer-Rocher *et al.* (1988): shoulder, neck, ribs 1-5, ribs 6-onwards, breast, pelvic limb and tail. Shoulder was dissected into muscle, bone, subcutaneous fat, intermuscular fat and other tissues according to the procedure of Fisher and de Boer (1994).

Statistical analysis

The data were subjected to analysis of variance to examine the effects of sex, rearing system and their interaction. Analyses were performed using the GLM procedure of SAS package (SAS, 1989).

Results and discussion

Growth performance

Mean values of growth rate, age at slaughter, carcass weight and dressing proportion are presented in Table 1. Neither sex nor sex × rearing system interaction had a significant ($P > 0.05$) effect on these parameters. Carcass weight and dressing proportion were not significantly ($P > 0.05$) affected by the rearing system either. However, NR lambs showed higher growth rates and, consequently, a lower age at slaughter than AR lambs. Although ewes were milked twice daily, these differences were expected since NR lambs remained continuously with their mothers, which are high yielding dairy ewes (Ugarte *et al.*, 2001). The higher growth rates added to the greater fat deposition in NR than AR lambs (see Table 2) suggest that feed intake could have been greater in NR lambs.

Most of milk-fed lambs produced in Spain belong to Churra, Lacha and Manchega breeds. These dairy native Spanish breeds are much less productive than Assaf ewes (Ugarte *et al.*, 2001) and therefore, as expected, growth rates observed at the present study were greater than those reported previously for Spanish breeds. As a consequence, naturally reared Assaf lambs are in average

around 7 to 14 days younger at slaughter (Peláez, 1976; Maseda *et al*., 1984; Beriain *et al*., 2000). Nevertheless, carcass weight and dressing proportion obtained at the present study were similar to the values reported in the literature for the above mentioned native Spanish breeds (Huidobro and Cañeque, 1994; Sañudo *et al*., 1997; Beriain *et al*., 2000).

Table 1. Effect of rearing system [Natural (NR) vs Artificial (AR)] and sex on daily live body weight gain (LWG), age at slaughter (SA), cold carcass weight (CCW) and dressing proportion (D)

	Feeding system		Sex		RSD†	Significance		
	NR	AR	♀	♂		F	S	F × S
LWG (g/lamb/day)	307.2	253.2	276.7	283.7	46.01	**	ns	ns
SA (days)	18.2	24.5	21.6	21.2	4.65	**	ns	ns
CCW (kg)	5.3	5.3	5.3	5.3	0.22	ns	ns	ns
D (%)	52.3	52.5	52.5	52.3	2.03	ns	ns	ns

†RSD: residual standard deviation.
*P < 0.05; ns: P > 0.05.

Table 2. Effect of rearing system [Natural (NR) vs Artificial (AR)] and sex on carcass (CF, perirenal-retroperitoneal) and non-carcass (NCF, omental + mesenteric) fat depots

	Feeding system		Sex		RSD†	Significance		
	NR	AR	♀	♂		F	S	F × S
CF (g)	82	72	91	63	20.0	ns	**	ns
NCF (g)	134	130	144	120	22.1	ns	*	ns
NCF + CF (g)	216	201	235	183	26.4	ns	**	ns

†RSD: residual standard deviation.
*P < 0.05; ns: P > 0.05.

Fat deposition

As shown in Table 2, fat depots were not significantly influenced (P > 0.05) by the rearing system, although values were always greater for NR than AR lambs. It is well known that fat deposition increases as feed intake does even in milk-fed lambs (Pálsson and Vergés, 1952; Castrillo, 1979). However, at in this experiment no large differences between NR and AR lambs were expected because the growth of adipose tissue is very slow during the early postnatal life (Robelin, 1986).

In relation to adipose tissue growth, females reached the phase of greater fat deposition at lower body weights than males. Nevertheless, this body weight varies with sheep breed and is positively correlated to adult size. Differences between sexes in milk-fed lambs have been reported in Churra and Manchega breeds (Castrillo, 1979; Huidobro and Cañeque, 1994). The present experiment confirms that, in Assaf breed, differences due to sex are also evident at a very low body weight, although adult size is greater for Assaf than other native Spanish breeds.

Carcass characteristics

Carcass conformation, fatness score and morphology

Effects of sex or rearing system × sex interaction on carcass fatness score (FS) and morphological measurements were not significant (P > 0.05) (Table 3). In contrast, lambs naturally reared showed

higher values of FS and lower values of K, L and B measurements than those artificially reared. These results may be partly explained by a possible higher intake and consequently greater fattening of NR lambs compared to AR lambs, as previously discussed. In any case, differences between rearing systems in carcass linear traits were not quantitatively important (less than 3%).

Table 3. Effect of rearing system [Natural (NR) vs Artificial (AR)] and sex on carcass fatness score (FS), carcass external (K) and internal length (L), pelvic limb length (F) and buttock width (G) and circumference (B)

	Feeding system		Sex		RSD†	Significance		
	NR	AR	♀	♂		F	S	F × S
FS (points 1 to 4)	2.9	2.5	2.8	2.7	0.42	*	ns	ns
K (cm)	51.0	53.1	52.1	52.0	1.81	*	ns	ns
L (cm)	38.8	40.0	39.8	39.0	1.34	*	ns	ns
F (cm)	25.7	26.4	25.9	26.1	0.98	ns	ns	ns
G (cm)	14.6	14.8	14.5	14.9	0.73	ns	ns	ns
B (cm)	41.6	42.2	41.8	42.0	0.74	*	ns	ns

†RSD: residual standard deviation.
*P < 0.05; ns: P > 0.05.

The values observed at this study for morphological parameters were similar to those obtained with Churra and Manchega milk-fed lambs raised under different feeding systems (Huidobro and Cañeque, 1994; Sañudo *et al*., 1997).

Carcass commercial joints and shoulder composition

Neither sex nor rearing system × sex interaction effects were significant (P > 0.05) for the percentage of the commercial joints or the proportion of dissectable components from the shoulder (Table 4). The lack of an effect on shoulder composition seems to be in agreement with carcass FS data. Nevertheless, FS is a subjective assessment of carcass fattening and differences in shoulder composition were expected because there had been differences between sexes in both carcass and non-carcass fat depots. It must be also taken into account that intermuscular adipose tissue growths faster than non-carcass fat depots (Robelin, 1986).

Rearing system did not affect the joints weight distribution (P > 0.05). However, there were significant (P < 0.05) differences between NR and AR lambs in shoulder composition. NR lambs shown a higher proportion of subcutaneous and intermuscular fat, which probably was related to a greater nutrient supply.

The fat accumulation on the tail region and the higher mature size of Awassi compared to native Spanish breeds have been used as arguments to explain breed differences in carcass fatness, which is an important factor for market value. As expected, Assaf (Awassi × Milchschaff) lambs have a higher tail weight than Churra or Manchega (Sañudo *et al*., 1997) but lower than Awassi milk-fed lambs (Sañudo *et al*., 1997). However, it must be pointed out that carcass fattening, as suggested by the values of perirenal-retroperitoneal, subcutaneous and intermuscular fat, was similar to that reported for Manchega milk-fed lambs, although carcasses of Churra and Lacha milk-fed lambs seem to be fatter, which is consistent with their greater precocity (Sierra *et al*., 1994; Sañudo *et al*., 1997; Beriain *et al*., 2000).

Conclusions

According to these results Assaf lambs can be raised on artificial rearing. However, growth performance and carcass characteristics were better for natural suckled than artificial reared lambs. The present study also confirms that differences between sexes appears at very low body weight in

Assaf breed. Furthermore, it is important to mention that milk-fed Assaf lambs carcasses were adequate according to Spanish market requirements. However, there are some differences with native breeds that must be taken into account.

Table 4. Effect of rearing system [Natural (NR) vs Artificial (AR)] and sex on proportion of carcass commercial joints and dissectible components from the shoulder

	Feeding system		Sex		RSD†	Significance		
	NR	AR	♀	♂		F	S	F × S
Carcass commercial joints								
Shoulder (%)	19.2	18.8	18.7	19.3	1.08	ns	ns	ns
Neck (%)	8.6	8.5	8.6	8.5	1.10	ns	ns	ns
Ribs 1-5 (%)	7.2	7.8	7.3	7.8	0.67	*	ns	ns
Ribs 6-onwards (%)	15.8	16.5	16.5	15.8	1.36	ns	ns	ns
Pelvic limb (%)	33.3	32.8	32.6	33.5	1.33	ns	ns	ns
Tail (%)	2.7	2.5	2.8	2.4	0.95	ns	ns	ns
Breast (%)	10.5	10.5	10.6	10.4	1.19	ns	ns	ns
Shoulder composition								
Lean (%)	58.1	61.5	59.5	60.0	0.91	*	ns	ns
Bone (%)	24.1	24.1	24.0	24.1	1.32	ns	ns	ns
Subcutaneous fat (%)	7.2	5.7	6.7	6.2	1.24	**	ns	ns
Intermuscular fat (%)	7.0	5.6	6.5	6.1	0.99	**	ns	ns
Other tissues (%)	3.5	2.9	3.1	3.3	0.53	*	ns	ns

†RSD: residual standard deviation.
*P < 0.05; ns: P > 0.05.

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