



Full Length Article

Effects of Dietary Extruded Linseed (*Linum usitatissimum*) and Oregano (*Origanum vulgare*) on Growth Traits, Carcass Composition and Meat Quality of Grigia di Potenza Suckling Kids

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Abstract

The aim of this trial was to compare the influence of supplementing diets with extruded linseed and oregano on growth parameters and meat qualitative traits in Grigia di Potenza breed suckling kids. Twenty-four male kids, exclusively fed milk from their dams, were assigned to the following diets: C) group control fed without any supplement; L) group fed control feed containing 3% extruded linseed (*Linum usitatissimum* L.); and LO) group fed control diet with 0.6% dried oregano (*Origanum vulgare*) and 3% extruded linseed. Growth performance as well as slaughtering traits and meat cuts of kids were not significantly influenced ($P > 0.05$) by dietary treatments. Conversely, kids in linseed group reported the lower ($P < 0.05$) percentage of dissectible fat in leg and loin. The meat from *Longissimus lumborum* and *Semimembranosus* muscles of kids in linseed diet had the lowest ($P < 0.05$) cooking loss percentage, whereas the proximate chemical composition of both meat muscles did not vary among treatments ($P > 0.05$). The experimental diets partially modulated the kid meat fatty acid composition in both muscles, where feeding linseed and oregano improved ($P < 0.05$) the content of DPA and reduced MUFA. Based on the current findings, it can be concluded that linseed and oregano supplementation can be used in goat diet as no significant detrimental effects on productive performance and meat quality of suckling kids were observed. © 2021 Friends Science Publishers

Keywords: Diet; Extruded linseed; Goat; Meat quality; Oregano; Suckling kids

Introduction

Small ruminants are the dominant species of domestic livestock animals in the South of Italy, including the Basilicata region. Generally, in this area sheep and goats are mainly farmed under extensive or semi extensive conditions based on natural pastures. In these marginal areas, small ruminant rearing system is performed traditionally using local breeds due to their excellent flexibility to the environmental conditions and utilization of the existing feeding resources (Selvaggi and Tufarelli 2012). Goat autochthonous breeds are typical dual-purpose, developed to produce the unweaned slaughter kids at an early age, so that farmer can continue long milking goats to process milk into traditional cheeses.

The Grigia di Potenza goat is the most common autochthonous breed reared in Matera province, Basilicata

region of Italy (www.capre.it). This goat breed has an average size, with a weight of about 50–70 kg, having fine and light head, with big hanging ears, usually horned, and this goat can produce up to 300–350 litre of milk per lactation. Livestock species graze on natural pastures and receive additional feeds based on concentrate mixture composed in function of productivity level and nutrient requirements. New feeding strategies can include the use of natural feed additive to increase the polyunsaturated fatty acids (PUFA) content of meat. In the last decade several attempts have been made to increase the PUFA content in meat from livestock species, including diet raw linseed and linseed oil supplementation in lambs (Giannico *et al.* 2009; Colonna *et al.* 2011; Totoda *et al.* 2011; Facciolongo *et al.* 2018), kids (Rotondi *et al.* 2018), steers (Ragni *et al.* 2014; Tarricone *et al.* 2019a) and pigs (Tarricone *et al.* 2019b). However, achieving this enrichment in ruminants is

challenging owing to the biohydrogenation of fatty acids which occurs in rumen (Lunn and Theobald 2006). The supplementation of ruminants' diets with natural antioxidants is considered an effective strategy for modulating and improving fatty acid composition of meat (Cimmino *et al.* 2018). Natural antioxidants such as oregano, sage, thyme and rosemary are well accepted by consumers, because of they are considered safe and healthy (Naveena *et al.* 2016). The antioxidant activity in oregano is mainly attributed to carvacrol and thymol (Tufarelli *et al.* 2017). Trials using oregano (*Origanum vulgare*) supplied to lamb diet have assessed its efficacy in enhancing meat quality as well its sensory parameters (Simitzis *et al.* 2008); nevertheless, to date limited data are available on the dietary effects of oregano to the kids (Rotondi *et al.* 2018). The relevance and high quality of kid meat produced in Basilicata region of southern Italy were studied by many researchers (Ragni *et al.* 2015; Colonna *et al.* 2020). However, to the best of our knowledge, data on qualitative traits of Grigia di Potenza kids are to date not available.

Therefore, the aim of this research was to compare the influence of supplementing goat diet with oregano and extruded linseed on productive traits and quality of meat in suckling kids belonging the Grigia di Potenza goat breed.

Materials and Methods

Animal management and diet

The feeding trial was conducted out at the farm "Masseria Pian del Camino" located in Albano di Lucania, Basilicata region, Italy (40°36'03.7"N, 16°03'00.1"E; 899 m above sea level) and involved twenty-four male Grigia di Potenza breed kids, born as twins. Kids were managed following the traditional local rearing method for Grigia di Potenza goat breed as kids fed exclusively milk their from dams (about up to 21 days of age). So, kids were assigned to the following treatments: C) group control fed without any supplement; L) group fed control feed containing 3% extruded linseed (*Linum usitatissimum* L.); and LO) group fed control diet with 0.6% dried oregano (*Origanum vulgare*) and 3% extruded linseed. Supplied concentrates were isoenergetic and isoproteic, and to cover the kids requirements as for NRC (2007) indications (Tables 1 and 2). During the day the dams grazed and received *ad libitum* hay and concentrate (about 600 g per head daily) during the evening at housing. Maternal goat milk samples were collected twice daily for nutrient and fatty acid analysis (Table 2).

Animals were housed individually in pens (space allowance: 8000 cm² per head) with *ad libitum* water, and rearing temperature conditions in pens varied from 7–15°C. At sixty days kids were slaughtered, following exsanguination, by an official veterinarian after a fasting of 12 h, having kids free water, and registering the kids weight. The weight of hot carcass, fleece, skin, pluck, and gut were recorded. Each carcass was hung and chilled at refrigeration

temperature of 4°C (relative humidity: 80–82%) for 24 hours and immediately weighed. The carcass dressing percentage was also calculated. The carcass refrigerated were split into two halves by midline; the right side was divided into cuts. The right-side carcass was cut into wholesale cuts and separately weighed following the indications of Sarvar *et al.* (2009). The kids leg and loin were conducted from slaughterhouse to lab at 4°C. The two cuts of meat, except tail fat, were stored under refrigeration for additional 24 h, and separated into the three parts (lean, dissectible fat and bone) and each weight recorded (Tufarelli *et al.* 2011).

Feed and milk chemical composition

Samples of concentrates were collected every 15 days and mixed to get a final pool for each treatment, then analysed to assess the nutritional characteristics. Sample was ground in a hammer mill using a 1-mm screen and analysed (AOAC 2000). Goat milk samples were collected twice daily (morning and evening), stored at 4°C and transported immediately to lab and analysed for total protein, lactose and fat (Milko Scan 133B; Foss Electric, DK-3400, Denmark).

Meat parameters

Values of meat pH were determined on kid muscles (*Longissimus lumborum* and *Semimembranosus*) at slaughter and after 24 h at 4°C, by a pH-meter, and at two-point calibration. On both muscles meat colour and tenderness were determined. The colour of meat, in terms of lightness L^* , redness a^* , and yellowness b^* , was assessed using a spectrophotometer (Tarricone *et al.* 2019a). The readings ($n=3$) were done for individual samples placing the instrument on diverse areas of meat as reported by Šicklep and Čandek-Potokar (2007). Samples of the three meat (about 1.25 cm thick and diameter) from each muscle were tested to determine the Warner-Bratzler Shear (WBS) as for Tarricone *et al.* (2019a). To assess meat cooking loss, samples of about 5 cm thick were cut from the muscles and weighed before and after cooking using an oven ventilated at 165°C, until reaching an internal temperature of 75°C in meat. To determine the meat nutritional composition (AOAC 2000), sub-samples of kids meat muscles were analysed for fat content (Folch *et al.* 1957). Concentrate feeds were used for FA profile based on the method as above; also, the FA were reported as percent of total methylated FA.

Statistical analysis

Data were analyzed using the GLM procedure of SAS application package (SAS 2004). The differences among means were assessed using the LSD procedure. The effect of initial kid body weight as a linear covariate was omitted from model due to its not significant effect. The significance level was set at $P < 0.05$.

Table 1: Composition of the experimental diets fed to goats

Ingredients (% as-fed basis)	Diets ¹		
	C	L	LO
Corn	31.00	31.00	30.40
Faba bean	10.00	8.50	8.50
Wheat bran	10.00	10.00	10.00
Barley	9.00	9.00	9.00
Wheat flour shorts	9.00	9.00	9.00
Sunflower meal	8.00	7.50	7.50
Dehulled soybean	6.00	6.00	6.00
Sugar beet pulp	6.00	6.00	6.00
Soybean hulls	4.00	4.00	4.00
Molasses	3.00	3.00	3.00
Vitamin-mineral premix	3.00	3.00	3.00
Soybean oil	1.00	-	-
Extruded linseed	-	3.00	3.00
Oregano (dried inflorescences)	-	-	0.60

¹C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano

Table 2: Chemical and fatty acid composition of diets and maternal goat milk

Item	Diets ¹			Milk
	C	L	LO	
Chemical composition (% on DM basis)				
Crude protein	16.79	16.68	17.23	3.46
Ether extract	4.59	5.58	6.16	4.73
Ash	9.09	9.07	9.01	0.86
Lactose	-	-	-	4.35
Crude fiber	15.18	13.43	14.97	-
NDF ²	33.85	36.00	36.55	-
ADF ²	10.93	11.68	11.95	-
ADL ²	2.64	2.91	3.07	-
Fatty acid composition (% FA methyl esters)				
C6:0	-	-	-	1.18
C8:0	-	-	-	2.17
C10:0	-	-	-	9.15
C12:0	0.95	-	-	4.42
C14:0	0.94	-	-	9.47
C16:0	9.17	7.64	7.63	24.70
C17:0	0.66	-	-	0.63
C18:0	1.15	3.69	4.03	10.94
C18:1 n-9, cis 9	17.91	18.83	17.95	22.32
C18:2 n-6	39.16	22.03	20.58	3.04
C18:3 n-3	4.54	31.06	30.70	0.88
C20:4 n-6	0.21	-	-	0.32
C22:5 n-3	0.54	0.17	0.27	0.54
C22:6 n-3	0.29	0.28	0.28	0.30

¹C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano. ²NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin

Results

The initial body weight of suckling kids was similar among dietary treatments (Table 3). The difference in final weight was reflected in a greater trend of weight gain of kids during trial. The LO diet had the lowest ($P > 0.05$) weight gains in comparison to the other treatments. The FCR resulted similar among dietary groups. Kids' slaughtering characteristics and meat cuts are given in Table 4. The three dietary groups performed quite equally for most carcass parameters and meat cuts evaluated. Both hot- and cold-carcass dressing (as percentage on body weight) in this research were similar among treatments (respectively: $P =$

Table 3: Effect of diet on *in vivo* performances of kids

Item	Diet			SEM ²	P-value
	C	L	LO		
Initial BW (kg)	3.36	3.24	3.37	0.356	0.911
Final BW (kg)	10.08	9.76	9.03	1.226	0.335
Average daily BW gain (kg/d)	111.9	108.9	94.2	9.587	0.051
Average daily milk intake (kg/d)	0.82	0.78	0.72	0.098	0.075
Feed conversion ratio (kg/kg)	7.32	7.17	7.64	0.202	0.061

C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano. SEM: Standard error of means

Table 4: Slaughtering traits and meat cuts of kids

Item	Diet			SEM	P-value
	C	L	LO		
<i>Slaughtering traits, kg</i>					
Slaughter weight	10.08	9.76	9.03	2.009	0.063
Right half carcass	2.56	2.30	2.07	1.014	0.456
Skin	0.84	0.74	0.76	0.480	0.511
Head	0.63	0.59	0.57	0.098	0.752
Empty GI tract	0.48	0.51	0.65	0.033	0.101
Offals	0.74	0.58	0.59	0.074	0.095
Hot carcass dressing, % ¹	67.95	69.15	68.32	0.885	0.057
Cold carcass dressing, % ¹	64.40	66.09	65.11	0.871	0.052
<i>Meat cuts, kg</i>					
Neck	0.192	0.199	0.151	0.150	0.621
Shoulder	0.581	0.474	0.408	0.092	0.188
Leg	0.755	0.636	0.581	0.171	0.085
Steaks	0.326	0.257	0.217	0.054	0.341
Loin	0.134	0.142	0.129	0.079	0.436
Brisket	0.265	0.209	0.220	0.086	0.638

C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano. ¹% on body weight

Table 5: Dissection data (% on weight) of leg and loin of kids

Item		Diet			SEM	P-value
		C	L	LO		
<i>Leg</i>	kg	0.755	0.636	0.581	0.071	0.085
Lean	%	61.07	61.55	62.85	0.652	0.226
Dissectible fat		6.31 b	4.50 a	6.13 b	0.072	0.042
Bone		32.63	33.95	31.02	1.233	0.055
<i>Loin</i>	kg	0.134	0.142	0.129	0.071	0.436
Lean	%	44.79	46.04	44.04	0.708	0.061
Dissectible fat		13.97 b	9.53 a	9.86 ab	2.066	0.039
Bone		41.24	44.43	46.10	1.014	0.062

C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano; a-b: $P < 0.05$

0.057 and $P = 0.052$). No influence of feeding extruded linseed and oregano was observed on the main meat cuts and offal parts; however, the lean, fat and bone proportions of kids' leg and loin (Table 5) reported a lower percentage of dissectible fat in animals in extruded linseed group compared to the other two treatments (leg: $P = 0.042$ and loin: $P = 0.039$). In the present trial no difference was observed in *L. lumbrorum* and *Semimembranosus* meat muscles physical characteristics of suckling kids in terms of meat pH colour indices and WBS (Table 6), except for the meat cooking loss percentage that resulted significantly reduced ($P < 0.05$) in extruded linseed group for both meat muscles evaluated. Meat proximate composition of *L. lumbrorum* and *Semimembranosus* meat muscles was reported in Table 7, and from the obtained results, the kid

Table 6: Meat characteristics from *L. lumorum* and *Semimembranosus* muscles

Item	Diet			SEM	P-value
	C	L	LO		
<i>Longissimus lumorum</i>					
pH ₁	6.37	6.22	6.11	0.050	0.152
pH ₂ [#]	5.88	5.79	5.54	0.088	0.223
L*	47.27	46.38	44.50	0.747	0.061
a*	5.20	4.98	5.55	0.369	0.059
b*	12.52	10.89	10.63	0.971	0.063
WBS raw, kg/cm ²	2.40	2.24	2.30	0.092	0.369
WBS cooked, kg/cm ²	1.73	1.71	1.72	0.101	0.444
Cooking loss, %	13.34 c	7.16 a	9.81 b	2.215	0.030
<i>Semimembranosus</i>					
pH ₁	6.55	6.39	6.05	0.074	0.113
pH ₂ ¹	6.06	6.03	5.63	0.062	0.532
L*	47.56	43.90	43.12	1.001	0.062
a*	5.77	7.41	7.55	0.923	0.058
b*	10.82	11.29	10.41	0.852	0.105
WBS raw, kg/cm ²	2.23	2.14	2.27	0.113	0.321
WBS cooked, kg/cm ²	1.76	1.79	1.81	0.092	0.465
Cooking loss, %	16.06 b	13.50 a	17.03 c	1.201	0.040

pH₂ at 24 h post-mortem; C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano; WBS, Warner-Braztler shear force; a-c: P < 0.05

Table 7: Chemical composition (%) from *Longissimus lumorum* and *Semimembranosus* muscles

Item	Diet			SEM	P-value
	C	L	LO		
<i>Longissimus lumorum</i>					
Moisture	74.05	75.53	75.13	0.110	0.114
Protein	21.25	20.05	20.53	0.352	0.070
Lipid	2.01	2.10	2.05	0.096	0.145
Ash	2.69	2.31	2.30	0.063	0.095
<i>Semimembranosus</i>					
Moisture	76.78	76.09	75.97	0.125	0.128
Protein	18.47	18.43	18.73	0.322	0.201
Lipid	1.93	1.82	1.77	0.049	0.087
Ash	2.81	3.65	3.53	0.052	0.062

C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano

meat nutritive value did not differ among dietary groups ($P > 0.05$) as previously observed by Jambrenghi *et al.* (2007). The Tables 8 and 9 report respectively the *L. lumorum* and *Semimembranosus* meat muscles fatty acid composition, being marginally influenced by the tested diet. As expected, however, kids' meat fatty acid profile was influenced by the nutritional characteristics of diets fed to goat. A significant increase ($P < 0.05$) with linseed and oregano (LO) inclusion in diet was found in *L. lumorum* meat for total SFA (palmitic acid) compared to the other two kid groups. Further, the same meat muscle had the lower content of EPA (C20:5 n3, eicosapentaenoic acid) and the high content of DPA (C22:5 n3, docosapentaenoic acid) in kids on L and LO treatments ($P < 0.05$). As given in Table 9, a significant increase ($P < 0.05$) in oleic acid was detected in group linseed for *Semimembranosus* muscle, and in the same kids group a lower C20:1 n9 level was also detected. On the other hand, feeding experimental diets did not result in significant ($P > 0.05$) changes in total PUFA for both examined kid meat muscles.

Table 8: Fatty acid composition (% total FA methyl esters) of kid meat from *L. lumorum* muscle

Item	Diet			SEM	P-value
	C	L	LO		
C10:0	0.11	0.16	0.23	0.031	0.256
C12:0	0.52	0.60	0.65	0.101	0.574
C14:0	5.46	5.74	6.95	0.955	0.095
C15:0	0.35	0.31	0.39	0.042	0.464
C16:0	23.04	22.95	24.89	1.147	0.075
C17:0	0.51	0.48	0.56	0.098	0.297
C18:0	11.88	12.40	11.41	1.023	0.063
C20:0	0.05	0.04	0.06	0.001	0.355
C21:0	0.05	0.04	0.05	0.002	0.369
C22:0	0.34	0.26	0.27	0.040	0.222
C23:0	0.89	0.93	0.79	0.225	0.188
∑ SFA	43.18 a	43.91 a	46.27 b	1369	0.043
C14:1	0.05	0.12	0.19	0.005	0.396
C15:1	0.18	0.19	0.25	0.006	0.299
C16:1 <i>trans</i>	0.38	0.39	0.44	0.098	0.458
C16:1 <i>cis</i>	1.68	1.43	1.89	0.274	0.366
C17:1	0.40	0.32	0.36	0.052	0.501
C18:1 n9 <i>trans</i>	0.15	0.23	0.14	0.010	0.133
C18:1 n9 <i>cis</i>	34.11	34.21	32.84	1.526	0.077
C20:1 n9	0.92	0.46	0.60	0.195	0.085
C22:1 n9	3.69	2.65	2.76	0.210	0.057
∑ MUFA	41.56	40.01	39.47	1.035	0.059
C18:2 n6 <i>trans</i>	0.11	0.09	0.36	0.015	0.113
C18:2 n6 <i>cis</i>	8.48	7.23	7.47	1.114	0.071
C18:3n6	1.15	1.27	1.10	0.206	0.256
C18:3n3	0.10	0.18	0.09	0.003	0.118
C20:2 n6	0.54	0.44	0.47	0.062	0.254
C20:3 n6	4.88	4.96	4.75	0.369	0.137
C20:4 n6 ARA	0.03	0.08	0.06	0.003	0.266
C20:3 n3	0.10	0.04	0.06	0.003	0.341
C22:2n6	0.16	0.10	0.10	0.010	0.478
C20:5 n3 EPA	1.01 b	0.42 a	0.51 a	0.104	0.033
C22:5 n3 DPA	0.53 b	0.89 a	0.90 a	0.147	0.040
C22:6 n3 DHA	0.59	0.60	0.64	0.071	0.115
∑ PUFA	17.67	16.29	16.51	0.804	0.060

C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano. EPA: eicosapentaenoic acid; DPA: docosapentaenoic acid; DHA: docosahexaenoic acid; a-b: P < 0.05

Discussion

The productivity of small ruminants, in particular kids, in many countries is quite reduced and it resulted mainly related to nutrition, breed and rearing conditions. The limits of goats and kids nutrition in Mediterranean regions can be partially correlated to the environmental conditions influencing feed availability and pasture qualitative characteristics.

In our research, suckling kids did not vary among diets, and these differences are also reflected only in a greater trend of body gains. The findings observed in present study are consistent with those previously found by Giannico *et al.* (2009) and more recently by Rotondi *et al.* (2018), who fed respectively lambs and kids with diets containing extruded linseed and oregano as feed supplement. Further, other previous researchers confirmed that extruded linseed can be an effective ingredient in goat concentrate with no adverse effect on suckling kids or lambs' performance compared to control diet (Colonna *et*

Table 9: Fatty acid composition (% total FA methyl esters) of kid meat from *Semimembranosus* muscle

Item	Diet				
	C	L	LO	SEM	P-value
C10:0	0.09	0.17	0.17	0.009	0.158
C12:0	0.45	0.64	0.68	0.287	0.202
C14:0	4.67	5.83	6.70	0.801	0.064
C15:0	0.27	0.34	0.37	0.150	0.096
C16:0	22.16	22.76	24.15	1.114	0.060
C17:0	0.45	0.55	0.55	0.236	0.147
C18:0	12.66	12.14	12.03	1.098	0.212
C20:0	0.04	0.05	0.06	0.002	0.696
C21:0	0.06	0.05	0.04	0.002	0.854
C22:0	0.42	0.29	0.31	0.111	0.322
C23:0	1.13	0.98	0.93	0.165	0.165
Σ SFA	42.39	43.80	45.99	1.152	0.052
C14:1	0.04	0.17	0.14	0.008	0.095
C15:1	0.16	0.21	0.24	0.085	0.177
C16:1 <i>trans</i>	0.32	0.44	0.41	0.049	0.369
C16:1 <i>cis</i>	1.37	1.51	1.52	0.174	0.828
C17:1	0.28	0.43	0.19	0.033	0.125
C18:1 n9 <i>trans</i>	0.13	0.24	0.13	0.010	0.163
C18:1 n9 <i>cis</i>	31.98 b	34.69 a	31.55 b	2.005	0.029
C20:1 n9	1.08 b	0.57 ab	0.32 a	0.099	0.038
C22:1 n9	4.78	3.42	3.32	0.552	0.059
Σ MUFA	40.12 ab	41.67 a	37.83 b	0.715	0.042
C18:2 n6 <i>trans</i>	0.12	0.18	0.12	0.006	0.774
C18:2 n6 <i>cis</i>	7.88	7.64	8.66	0.566	0.146
C18:3n6	1.17	1.24	1.12	0.074	0.363
C18:3n3	0.11	0.18	0.17	0.009	0.622
C20:2 n6	0.70	0.47	0.32	0.022	0.179
C20:3 n6	4.21	4.17	4.22	0.061	0.696
C20:4 n6 ARA	0.02	0.03	0.02	0.001	0.785
C20:3 n3	0.13	0.08	0.06	0.005	0.444
C22:2n6	0.20	0.12	0.14	0.013	0.312
C20:5 n3 EPA	1.12	0.67	0.35	0.101	0.058
C22:5 n3 DPA	0.66	1.01	1.14	0.040	0.061
C22:6 n3 DHA	0.67	0.70	0.56	0.022	0.254
Σ PUFA	16.99	16.49	16.88	0.113	0.102

C, control feed; L, control feed + 3% extruded linseed; LO, control feed + 3% extruded linseed + 0.6% oregano. EPA: eicosapentaenoic acid; DPA: docosapentaenoic acid; DHA: docosahexaenoic acid; a-b: P < 0.05

al. 2011; Rotondi *et al.* 2018).

The slaughtering characteristics and meat cuts of suckling kids under the three treatments performed similarly for most of the parameters examined. However, the observed findings resulted quite lower than those assessed in previous reports using different goat breed in Italy (Rotondi *et al.* 2018; Colonna *et al.* 2020), and this might be mainly due to feeding practice and management as well as related to the composition of goat concentrate diet. Moreover, other studies evaluating different natural dietary supplements reported inconstant findings regarding the carcass parameters. In the current study no significant differences were observed in *L. lumbrorum* and *Semimembranosus* meat muscles physical characteristics of suckling kids, even if it was found that meat cooking loss percentage that resulted reduced in suckling kids in extruded linseed group. Unfortunately, there are no available reports on the effects of extruded linseed and oregano supplementation on suckling kid meat physical characteristics. In particular, among other meat-producing

livestock species, it observed a similar trend in meat from lambs (Colonna *et al.* 2011), bulls (Ragni *et al.* 2014; Tarricone *et al.* 2019a) and pigs (Tarricone *et al.* 2019b). Nevertheless, the variations between our results and the findings observed in previous trials can be mainly due to the difference in using other animal breeds, feedstuffs, and concentrate characteristics (Toteda *et al.* 2011; Tufarelli *et al.* 2013). In the examined meat muscles *L. lumbrorum* and *Semimembranosus* of suckling Grigia di Potenza kids, the dietary treatments did not influence the proximate nutritional composition of meat, and this trend was also observed by Jambrenghi *et al.* (2007) in suckling kids. In our feeding trial, the FA profile of both meat muscles were to some extent influenced by the dietary treatments; however, as expected, the kids' meat FA profile varied based on the nutritional characteristics of diets fed to goat. A increase with linseed plus oregano in diet was found in *L. lumbrorum* meat for total SFA (palmitic acid) compared to the other two kid groups. Further, a significant increase in oleic acid was detected in linseed group for *Semimembranosus* muscle. At this regard, the main monounsaturated fatty acid in meat muscle was the oleic acid, which might be linked to the high concentration in linseed oil, as previously demonstrated by Colonna *et al.* (2011) and Rotondi *et al.* (2018). The high level of oleic acid in diet including extruded linseed determined higher concentration of this fatty acid in the meat of suckling kids fed the tested high-quality feed ingredient than those fed the other diets. Also, there were no dietary effects on the total PUFA (polyunsaturated fatty acid) in both kid meat cuts, and this was in accordance with the results of Berthelot *et al.* (2010) in meat from lambs.

Conclusion

Based on the findings, the present study confirms that both extruded linseed and oregano can be added in goat diet as no decrease in growth traits and meat quality was assessed in suckling kids, being also capable to positively modulate meat lipid profile. Therefore, this experiment therefore supported the idea that including extruded linseed and oregano in the feeding system of lactating goat would produce kid meat with a healthier lipid profile with no detrimental effect on growth performance.

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Author Contributions

All authors have equally contributed to the manuscript and

read and approved the content of the manuscript.

Conflicts of Interest

All other authors declare no conflicts of interest

Data Availability

Data presented in this study are available on fair request to the corresponding author.

Ethics Approval

Ethical review and approval were waived for this study, due to animals were cared for and handled in compliance with the EU legislation on animal welfare regulations (Directive 2010/63/EU which updates and replaces the 1986 Directive 86/609/EEC on the protection of animals used for scientific purposes) and following the University research policy.

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