Extruded linseed and linseed oil as alternative to soybean meal and soybean oil in diets for fattening lambs

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ABSTRACT - The study evaluated the effects of replacing soybean meal and soybean oil respectively with extruded linseed and linseed oil on the productive performances and meat quality traits in lambs slaughtered at 90 days. Lambs weaned at 40 days were divided into 3 groups (N.=10) fed *ad libitum* for 6 weeks as follows: C (control, commercial feed containing soybean meal and soybean oil); LO (feed containing linseed oil instead of soybean oil); EL (feed containing extruded linseed). Meat quality traits were evaluated on the *Longissimus lumborum* (Ll) and *Semimembranosus* (Sm) muscles. The lambs' growth performances and the slaughtering and sectioning data did not differ between groups. The redness of meat was significantly higher (P<0.05) for the LO and EL groups compared to the control for both the muscles tested. Ll meat samples of the EL group showed a greater cooking loss compared to LO (P<0.01) and to the control (P<0.05). The amount of linoleic acid in raw Ll meat samples was significantly (P<0.01) lower in both LO and EL groups with respect to control. The concentration of α-linolenic acid was significantly (P<0.01) higher in the EL group and this positively affected the total content of ω3 as well as the ω6/ω3 ratio.

Key words: Extruded linseed, Linseed oil, Lamb, Meat quality.

Introduction - Dietary manipulation of ruminant feeding aiming to improve the fatty acid profile of meat represents a target pursued since a long time (Sañudo *et al.*, 2000). Several feed strategies have been tested to increase the ω-3 PUFA content of lamb meat such as fish oil used in the past or more recently vegetal sources like linseed (Ponnampalam *et al.*, 2002; Caputi Jambrenghi *et al.*, 2004a; Bas *et al*., 2007). Linseed (*Linum usitatissimum*) has a normalising gastro-intestinal function, positive effects on milk production and quality (Mele *et al*., 2007; Pezzi *et al*., 2007) and contains proteins characterised by a high rumen solubility. Therefore, linseed may represent a valid alternative to the genetically modified soybean because of its high content of oil (35%) rich in PUFAs and its cultivation sustainability. However, whole linseed contains antinutrients (i.e. linamarin) that can be inactivated by heat treatments such as extrusion. This research was carried out to assess the effects of replacing soybean meal and soybean oil respectively with extruded linseed and linseed oil on the productive performances and meat quality traits in lambs slaughtered at 90 days.

Material and methods - Thirty male Gentile di Puglia lambs weaned at about 40 days of age were used. After a week of adjustment with a commercial weaning feed, the lambs were divided into 3 homogeneous groups (N.=10) and given one of the following feeding treatments *ad libitum* for 6 weeks: C (control, commercial feed containing soybean meal and soybean oil); LO (feed containing 3% linseed oil instead of soybean oil); EL (feed containing 9% extruded linseed). The diets were formulated in order to have the same energy, protein, fiber and fat content. Linseed oil was extracted from the seeds by a cold extraction method. The lambs were slaughtered at approximately 90 days of age. Chemical and fatty acid analyses were conducted on the feeds and on the meat samples. Slaughter and carcass sectioning procedures were performed according to the ASPA guidelines (1991). Meat quality traits (colour, pH, cooking loss, tenderness, chemical and fatty acid composition) were evaluated on the *Longissimus lumborum* (Ll) and *Semimembranosus* (Sm) muscles (ASPA, 1996). The fatty acid composition of meat samples was assessed by methyl esters capillary gas chromatography. The derivatisation of fatty acids was made in basic catalysis, by the rapid methylation method. Each peak of the chromatography track was identified by comparing the retention time of the fatty acids with the external standard Menhaden Oil FAME (SGE Analytical Science). The mix of isomers cis-9 trans-11 and trans-10 cis-12 conjugated octadecadienoic acid methyl esters was used as the external standard for the identification of Conjugated Linoleic Acid (CLA). The data concerning the chemical and physical features of meat were processed by ANOVA using the GLM procedure of SAS (SAS/STATTM, 2000) according to a mono-factorial model with only the diet effect, while the data concerning the fatty acid profile of meat were analysed taking into consideration as main effects diet, meat status (raw vs cooked) and their interaction. Means were compared by the Student's t test.

Results and conclusions - There were no significant differences between feeding treatments with concern to the lambs' growth performances and to the slaughtering and sectioning data, as also reported in a previous research (Caputi Jambrenghi *et al*., 2004b). Some meat quality traits are reported in Table 1. The redness index was significantly higher (P<0.05) for the LO and EL groups compared to the control for both the muscles tested. Ll meat samples of the EL group showed a greater cooking loss compared to the LO (P<0.01) and to the control groups (P<0.05), probably due to the higher, though not significant, pH values (data not shown) of these meat samples (Bouton *et al*., 1971).

Table 1. Chemical and physical features of Ll and Sm meat samples.

		Control	Linseed oil	Extruded linseed	SED (DF = 30)
Ll	L	49,70	48,80	48,09	3,049
	a	10,10b	10,99a	11,33a	1,379
	b	15,49	15,49	15,60	3,363
	Cooking loss (%)	37,22b	34,39Bb	41,71Aa	4,733
Sm	L	49,84a	47,17b	48,42ab	2,582
	a	9,48b	10,82a	10,53a	0,917
	b	11,13	11,72	11,90	0,946
	Cooking loss (%)	41,30	40,57	40,68	4,167

A, B: P<0.01; a, b: P<0.05.

Some of the fatty acids present in raw and cooked Ll and Sm meat samples are shown in Table 2. In the Ll muscle the amount of linoleic acid in raw meat samples was lower (P<0.01) in both LO and EL groups compared to control. An important and positive result was observed for the α-linolenic acid found in both raw and cooked samples. The concentration of this fatty acid was significantly (P<0.01) higher in the EL group compared to the LO and to the control and this positively affected the total content of ω3 as well as the ω6/ω3 ratio. The same trend was observed also for the Sm muscle. Our results are in agreement with those reported by Mughetti et al. (2007) who found that heat treatments such as extrusion seem to decrease linseed fat degradability thus ensuring a higher ruminal by-pass of dietary fatty acids that become more available for the animal. Indeed, in this trial the inclusion of extruded linseed in the lambs' diet improved the fatty acid profile of meat much more than linseed oil that inevitably undergoes biohydrogenation inside the rumen. Even though cooking lowers the concentration of the desirable fatty acids for human health such as ω3, EL cooked meat samples have on the whole better characteristics than the control group, and this is a useful result in terms of meat's effective healthiness. In conclusion, extruded linseed may be successfully used for the diet of fattening lambs since it positively influences meat fatty acids.

Table 2. Fatty acid composition (% on total FA) of Ll and Sm raw and cooked meat samples.

		Control		LO		EL		Level of significance			SED
	Acid	Raw	Cooked	Raw	Cooked	Raw	Cooked	Diet (D)	Meat (M)	D*M	(DF=120)
Ll	C18:2ω6	5.43A	3.55	4.63B	3.56	4.34B	3.68	<0.001	<0.001	ns	0.773
	C18:3ω3	0.79C	0.48C	1.16B	0.78B	1.47A	1.11A	<0.001	<0.001	ns	0.224
	CLA	0.61	0.57	0.68	0.51	0.75	0.61	ns	<0.001	ns	0.200
	ω3	1.59B	0.91C	1.95A	1.25Bb	2.22A	1.48Aa	<0.001	<0.001	ns	0.408
	ω6/ω3	3.66A	4.38Aa	2.54B	3.36b	2.31B	2.92B	<0.001	<0.001	ns	0.872
	PUFA	7.67	5.41	8.08	5.73	8.06	6.29	ns	<0.001	ns	1.278
	MUFA	37.48	35.01	37.56	35.90	35.62	37.46	ns	ns	ns	4.652
	SFA	44.64	46.53	45.97	47.03	46.86	47.46	ns	<0.01	ns	4.649
Sm	C18:2ω6	5.63a	4.38A	5.21	4.02	4.79b	3.60B	<0.001	<0.001	ns	0.773
	C18:3ω3	0.68C	0.53B	1.10B	0.87Ab	1.47A	1.06Aa	<0.001	<0.001	ns	0.224
	CLA	1.04	0.68a	0.96	0.67	0.90	0.58b	ns	<0.001	ns	0.200
	ω3	1.69B	1.03b	2.41A	1.44a	2.63A	1.44a	<0.001	<0.001	ns	0.408
	ω6/ω3	3.78A	4.81A	2.38B	3.32B	2.04B	2.89B	<0.001	<0.001	ns	0.872
	PUFA	8.78	6.44	9.11	6.63	8.93	6.08	ns	<0.001	ns	1.278
	MUFA	36.56b	38.24a	38.76a	39.10a	37.00	36.91b	ns	ns	ns	4.652
	SFA	44.53	45.40b	44.03	46.52b	46.10	48.96a	ns	<0.01	ns	4.649

Differences between diets within the same meat status: A, B, C: P<0.01; a, b: P<0.05; ns = not significant.

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