Effect of type of suckling and polyunsaturated fatty acid use on lamb production. 1. Productive performances and quanti-qualitative characteristics of the carcass

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ABSTRACT

The aim of the study was to estimate the influence of artificial rearing and of the addition of polyunsaturated fatty acids (PUFA) to an acidified milk replacer on the productive performances and on the quanti-qualitative characteristics of the carcass. Fifty one twin-born Gentile di Puglia lambs were subdivided into three homogenous groups (9 females and 8 males) assigned the following feeding treatments: maternal milk (MM); acidified milk replacer (MR); acidified milk replacer + 10 ml/l of a mixture of linseed and fish oil rich in PUFA (MR+PUFA).
Milk consumptions and live weights were recorded weekly. Seven males from each group were slaughtered at 45 days of age and the net warm dressing percentage, the composition of the carcass and the colorimetric characteristics of the *Longissimus lumborum* muscle were estimated. Artificial rearing improved the daily weight gain (0.182-0.172 vs 0.128 Kg; P<0.01) of lambs, provided fatter carcasses and meat with a better red index (6.16-6.43 vs 8.03; P<0.01).
The addition of omega-3 fatty acids to the diet did not influence the weight gain, the feed conversion index, the net warm dressing percentage and the incidence of the different meat cuts of the half carcass. However, it significantly increased the half carcass length (37.86 vs 35.0 cm; P<0.05), the thoracic depth (19.71 vs 16.50 cm; P<0.01) while, it compared to the MR group reduced the proportion of lean (63.21 vs 53.98 %; P<0.01) in favour of bone (20.94 vs 29.40 %; P<0.01) in the lumbar region.

Key words: Suckling lambs, PUFA, Productive performances, Carcass characteristics, Meat quality.

RIASSUNTO

EFFETTO DEL TIPO DI ALLATTAMENTO E DELL'IMPIEGO DI ACIDI GRASSI POLINSATURI SULLA PRODUZONE DELL'AGNELLO. 1. PERFORMANCES PRODUTTIVE E CARATTERISTICHE QUANTI-QUALITATIVE DELLA CARCASSA

La ricerca è stata condotta per valutare l'influenza del tipo di allattamento e dell'aggiunta di acidi grassi omega-3 al latte ricostituito sulle performance produttive e sulle caratteristiche quanti-qualitative della carcassa. Cinquantuno agnelli di razza Gentile di Puglia, provenienti da parto gemellare, sono stati suddivisi in tre lotti omogenei (9 femmine e 8 maschi)

così alimentati: latte materno (MM); latte acido ricostituito (MR); latte acido ricostituito + 10 ml/l di olio plus omega-3 contenente olio di lino e olio di pesce (MR+PUFA).
Settimanalmente sono stati rilevati i consumi di latte e i pesi vivi. Su sette maschi per lotto è stata valutata la resa alla macellazione, la composizione della carcassa e sul Longissimus lumborum le caratteristiche colorimetriche.
I risultati indicano che con l'allattamento artificiale si sono ottenuti migliori incrementi ponderali giornalieri (0,182-0,172 vs 0,128 Kg; P<0,01), carcasse più grasse e carni con un migliore indice del rosso (6,16 - 6,44 vs 8,03; P<0,01). L'arricchimento della dieta con acidi grassi omega-3 non influenza gli accrescimenti, gli indici di conversione alimentare, la resa alla macellazione e l'incidenza dei vari tagli della mezzena ma aumenta significativamente la lunghezza della mezzena (37,86 vs 35,00 cm; P<0,05), la profondità toracica (19,71 vs 16,50 cm; P<0,01) e nella lombata, rispetto al lotto MR, riduce l'incidenza del magro (63,21 vs 54,81%; P<0,05) a favore dell'osso (22,70 vs 29,40 %; P<0,01).

Parole chiave: Agnelli, Allattamento, PUFA, Performance produttive, Caratteristiche carcassa.

Introduction

Artificial rearing in sheep and goat breeding has been object of many studies (Congiu 1986; Lanza et al., 1990; 1992; Andrighetto et al., 1993) since it offers remarkable economic advantages to the breeder, priming a production cycle based on the commercialization of milk and cheeses. Moreover, animals can be slaughtered at a higher live weight and twins (frequent due to the technique of estrus synchronization) can be reared as well as orphans or lambs of mothers with an inconsistent milk production (Verità and Cianci, 1992; Bittante et al., 1997).

It is also important that artificially reared lambs adapt more easily to the use of weaning fodders (Sevi et al., 1996) and not being in contact with the mothers they are protected from some contagious pathologies. In mutton breeding, artificial rearing reduces the interval between lambing and breeding. In addition, the use of acidified milk replacers may reduce the difficulties of practical management and elevated labour and equipment costs of this technique (Andrighetto et al., 1993; Sahlu et al., 1992; Massari et al., 1994 a, b; Pinna et al., 1994; Celi et al., 1997; Galina et al., 1996).

With regard to the influence of artificial rearing on productive performances and on quantitative and qualitative characteristics of the carcass, the results so far reported are quite controversial (Girolami et al., 1994; Sevi et al., 1996; Vergara and Callego, 1999; Napolitano et al., 2002 a, b).

Some fatty acids are essential for the human body (Stubs and Smith, 1984; Dutta-Roy, 1994) which is not able to synthesize them and unsaturated fatty acids, especially those of the omega-3series, have positive effects on metabolic diseases (Sim, 1997; Simopoulos, 1997; Sheard, 1998; Nordoy et al., 2001), on the development and function of the retina and brain (Uauy et al., 1989; Innis 1991; Hoffman et al., 1993) and prevent prostate cancer (Norrish et al., 1999; William et al., 2001). For this reason many research projects have been carried out with the aim of producing meat and milk with a higher content of these fatty acids, from sheep (Mir et al., 2000; Kitessa et al., 2001a; 2003; Ponnampalam et al., 2001a, b, c; Velasco et al., 2001), goat (Mir et al., 1999; Kitessa et al., 2001b; Ragni et al., 2001; Vicenti et al., 2001) and pig (Van Oeckel et al., 1996). During the pre-ruminant stage of life, omega-3 fatty acids may be administered directly with the diet since they do not undergo hydrogenation at the rumen level and so pass directly into the abomasum in a similar way to monogastrics (Bernardini et al., 1997; Piva et al., 1998; Castellini et al., 1999).

In this study, we investigated the influence of the type of rearing and of the addition of polyunsaturated fatty acids to an acidified milk replacer on the productive performances and on some quantitative and qualitative characteristics of the lamb carcass.

Material and methods

The experiment was carried out in Bovino, near Foggia (Apulia, South Italy; 41° N, 600 m above the sea level). In November, 51 twin Gentile

di Puglia lambs born from sheep submitted to estrus synchronization were subdivided into three homogenous groups of 17 subjects each (9 females and 8 males) and given the following feeding treatments: maternal milk (group MM); acidified milk replacer (group MR); acidified milk replacer supplemented with 10 ml/l of a mixture of linseed and fish oil containing polyunsaturated fatty acids (group MR + PUFA).

In order to balance the fat content of the MR+PUFA diet, 10 ml/l coconut oil was added to the MR diet. Of the two twins, one was assigned to natural suckling while the other to one of the two artificial suckling groups. Artificial rearing was performed in single 0.80 m^2 boxes in a closed and ventilated barn where the average temperature during the trial ranged between 10 and 15° C. Lambs in the MR and MR+PUFA groups were separated from their dams two days after birth and the addition of lipids to the milk replacers began in the second week of experimentation. The milk replacer was prepared with 200 g milk powder/litre water, kept at room temperature and distributed 3 times daily in buckets equipped with teats from which lambs could suck the milk *ad libitum*. The residual amounts of milk were measured daily before the new distribution. In order to avoid ingestion of litter, the bedding was covered with a plastic net. During the third week of the trial, lambs were treated with sulphonamide because they were infested with coccids.

Live weights and milk consumptions were recorded weekly in order to calculate the daily weight gain and the feed conversion index. Every 10 days, samples of milk were collected from the ewes in order to assess the chemical composition. Due to health problems, two subjects in the MM group and one each in the MR and MR+PUFA groups were discarded for the statistical processing of data. At 45 days of age, after 12 hours of fasting, six male lambs in the MM group and seven in each of the MR and MR+PUFA groups were slaughtered. After refrigeration at 4° C for 24 hours, the carcasses were measured, sectioned into cuts, and the pelvic limb and the lumbar region were dissected into tissue components (lean, fat and bone) (ASPA, 1991). A spectro-photometer (Hunter Lab with D65 illuminant) was used to evaluate colorimetric parameters (L, a, b) of the *Longissimus lumborum* muscle.

Data were analyzed by ANOVA using the GLM procedure of SAS (1999-2000), taking into consideration only the diet effect in a mono-factorial model. Means were compared using Student's T test.

Results and discussion

Productive performances

Since no significant differences between sexes were recorded, data have been pooled. The daily weight gain (Table 1) was significantly ($P<0.01$) higher following artificial rearing both in the MR and in the MR+PUFA groups (0.182 and 0.172 Kg/d, respectively) than in the MM group (0.128 Kg/d); therefore, the weight of the naturally reared lambs at the end of the trial was approximately 2 Kg less than that recorded for both artificially

Table 1. In vivo performances.

Parameters		Group			SED
		MM	MR	MR+ PUFA	DF = 44
Lambs	n.	15	16	16	
Initial live weight	Kg	3.06	3.14	3.08	0.559
Final live weight	"	8.42 B	10.78 A	10.31 A	1.880
Weight gain	Kg/d	0.128 B	0.182 A	0.172 A	0.044
Dry matter consumption	"	0.130 B	0.253 A	0.235 A	0.042
Feed conversion index	Kg/kg	1.08 B	1.45 A	1.39 A	0.278

Mean within rows bearing different superscript (A, B) differ significantly at P<0.01.

reared groups (8.42 vs 10.78-10.31 Kg; P<0.01). The moderate weight gain found in all the groups may be explained by the low environmental temperatures and the coccid infection, and also by the fact that twin delivery determined a low birth weight, which according to Peters et al. (1996) may exert a negative effect on the subsequent body weight increases.

In the MM group, a smaller weight gain was associated to a smaller daily ingestion of dry matter (0.130 vs 0.253-0.235 Kg; P<0.01) and to a better feed conversion index (1.08 vs about 1.4; P<0.01). We must take into account, however, that the milk replacers had a lower percentage of fat (4.30 vs 4.90) and protein (3.97 vs 5.53) in comparison with the dam's milk. In this study, the conversion indexes of milk into meat are similar to those reported in other researches (Lanza et al., 1992; Casamassima et al., 1990; 1991) and more satisfactory than those reported by Andrighetto et al. (1993); this difference may be attributable to the genetic type and/or to the chemical composition of milk. The best weight increases recorded with artificial rearing are in contrast with researches in which no influence (Sevi et al., 1996; Napolitano et al., 2002a) or even a worsening effect of artificial suckling has been found (Napolitano et al., 2002b). Likewise, the differences may be due to the genetic type, to the quantitative and qualitative characteristics of the maternal milk or to the different method of administration of the milk replacer.

Furthermore, it must be considered that the *ad libitum* administration of milk allows more frequent and less abundant meals which may have positively affected the digestibility and ingestion of dry matter.

Slaughtering data

Lambs fed with maternal milk (Table 2) showed a lower empty body weight (8.27 Kg; P<0.05) and a greater incidence of the gastroenteric apparatus (9.80%) than the MR+PUFA group (8.24%; P<0.05) and especially the MR group (8.01%; P<0.01), and of the head (6.63 vs 5.43-5.56%; P<0.01). On the other hand, the incidence of the pluck (5.24%) and of the omentum (0.28%) was significantly lower (P<0.05) only compared with the values recorded for the MR+PUFA group. The lowest (65.70%) net warm dressing percentage was recorded in the MR+PUFA group and the highest (67.57%) in the MM one.

In general, the slaughtering yield obtained in our study was higher than the results reported for Comisana lambs (Napolitano et al., 2002a), while quite similar to Sardinian lambs (Napolitano et al., 2002b). Moreover, Sanudo et al. (1997) obtained a yield ranging between 50.3 and 55.9%, with statistical differences (P<0.05) between the genotypes in a study involving lambs of four different breeds in natural suckling and slaughtered at one month of age. In the present research, significant effects of the type of suckling were not observed on the slaughtering yield and this result

Table 2. Slaughtering data.

Parameters		Group			SED
		MM	MR	MR+PUFA	DF = 17
Empty body weight (EBW)	Kg	8.27 b	10.97 a	10.56 a	1.786
Hide	% EBW	13.07	14.00	13.98	1.071
Empty digestive tract	"	9.80 Aa	8.01 B	8.24 ABb	1.162
Omentum	"	0.28 b	0.48 ab	0.53 a	0.218
Net warm dressing percentage	"	67.57	67.38	65.70	2.263
Chilling loss	"	4.09 a	3.28 ab	2.25 b	1.604
Head	"	6.63 A	5.56 B	5.43 B	0.504
Pluck	"	5.24 b	5.78 ab	6.32 a	0.759

Mean within rows bearing different superscript (A, B; a, b) differ significantly at P<0.01 and P<0.05.

is in substantial agreement with Napolitano et al. (2002a) but in contrast with the findings reported by Vergara and Gallego (1999), who found a higher yield with natural suckling, and with those of Girolami et al. (1994) and Napolitano et al. (2002b), who recorded a higher yield following artificial rearing. The differences are probably due to the different amounts of forage ingestion.

The chilling loss was higher in lambs nursed by the mothers, but this difference is pronounced only in comparison with lambs receiving PUFA (4.09 vs 2.25%; P<0.05).

Sectioning data

The half carcass weight (Table 3) was similar for the artificial suckling groups (2.78-2.95 Kg) and higher than the group fed with maternal milk (2.21 Kg), especially when compared to the MR group (P<0.05). The incidence of several cuts, except for the neck, steaks, lumbar region and pelvic limb, was statistically different between the group nursed by ewes and those receiving the milk replacers. In fact, in MM lambs a greater incidence of the shoulder (19.81 vs 18.09 - 17.76 %) and of shanks (3.92 vs 3.24-3.52 %) was found, whereas in both the artificially reared groups there was a higher incidence of chest, abdominal region, kidney fat and kidneys.

With regard to the dissecting data (Table 4), no marked differences emerged between the groups regarding the lean, bone and the fat fractions of the pelvic limb; MR lambs showed a significantly greater lean percentage for the lumbar region, in comparison with the MR+PUFA group (60.62 vs 54.81 %; P<0.05) and a smaller incidence of bone (22.70 vs 29.40-31.04 %; P<0.01). When calculating the overall amount of lean meat obtained from the two cuts, the absolute value recorded for artificially reared lambs was greater than that from lambs fed under mothers (670.3 vs 545.9 g).

Lambs fed with maternal milk and those fed the milk replacer supplemented with PUFA showed significantly higher (P<0.01) lean/bone (1.89 vs 2.74) and lean+fat/bone (2.28 - 2.43 vs 3.52) ratios in the lumbar region, in comparison with the MR group.

The percentage of lean in the pelvic limb obtained in our study was higher than the data reported by Perez et al. (2002) in Suffolk lambs but quite similar to that recorded by Ruiz de Hidobro and Caneque (1994). The differences may be attributed to the dissection technique or to the different growth rate of the muscle in the different breeds.

With reference to the pelvic limb, the lean/bone

Table 3. Sectioning data.

Parameters		Group			SED
		MM	MR	MR+PUFA	DF = 17
Half carcass weight (HCW)	Kg	2.21 b	2.95 a	2.78 ab	0.527
Neck	% HCW	8.84	8.66	8.36	1.628
Shoulder	"	19.81 A	18.09 B	17.77 B	0.982
Steaks	"	15.00	15.37	15.27	1.724
Brisket	"	9.09 Bb	10.19 ABa	10.62 A	0.919
Loin	"	7.45	7.05	8.25	1.305
Abdominal region	"	2.68 B	4.48 A	4.13 A	0.611
Leg	"	31.74	30.66	30.07	1.532
Kidney fat	"	0.66 B	1.30 A	0.94 AB	0.360
Kidneys	"	0.79 b	0.96ab	1.07 a	0.216
Shanks	"	3.92 Aa	3.24 B	3.52 ABb	0.273

Mean within rows bearing different superscript (A, B; a, b) differ significantly at P<0.01 and P<0.05.

and lean+ fat/bone ratios were more satisfactory in the MR+PUFA group, whereas the highest lean/fat ratio was found in lambs fed with maternal milk. Perez et al. (2002) found a better meat/bone ratio in Suffolk male lambs slaughtered at a similar weight, while the fat/lean ratio was approximately half the value recorded in this trial.

The higher quantity of fat in artificially suckled lambs as evidenced by the relative values of the omentum, perineal fat, abdominal region, cuts of the pelvic limb and lumbar region, may be ascribed to higher feed ingestion that may have determined a greater growth rate increase. In fact, some authors (Wan Zahari et al., 1989) have reported that a high growth rate may cause greater development of the adipose tissue while others (Rattray et al., 1973) observed that fatter carcasses have been obtained in lambs fed ad libitum.

Carcass measurements

With concern to carcass measurements, no differences between the groups were recorded for the length of the body and the width of the rump (Table 5); however, the depth of the thorax was significantly greater in the MR+PUFA group (19.71 cm) than in the group suckled naturally (17.71 cm; $P<0.05$) and the MR group (16.50 cm; $P<0.01$). Marked differences ($P<0.05$) were found between the MR+PUFA and the MR group for the half carcass length (37.86 vs 35.0 cm). Lambs nursed by mothers presented a shorter pelvic limb than both the artificial suckling groups (24.0 vs 26.29 - 26.50 cm; $P<0.05$).

Colour assessment

Assessment of the colour parameters of meat (Table 6) showed that diet did not affect the brightness (L) (46.55 – 49.51) and the yellow (b) (11.59 – 12.40) indexes, whereas the red index (a) was significantly ($P<0.01$) higher in lambs fed with maternal milk than in both artificially reared groups (8.03 vs 6.16-6.43). These data are in contrast with the findings of Vergara and Callego (1999), who obtained a higher L value following natural suckling, while no marked differences emerged for the red and yellow indexes. Moreover, Sanudo et al. (1998) reported that milk diets produce lighter-coloured meat while Okeudo et al.

Table 4. Dissection data.

Parameters		Group MM	Group MR	Group MR + PUFA	SED DF = 17
Leg weight	g	700 b	903 a	833 ab	186.250
Lean	% leg weight	64.40	63.29	62.19	3.874
Fat	"	7.35	9.51	8.25	2.972
Bone	"	28.24	27.20	29.56	2.665
Lean /bone (on leg)		2.32	2.34	2.12	0.307
Lean + fat /bone (on leg)		2.58	2.69	2.40	0.322
Lean /fat (on leg)		10.41	6.90	9.74	5.065
Loin weight	g	166 b	207 ab	229 a	52.03
Lean	% loin weight	57.27 ab	60.62 a	54.81 b	5.32
Fat	"	11.68	16.67	15.78	4.485
Bone	"	31.04 A	22.70 B	29.40 A	4.067
Lean /bone (on loin)		1.89 B	2.74 A	1.89 B	0.405
Lean + fat /bone (on loin)		2.28 B	3.52 A	2.43 B	0.550
Lean /fat (on loin)		5.43	3.86	3.89	1.652

Mean within rows bearing different superscript (A, B; a, b) differ significantly at P<0.01 and P<0.05.

Table 5. Carcass measurements.

Parameters		Group MM	Group MR	Group MR + PUFA	SED DF = 17
Thorax width	cm	11.00 b	13.67 a	13.00 ab	1.868
Leg length	"	24.00 b	26.50 a	26.29 a	1.893
Body length	"	45.71	47.00	47.71	2.436
Half carcass length	"	35.57 ab	35.00 b	37.86 a	2.855
Thorax depth	"	17.71 ABb	16.50 B	19.71 Aa	1.788
Rump width	"	14.14	15.17	14.71	1.215

Mean within rows bearing different superscript (A, B; a, b) differ significantly at P<0.01 and P<0.05.

Table 6. Colorimetric characteristics of the meat.

Parameters	Group MM	Group MR	Group MR + PUFA	SED DF = 17
L	46.55	49.51	46.71	3.889
a	8.03A	6.16B	6.43B	0.925
b	11.59	12.40	12.22	1.129

Mean within rows bearing different superscript (A, B) differ significantly at P<0.01.

(1994) report that the administration of milk diets in place of solid meals does not seem to influence meat colour. Other studies report that meat colour is influenced by the genotype (Sanudo et al., 1997) as well as by the duration and temperature of meat storage (Ledward et al., 1986).

Conclusions

From the results obtained in our study, the following conclusions may be drawn:

- artificial rearing does not influence lamb viability and it positively affects the daily weight gain, probably because of a greater food availability;
- it does not influence the slaughtering yield and the proportion of the valuable cuts of the carcass;
- the higher level of fat deposition may be due to the greater growth rate of lambs. Within the artificial suckling groups, the addition of polyunsaturated fatty acids to the acidified milk replacer does not seem to influence the live weight increase, the feed conversion index, the slaughtering yield or the other parameters taken into consideration. However, dissection of the lumbar region revealed a higher incidence of bone than of lean meat.

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