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Use of weaning concentrate in the feeding of suckling kids: Effects on meat quality

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Abstract

A study was conducted to investigate the effect of a feeding supplementation with starter concentrate on "Capretto" meat production and its qualitative characteristics. To this end, 31 Girgentana kids, slaughtered at 59 days of age from two feeding groups (concentrate group (CG) and milk group (MG)) were utilised. Carcass measurements (body components, carcass joints, pelvic limb tissue composition, meat fatty acid composition and M. *longissimus dorsi* (LD) physical characteristics), body weight at birth, and at slaughter, were evaluated. The effect of concentrate supplementation did not influence the slaughter weight, slaughter and dissection data, tissue composition and meat chemical composition of the pelvic limb, and no differences were found for rheological characteristics of LD meat, except cohesiveness values, which were higher ($P < 0.05$) in the CG kids.

The effect of concentrate supplementation determined a significant variation of saturated fatty acids, which resulted higher for MG kids (41.77% versus 38.43%; $P \leq 0.05$). In fact, goat milk had an unsaturated fatty acids (UFA)/saturated fatty acids (SFA) ratio that was 0.25 lower than the fatty acid composition of concentrate (0.84). Litter size (single or twin) influenced many of the parameters studied statistically, probably because of the greater body weight of the single kids.
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1. Introduction

In the last few years several studies have been conducted on goat meat quality and, in particular, on

"Capretto" meat (Dhanda et al., 1999a,b, 2003a,b; Todaro et al., 2002, 2004), which is highly appreciated by European consumers. Goat meat is leaner than mutton and beef because it incorporates less subcutaneous and intra-muscular fat (Smith et al., 1978). Studies on chemical composition have suggested that kid meat is similar to lamb meat (Babiker et al., 1990); furthermore, a review on fatty acid composition of goat muscle

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(Banskalieva et al., 2000) reported that the mean concentration of SFA in goat muscles is not different from that in lamb and beef, but it is slightly higher than in pork. Moreover, goat muscle lipids are higher in PUFA (C 18:2, C 18:3 and C 20:4) than noted in lamb and beef, but lower when compared with pork (Banskalieva et al., 2000).

It is well known that plasma cholesterol concentration is influenced by the fatty acid composition of dietary fat: high dietary levels of long chain SFA increase plasma cholesterol levels compared with high levels of MUFA and PUFA (Grundy and Denke, 1990). The chemical composition of goat kid carcasses (a pre-ruminant animal) depends on the composition of the diet; several studies have reported that when the composition of milk replacers was modified, the fatty acid composition was too (Titi et al., 2000; Vicenti et al., 2001; Mahgoub et al., 2002; Yeom et al., 2002, 2005). Increased milk intake in nursing kids leads to decreased saturation of adipose tissue fats and an increased proportion of fatty acids with odd carbon numbers and branched chains (Sauvant et al., 1979). Feeding a total milk diet to growing kids produced carcasses with elevated concentrations of SFA and lower PUFA/SFA ratios (Potchoiba et al., 1990), thus worsening the quality of the meat.

With the aim of increasing the national kid meat production (only 77% of kid meat utilised is produced in Italy), a trial was conducted to study the effect of a feeding supplementation with starter concentrate on kid meat production and its qualitative characteristics.

2. Material and methods

Thirty-one intact male kids of the Girgentana breed were selected and assigned to one of two dietary treatments according to birth weight and litter size. All newborn goat kids were fed with maternal colostrum and successively with maternal milk for 20 days. At the beginning of the third week, the kids were housed indoors in two groups, according to dietary treatments: the 15 kids (single and twins) of the milk group (MG) were fed only with maternal milk at 7.00 a.m. and at 6.00 p.m.; the 16 kids of the concentrate group (CG) were fed with maternal milk at 7.00 a.m. and at 6.00 p.m.; during the day the starter concentrate was offered

ad libitum. Every day, the residual concentrate offered to CG kids was weighed and the voluntary feeding intake was calculated. Starter concentrate was analysed to determine chemical and fatty acids composition. Half way through the trial all dams were machine-milked and the milk was analysed for its chemical and fatty acid composition.

After 12 h of fasting, all kids were slaughtered at 59 days of age, using traditional procedures (ASPA, 1989), and the weight of the warm carcass, dress-off items and gastrointestinal content were recorded. Subsequently, the carcasses were chilled at 4 °C for 24 h, the right halves of the carcasses were divided into cuts following the standard procedure (ASPA, 1989). The pelvic limb of each carcass was dissected into muscle, fat, bone and "other tissues". After pelvic limb dissection, the meat was immediately homogenised and frozen dried. Dry matter at 105 °C, fat extracted with petroleum ether in Soxhlet apparatus, ash at 525 °C and protein by the Kjeldhal procedure were determined (AOAC, 1990) in the frozen dried samples.

Lipids were determined after extraction, in duplicate, of frozen dried meat samples, which were treated with *n*-hexane at 60 °C for 8–10 h. Methyl esters of fatty acids of the neutral triglycerides were prepared according to the transesterification method, in a vial at ambient temperature for 30 min, by means of *m*-trifluoromethyl-phenyl-trimethylamonium hydroxide (Meth-Prep II, Alltech) (0.2N) in methanol. The methyl esters were analysed using a Perkin-Elmer 8500 gas chromatograph equipped with a flame ionisation detector and an Omegawax 320 fused silica capillary column (30 m × 0.32 mm i.d. × 0.25 μm film thickness). Following sample injection, the column temperature was kept initially for 4 min at 155 °C, then increased at a rate of 4 °C/min to 250 °C and maintained at that level until all esters had been eluted. The injector temperature was 250 °C and detector temperature was 270 °C The carrier gas was nitrogen (15 ml/min). Standards for the fatty acid methyl esters were obtained from Sigma–Aldrich (Sigma, St. Louis, USA). Fatty acids were expressed in both normalised (molar proportion) and gravimetric (milligrams per gram of fresh tissue) formats.

The softness index was estimated by dividing the sum of palmitoleic (C 16:1) and oleic (C 18:1) by the sum of palmitic (C 16:0) and stearic (C 18:0) content (Leat, 1976).

At 24 h after slaughter, samples of M. *longissimus dorsi* (LD), taken from the loin, were placed in polyethylene bags, frozen at $-20\,^{\circ}$C and kept for about 4 months. Then they were thawed for 24 h at 4 $^{\circ}$C in order to detect rheological traits by Texturometer (Zenken, Tokio). For each muscle physical parameters were evaluated on two samples (1 in. of diameter and 1/2 in. of height).

Data were statistically analysed using the GLM procedure of the SAS Package, 8.1 Version (SAS, 1991). Analysis was performed according to the following linear model:

$$Y_{ijk} = \mu + A_i + B_j + \varepsilon_{ijk}$$

where A and B are the effects of dietary group (CG or MG) and the litter size (single or twin), respectively, the interaction was not significant.

3. Results and discussion

Chemical and fatty acids composition of goat milk and starter concentrate are reported in Table 1. Milk fat and protein percentages are slightly lower than those reported for the Girgentana goat breed (Todaro et al., 1999), although the milk was analysed at the beginning of the lactation. The goat milk fatty acid composition was characterised by high values of palmitic (C 16), caprinic (C 10) and oleic acids (C 18:1), with the 79.47% of SFA and 20.05% of UFA. On the other hand, the principle fatty acids of concentrate fat were palmitic (C 16), oleic (C 18:1) and linoleic acids (C 18:2); therefore, the SFA were 54.43% while the UFA were 45.57%.

Growth performance (Table 2) showed no difference between the two feeding groups. The voluntary concentrate intake of CG kids was 85 g/head/day, corresponding to 583 g of milk in terms of dry matter. Probably, the concentrate supplementation did not influence the slaughter weight or the growth rate because the substitution effect of the concentrate with goat milk.

Significant differences were found between the weight at the birth of single and twin kids (2.92 kg versus 2.61 kg; $P \leq 0.05$) in accordance with literature (Congiu, 1987; Mourad, 1993; Todaro et al., 2004). Overall, the body weight at the birth of Girgentana kids was comparable with that of other breeds reared in Italy

Table 1
Chemical and fatty acid composition of goat milk and concentrate (% of total lipids)

	Goat milk	Concentrate
Chemical composition		
Dry matter (DM) (%)	12.94	88.80
Fat (%)	3.80	3.68
Protein (%)	3.63	22.34
Lactose (%)	4.81	–
Ash (%)	0.70	8.54
Weende fibre (%)	–	4.89
Fatty acid composition		
C 8	7.21	2.90
C 10	18.86	0.97
C 12	7.12	0.16
C 14	10.07	0.64
C 14:1	0.45	1.29
C 16	29.97	42.51
C 16:1	0.25	2.09
C 17	0.54	0.48
C 17:1	1.22	0.97
C 18	5.71	6.76
C 18:1	13.71	29.15
C 18:2-ω6	2.15	8.05
C 18:3-ω3	1.16	0.48
C 20:4-ω6	0.11	0.16
C 20:5-ω3 (EPA)	0.23	0.16
C 22:5-ω3 (DPA)	0.23	0.97
C 22:6-ω3 (DHA)	0.54	1.13
Conjugated linoleic acid (CLA)	0.48	1.13
Saturated fatty acids (SFA)	79.47	54.43
Unsaturated fatty acids (UFA)	20.05	45.57
Mono-unsaturated fatty acids (MUFA)	15.63	33.49
Poly-unsaturated fatty acids (PUFA)	4.41	12.08
UFA/SFA	0.25	0.84

(Liotta et al., 2000; Di Trana et al., 2000; Todaro et al., 2000) or slightly inferior (Todaro et al., 2004).

Litter size influenced the growth performance markedly: single kids showed a higher growth rate (131 g/day versus 98 g/day; $P \leq 0.01$), and consequently a higher slaughter weight (10.56 kg versus 8.43 kg; $P \leq 0.01$) than twin kids, contrary to other studies reported by the same authors (Todaro et al., 2002, 2004) and in accordance with other papers (Alexandre et al., 1999; Congiu, 1987).

The supplementation with starter concentrate did not influence the slaughter and dissection data statistically (Table 3), but there was a significant effect of litter size on slaughter data: EBW and carcasses of single kids resulted heavier than twin kids and with higher

Table 2
Growth performance of male Girgentana kids (LSM ± S.E.)

	Feeding group		Litter size	
	CG	MG	Single	Twin
No. of observations	16	15	14	17
Weight at the birth (kg)	2.71 ± 0.10	2.82 ± 0.10	2.92 ± 0.11[a]	2.61 ± 0.10[b]
Age at slaughter (day)	59 ± 0.7	59 ± 0.8	58 ± 0.8	59 ± 0.7
Slaughter weight (kg)	9.43 ± 0.34	9.56 ± 0.36	10.56 ± 0.37[A]	8.43 ± 0.33[B]
Growth rate (g/day)	114 ± 5.3	115 ± 5.5	131 ± 5.7[A]	98 ± 5.2[B]

On the row (within each factor): different letters are significant at $P \leq 0.05$; capital different letters are significant at $P \leq 0.01$.

dressing percentage (65.9% versus 64.0%; $P \leq 0.01$). Also the head and the limbs, as percentage of EBW, were more favourable for the single kids. The mean weight of the right side was higher for the single kids compared to the twin kids, but as regards dissection data, no statistical differences were found.

The tissue composition and meat chemical composition of the pelvic limb were not influenced by the feeding treatment (Table 4). Litter size influenced only the fat percentage statistically; in fact, the single kids had fatter pelvic limbs than twin kids (11.2% versus 7.92%; $P \leq 0.01$). All parameters of meat chemical composition were statistically influenced by litter size: single kids presented higher values of dry matter (23.18% versus 22.36%; $P \leq 0.05$), ether extract

(7.55% versus 5.64%; $P \leq 0.01$) and lower values of protein (88.15% versus 89.69%; $P \leq 0.01$) and ash (5.13% versus 5.29%; $P \leq 0.01$). Differences found in the chemical composition of kid meat are surely linked to different slaughter body weight (Mahgoub et al., 2002).

The principle fatty acids of pelvic limb fat were oleic (C 18:1), palmitic (C 16) and stearic (C 18) acids (Table 5), in accordance with international literature (Banskalieva et al., 2000). The effect of concentrate supplementation determined a significant variation in saturated fatty acids (SFA), which was higher for kids fed only with maternal milk (41.77% versus 38.43%; $P \leq 0.05$) in accordance with other papers (Potchoiba et al., 1990; Zygoyiannis et al., 1992). These results

Table 3
Slaughter and dissection data of male Girgentana kids (LSM ± S.E.)

	Feeding group		Litter size	
	CG	MG	Single	Twin
Slaughter data				
Empty body weight (EBW) (kg)	8.85 ± 0.34	9.19 ± 0.35	10.09 ± 0.36[A]	7.95 ± 0.33[B]
Carcass weight (kg)	5.79 ± 0.23	5.96 ± 0.24	6.65 ± 0.24[A]	5.10 ± 0.22[B]
Dressing percentage (%)	65.2 ± 0.39	64.7 ± 0.41	65.9 ± 0.42[A]	64.0 ± 0.38[B]
Hide (% of EBW)	10.0 ± 0.27	10.3 ± 0.28	10.0 ± 0.29	10.3 ± 0.26
Head (% of EBW)	8.1 ± 0.18	8.0 ± 0.18	7.6 ± 0.19[A]	8.6 ± 0.17[B]
Internal organs[a] (% of EBW)	7.1 ± 0.16	7.3 ± 0.17	7.4 ± 0.18	7.0 ± 0.16
Limbs (% of EBW)	1.3 ± 0.03	1.4 ± 0.03	1.3 ± 0.03[a]	1.4 ± 0.03[b]
Dissection data				
Right side (RS) (kg)	2.54 ± 0.11	2.54 ± 0.11	2.93 ± 0.12[A]	2.15 ± 0.11[B]
Kidney and pelvic fat (% of RS)	1.82 ± 0.14	2.09 ± 0.14	2.12 ± 0.15	1.79 ± 0.13
Loin (% of RS)	6.64 ± 0.29	6.78 ± 0.30	6.53 ± 0.31	6.89 ± 0.28
Pelvic limb (% of RS)	27.40 ± 0.48	28.44 ± 0.50	27.59 ± 0.52	28.25 ± 0.47
Shoulder (% of RS)	20.64 ± 0.31	21.18 ± 0.32	20.84 ± 0.33	20.98 ± 0.30
Neck, steaks, brisket (% of RS)	34.29 ± 0.73	33.58 ± 0.76	33.60 ± 0.78	34.26 ± 0.71

On the row (within each factor): different letters are significant at $P \leq 0.05$; capital different letters are significant at $P \leq 0.01$.

[a] Lungs, trachea, heart, liver.

Table 4

Tissue composition and meat chemical composition of the pelvic limb, according to age of slaughtering and litter size (LSM ± S.E.)

	Feeding group		Litter size	
	CG	MG	Single	Twin
Tissue composition (% of pelvic limb)				
Bone	22.11 ± 0.87	22.32 ± 0.91	21.75 ± 0.94	22.68 ± 0.85
Muscle	54.66 ± 0.64	54.97 ± 0.68	53.98 ± 0.69	55.65 ± 0.62
Fat	10.06 ± 0.99	9.48 ± 1.04	11.62 ± 1.07[A]	7.92 ± 0.96[B]
Other tissues	9.95 ± 0.40	10.44 ± 0.42	10.03 ± 0.43	10.37 ± 0.39
Chemical composition (% of DM)				
Dry matter (DM)	22.64 ± 0.24	22.90 ± 0.25	23.18 ± 0.25[a]	22.36 ± 0.23[b]
Ether extract	6.35 ± 0.28	6.84 ± 0.29	7.55 ± 0.30[A]	5.64 ± 0.27[B]
Protein	89.08 ± 0.33	88.76 ± 0.35	88.15 ± 0.36[A]	89.69 ± 0.32[B]
Ash	5.22 ± 0.03	5.21 ± 0.03	5.13 ± 0.03[A]	5.29 ± 0.03[B]

On the row (within each factor): different letters are significant at $P \leq 0.05$; capital different letters are significant at $P \leq 0.01$.

Table 5

Fatty acid composition of pelvic limb fat (g of fatty acid/100 g of meat fat)

	Feeding group		Litter size	
	CG	MG	Single	Twin
Fatty acid (g/100 g of fat)				
C 8	0.02	0.02	0.03[A]	0.02[B]
C 10	0.33	0.39	0.41[A]	0.32[B]
C 12	0.31	0.35	0.38[A]	0.28[B]
C 14	2.95	3.37	3.34	2.98
C 14:1	0.26	0.32	0.31	0.27
C 16	20.10	21.55	20.66	20.99
C 16:1	2.15	2.22	2.53[A]	1.85[B]
C 17	1.21	1.09	1.25[a]	1.05[b]
C 17:1	1.05	1.16	1.16	1.05
C 18	13.51	15.00	14.99	13.52
C 18:1	27.60	28.07	28.43	27.21
C 18:2-ω6	3.81	4.19	4.39[a]	3.61[b]
C 18:3-ω3	1.05	1.00	1.10	0.96
C 20:4-ω6	0.33	0.36	0.36	0.33
C 20:5-ω3 (EPA)	0.01	0.01	0.01	0.01
C 22:5-ω3 (DPA)	0.10	0.12	0.11	0.11
C 22:6-ω3 (DHA)	0.01	0.01	0.02[a]	0.01[b]
Conjugated linoleic acid (CLA)	0.26	0.25	0.26	0.25
$\sum \omega6$	4.12	4.55	4.75[a]	4.93[b]
$\sum \omega3$	1.18	1.14	1.23	1.09
$\sum \omega6/\sum \omega3$	3.58	4.15	4.06	3.67
Saturated fatty acids (SFA)	38.43[a]	41.77[b]	41.06	39.14
Unsaturated fatty acids (UFA)	36.34	37.46	38.41[A]	35.39[B]
Mono-unsaturated fatty acids (MUFA)	31.03	31.77	32.43[A]	30.37[B]
Poly-unsaturated fatty acids (PUFA)	5.31	5.69	5.98[A]	5.02[B]
UFA/SFA	0.96	0.90	0.95	0.91
Softness index	0.90	0.84	0.88	0.85

On the row (within each factor): different letters are significant at $P \leq 0.05$; capital different letters are significant at $P \leq 0.01$.

Table 6
Physical characteristics of *Longissimus dorsi* muscle (LSM ± S.E.)

	Feeding group		Litter size	
	CG	MG	Single	Twin
Hardness (kg)	1.49 ± 0.08	1.52 ± 0.08	1.51 ± 0.09	1.50 ± 0.08
Cohesiveness (UT)	0.59 ± 0.02a	0.53 ± 0.02b	0.54 ± 0.02	0.58 ± 0.02
Springiness (mm)	12.73 ± 0.01	12.73 ± 0.01	12.73 ± 0.01	12.73 ± 0.01
Adhesiveness (UT)	3.99 ± 0.85	5.99 ± 0.89	4.92 ± 0.91	5.06 ± 0.83
Chewiness (kgm)	1124 ± 76	1047 ± 80	1050 ± 82	1121 ± 74

On the row (within each factor): different letters are significant at $P \leq 0.05$.

reflect the dietary differences between the milk-only diet (animal fat), richer in saturated fatty acids and the diet with supplementation of concentrate (vegetable fat) (Table 1).

Litter size influenced the fatty acid composition of pelvic limb: single kid fat showed a higher percentage of unsaturated fatty acids (UFA) (38.41% versus 35.39%; $P \leq 0.01$), due to the greater presence of the MUFA (32.43% versus 30.37%; $P \leq 0.01$) and PUFA (5.98% versus 5.02%; $P \leq 0.01$), analogous results were found by Todaro et al. (2002, 2004). This fact is probably due to the higher body weight of single kids; Mahgoub et al. (2002) reported that SFA in kidney fat decreases, whereas UFA increases with increasing body weight.

The value of $\omega 6/\omega 3$ ratio was approximately around to four points, lower than that reported by other authors (Vicenti et al., 2001; Todaro et al., 2004) but close to that recommended ($\cong 5$) for human health (Carnovale and Marletta, 1997). The unsaturated/saturated fatty acid ratio was between 0.90 and 0.96, slightly lower than that reported by Todaro et al. (2002, 2004) for kids slaughtered at a younger age, but analogous to that reported by Potchoiba et al. (1990). The softness index went from 0.84 to 0.90, and was not influenced by feeding supplementation and litter size factors. On average, the softness index was lower than that reported by other authors (Todaro et al., 2002, 2004; Zygoyiannis et al., 1992).

The concentrate supplementation, as well as litter size, did not influence the rheological characteristics of meat, except for cohesiveness values (Table 6), which were higher ($P < 0.05$) in the kids fed with concentrate. Recently, Todaro et al. (2004) also observed that physical parameters of meat were not influenced by litter size.

4. Conclusion

This study showed that a feeding supplementation with starter concentrate offered ad libitum to suckling kids had no effect on growth performance and on meat quality with the exception of fatty acid composition. In fact, CG kids had lower SFA than MG kids. The concentrate influenced meat fatty acid composition in suckling kids at the same way as in pre-ruminant animals.

Litter size affecting growth and live weight, resulted an environmental factor influencing meat quality of suckling kids. Single kids resulted heavier at birth and at slaughter than twin kids and showed higher dressing percentage. The better performance produced fatter kid meat (separable fat and intra-muscular fat) with a healthy fatty acid composition relating to higher percentage of UFA, MUFA and PUFA.

Therefore, on the basis of chemical and fatty acid composition, the meat of Girgentana kids was found to be healthy and of high quality.

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