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Muscle fatty acids profile of finishing Black goat kids fed oil supplemented diets

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ABSTRACT

Objective: Effects of oil supplemented diets on muscle lipid profile was studied using 27 Black goat kids. **Methods:** All kids were male with a body weight of 19.4±0.41 kg at the beginning of the experiment. Kids were randomly divided into 3 groups of 9 kids each. Kids in each group individually received cereal grain-soybean meal (SBM) total mixed rations (TMR) with a fixed amount (30 g/kg DM) of oil being either: sesame (SES) oil, a product of sesame seed crushing, sunflower (SUN) or soybean (SOY) oil. All rations were isonitrogenous and isoenergetic. At the termination of the 105 d feeding study, all kids were slaughtered. **Results:** Results of the study showed that the SES kids muscles had higher ($P<0.05$) crude protein content compared to that of kids consuming the SOY or SUN diets, however, tissue fat and cholesterol contents were not affected by type of supplemental oil. Type of oil had no significant effects on both total saturated and unsaturated fatty acids. The addition of SES to the concentrate had no effect on C14:0 and C18:0, but significantly increased ($P<0.05$) C16:0 compared to diets supplemented with SUN and SOY. The SES supplemented diets resulted in lower ($P<0.05$) C18:1 *cis*-11. However, both SES and SOY oils increased ($P<0.05$) the C18:3 all *cis* proportion. Linolenic acid (C18:3) proportion lowered ($P<0.05$) when SUN was included in the diets, which led to a lower C18:2/C18:3 ratio. All types of oils supplemented had similar effect on C18:2 *trans*-9,12 and C18:2 *cis*-9,12. In conclusion, supplementation of SES has similar effects as SUN or SOY on most of tested parameters. Results of our study, the first in our region, showed potential advantages of feeding SES supplemented diets to kids in comparison with diets supplemented with SOY or SUN. In addition the lower price of SES makes it a feasible feed choice. **Conclusions:** Supplementation of SES has similar effects on most of tested parameters. Results of our study, the first in our region, regarding effects on tissue lipid profile of Black kids, showed potential advantages of feeding SES supplemented diets to kids in comparison with diets supplemented with SOY or SUN. In addition the lower price of SES makes it a feasible feed choic.

1. Introduction

Dietary fat supplementation has become a common practice to increase the energy density in diets for ruminants [1-3]. Conjugated linoleic acids (CLA), present in meat from ruminant animals are formed through isomerization of linoleic acid by ruminal bacteria[4-6]and via desaturation by body tissues of another product of biohydrogenation[7-8, 5]. Thus, it may be possible to increase the content of CLA in fat and muscle from animals through increased dietary availability of the substrate, linoleic acid[9-11]. Alteration of ruminal protozoa through feeding linoleic acid may increase CLA concentration, either directly through increased lipolysis, or indirectly by affecting the bacterial population that are thought to be primarily responsible for the biohydrogenation of dietary linoleic acid[12].

The only oil produced locally is the SES, a product of sesame seed crushing. This type of oil is unrefined and not suitable for human consumption[13-14]. However, SES supplemented diets are not fed to animals on a wide scale compared to diets supplemented with SUN or SOY oils. In Palestine as in some Middle East countries there is an increasing interest in incorporation of sesame oil (SES) as oil supplement in ruminant rations. SES is an oil supplement with high level of linoleic acid similar to sunflower and soybean oils. To our knowledge, inclusion of SES, SUN or SOY oil, especially SES, in diets for finishing Black goat kids and its effects on muscle lipid profile has not been

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investigated. Feeding of a linoleic acid-rich oil (Table 2) would enhance the concentration of CLA in kids tissues compared with an oleic acid-rich oil. However, to our knowledge little, if any, information available on its effects on fattening kids tissue lipid profile.

The objectives of this study were to compare the effects of feeding SES, a non conventional supplemental oil, SUN or SOY to a cereal grain based diet on muscle lipid profile of finishing Black goat kids.

2. Materials and methods

2.1 Study Site

The study was conducted at Hebron University, Hebron city, Palestine, semi-arid area, after approval of the Hebron University Animal Care and Use Committee.

2.2 Animals

Twenty-seven male Black goat kids (initial body weight (BW) = 19.4±0.41 kg) at 60 d of age (*i.e.*, soon after weaning) were used. Kids were individually housed in (1.5 m× 0.75 m) shaded pens and treated with IVOMEC (Merial Limited, Luluth, GA, USA) and Cogla Vac (Cogla Laboratories, Libourne, France) against internal and external parasites, and enterotoxaemia, respectively.

Table 2

Fatty acid profile of different sources of oil supplements

	Oil sourcea		
	SES	SUN	SOY
C14:0	0.5	1.0	0.5
C16:0	9.0	6.0	9.0
C16:1	0.5	1.0	0.5
C18:0	4.5	5.5	3.5
C18:1	42.0	19.0	24.0
C18:2	42.0	47.0	68.0
C18:3	1.0	1.5	7.0
C20:0	1.0	1.0	1.0

a SES, SUN, and SOY refer to dietary treatments containing sesame oil, sunflower oil, and soybean oil, respectively.

2.3 Diets

Kids were assigned on the basis of BW to one of three dietary treatments (Table 1) being a sesame oil diet

Table 1

Ingredient and chemical composition of diets containing different oil supplementsa

	Treatmentb		
	SES	SUN	SOY
n	9	9	9
Ingredient composition, g/kg DM			
Yellow corn grain	122	122	122
Soybean meal	190	190	190
Wheat bran	100	100	100
Wheat straw	100	100	100
Ammonium chloride	3	3	3
Dicalcium phosphate	10	10	10
Limestone	20	20	20
Salt	3	3	3
Premixc	1	1	1
Fat source	3	3	3
Barley grain	170	170	170
Wheat grain	242	242	242
Nutrient composition, g/kg DM			
Dry matter	907	903	897
Organic matter	830	831	839
Crude protein	180	184	178
Ether extractd	43	41	40
Acid detergent fiber	104	100	102
aNeutral detergent fiber	305	310	300
Ash	61	69	65
ME, MJ/ kge	8.3	8.7	8.5

a composition values obtained from the analysis of final diets.

b SES, SUN, and SOY refer to dietary treatments containing 30 g/kg sesame oil, 30 g/kg sunflower oil and 30 g/kg soybean oil on DM basis, respectively.

c Composition/kg contained, vitamin A, 2,000,000 IU; vitamin D3, 40,000 IU; vitamin E, 400 IU; Mn, 12.8 mg; Zn, 9.0 mg; I, 1.56 mg; Fe, 6.42 mg; Co, 50 mg; Se, 32 mg plus an antioxidant (Butylated hydroxyanisole, BHA).

dEther extract for both fat sources was estimated to be 999 g/kg.

eMetabolizable energy; based on tabular values (NRC, 1985). Metabolizable energy (ME) contents of SES, SUN and SOY were estimated using the following equation: ME; MJ/kg = digestible energy (DE) ' 0.82 ' 4.187 (NRC, 1985).

containing 30 g/kg DM sesame oil (SES; *n*=9) and two additional diets containing similar level of sunflower oil (SUN; *n*=9) or soybean oil (SOY; *n*=9). The study was 105 d. The 30 g/kg fat addition level was chosen to avoid negative effects associated with higher inclusion levels. Diets were composed of forage (*i.e.*, 100 g/kg DM wheat straw) and a concentrate (*i.e.*, 900 g/kg DM of a mixture of cereals, soybean meal, by products, minerals and a premix, (Table 1). Oils were obtained from commercial sources and were mixed into the concentrate which was later mixed with the straw and fed as a total mixed ration (TMR). All diets were formulated to be isonitrogenous and iso ME, and to meet all nutrient requirements for finishing kids[15].

The formulated rations were analyzed according to procedures of AOAC[16]. The ingredients and chemical composition are given in Table 1.

2.4 Slaughter and meat measurements

At the end of the study, all kids were slaughtered after being fasted for 18 h according to routine procedures at local commercial slaughter houses. The chemical composition of meat was determined on m.*longissimus* lumborum samples, which were analyzed for dry matter (AOAC official method 950.46), ash (AOAC official method 920.153), crude protein (AOAC official method 981.10) and fat (AOAC official method 960.39). *longissimus dorsi pars lumborum* muscle samples were used for intramuscular (IM) fat analysis. Samples were collected 24 h post-slaughter from the left side of the carcass and, after ageing for 72 h at − 4°C, they were frozen at − 20°C.

The total fatty acids were extracted, methylated and analyzed by the method of Aldai *et al*[17]. Isolation and quantification of the fatty acid methyl esters (FAMEs) was performed using a gas chromatograph (GC, Varian Star 3400CX, Varian Associates Inc., California, USA) equipped with a flame ionization detector and fitted with a BPX-70 capillary column (120 m, 0.25 mm i.d., 0.2 μm film thickness, SGE, Australia). The internal standard used was the tricosanoic acid methyl ester (C23:0 ME) at 10 mg/ml. Individual FAMEs were identified by comparing their retention times with those of an authenticated standard fatty acid mix Supelco 37 (Sigma Chemical Co. Ltd., Poole, UK). Identification of the CLA isomers (*e. g. cis9-trans11, cis11-13trans, trans10-cis12* and *cis*10-*cis*12 CLA) was achieved by comparing retention times with those of another known standard mix (Sigma Chemical Co. Ltd., Poole, UK). Fatty acids were expressed as a percentage of total fatty acids identified as saturated (SFA), monounsaturated (MUFA), polyunsaturated (PUFA) and total CLA. PUFA/SFA and n −3/n−6 ratios were also calculated.

2.4.Statistical analysis

Data (*longissimus* muscle composition of fat, protein, cholesterol and fatty acids) were subjected to one-way analysis of variance using SPSS V16.0[18]. An LSD test was used to assess significance among treatment means. Each kid was considered as the statistical unit. The model was:

$Yij = \mu + Ti + Eij$, where Yij is the observation (determination from the *longissimus* muscle) on the jth kid receiving ith treatment (oil source), μ is the overall mean, Ti is the effect of ith treatment (oil source), Eij is the residual for the jth observation receiving ith treatment (oil source).

3. Results

The muscle chemical composition is presented in Table 3. Tissue of SES kids had higher (P<0.05) crude protein content compared to that of kids consuming the SOY or SUN diets. Fat and cholesterol contents were not affected by type of supplemental oil.

Table 3

Chemical composition of muscles of Black kids fed different oil supplemented diets

	Treatment 1			
	SES	SUN	SOY	SEM
n	9	9	9	
Fat, %	29.37	30.18	30.40	2.447
Protein, %	19.94[a]	18.97[b]	19.11[b]	0.082
Cholesterol, mg/dl	162.0	159.0	154.0	15.34

1 SES, SUN, and SOY refer to dietary treatments containing sesame oil, sunflower oil, and soybean oil, respectively.

a,bMeans within rows with different superscript differ significantly (P<0.05).

Table 4

Intramuscular fatty acid composition (% of identified fatty acids).

	Treatment1			
	SES	SUN	SOY	SEM
C14:0	3.53	2.68	2.41	0.370
C16:0	22.61[a]	18.79[b]	19.01[b]	0.850
C16:1	3.17	2.61	2.38	0.221
C18:0	9.90	9.96	12.54	1.166
C18:1 *cis*-9	8.62	6.98	5.65	0.811
C18:1 *trans*-11	34.88	36.87	41.16	2.438
C18:1 *cis*-11	0.31[b]	0.48[a]	0.49[a]	0.045
C18:2 *cis*-9 *trans*-11	0.41	0.50	0.51	0.032
C18:2 *cis*-9 *cis*-12	3.48	3.89	3.76	0.410
C18:3	0.77[a]	0.41[b]	0.76[a]	0.055
C20:0	0.14	0.13	0.06	0.026
SFAw	38.74	34.97	38.17	2.060
MUFAx	46.78	46.94	49.68	3.066
PUFAy	5.07	5.41	5.55	0.426
Total CLAz	0.41	0.50	0.51	0.032
SFA/ MUFA+PUFA	0.70	0.60	0.64	0.058
C18:2/ C18:3	10.11	7.22	8.39	1.377
Atherogenicity indexzz	0.70[a]	0.56[b]	0.52[b]	0.042

1 SES, SUN, and SOY refer to dietary treatments containing sesame oil, sunflower oil, and soybean oil, respectively.

a,bMeans within rows with different superscript differ significantly (P < 0.05).

wSFA = C14:0 + C16:0 + C18:0 + C20:0

xMUFA = C16:1 + C18:1

yPUFA = C18:2 *cis*-9, *cis*-12 + C18:2 *cis*-9, *trans*-11 + C18:2 *trans*-10, *cis*-12 C20:4 n-6 + C20:5 n-3 + C22:5 n-3 + C22:6 n-3.

z Total CLA = C18:2 *cis*-9, *trans*-11 + C18:2 *trans*-10, *cis*-12.

zz Ulbricht and Southgate (1991).

Intramuscular fatty acid composition is presented in Table 4. The most abundant fatty acids being oleic acid (C18:1 *trans*-11) followed by palmitic (C16:0), stearic (C18:0) then C18:1 *cis*-9. The addition of SES to the concentrate had no effect on C14:0 and C18:0, but significantly increased (P<0.05)

C16:0 compared to diets supplemented with SUN and SOY. The SES supplemented diets resulted in lower ($P<0.05$) C18:1 *cis*-11. However, both SES and SOY oils increased ($P<0.05$) the C18:3 all *cis* proportion. Linolenic acid (C18:3) proportion lowered ($P<0.05$) when SUN was included in the diets, which led to a lower C18:2/C18:3 ratio. All types of oils supplemented had similar effect on C18:2 *trans*-9,12 and C18:2 *cis*-9.

Addition of SES to the diet increased C16:0 ($P<0.05$). C18:1 *trans*-11 and C:18 *cis*-9 proportions were statistically similar among treatments, however, C18:1 *cis*-11 was lower ($P<0.05$) in SES kids when compared to either SUN or SOY animals. Saturated (SFA), monounsaturated (MUFA) and long-chain polyunsaturated (PUFA) fatty acids. The atherogenicity index was significantly affected by oil supplementation. Kids fed the SES supplemented diets had higher ($P<0.05$) atherogenicity index compared to that of kids fed SUN or SOY supplemented diets (Table 4).

4. Discussion

Type of supplemental oil had no effect on the intramuscular fat chemical composition. Kids fed diets supplemented with SES, SUN or SOY at levels of 30 g/kg DM had similar total gain, however, SES kids had heavier kidney and lower mesenteric fats[3,19]. Values of fatty acids agree with those reported by previous research[20]. However, disagree with other research[21-22]. Results of this study showed that the most abundant fatty acid being oleic acid (C18:1 *trans*-11) followed by palmitic acid (C16:0), stearic acid (C18:0) then C18: *cis*-9. Addition of SES to the concentrate had no effect on C14:0 and C18:0, but significantly increased C16:0 compared to diets supplemented with SUN or SOY. The SES supplemented diets resulted in lower C18:1 *cis*-11. Manso *et al*.[2]showed a decrease in C16:0, C18:1 *cis*-11 and C18:3, and an increase in C18:1 *trans* when sunflower oil was fed to lambs. Results of this study were in partial agreement with those of Manso e al[2]and Ponnama[23], Zervas and Tsiplakou[24]and Aferri *et al*[13]where SUN reduced C18:1, while it had opposite effect on C18:3. Feeding linseed oil to lambs during the post-weaning period significantly increased the proportions of n-3 PUFA in tissues[25].

The high concentrate diet used in this experiment tended to reduce the number of cellulolytic bacteria in the rumen[26]. This high concentrate diet favours lipids which pass the rumen without being reduced, especially OA and LA[27], and other alternative biohydrogenation pathways occur with the appearance of some *trans* fatty acids[28].

All types of oils supplemented had similar effect on C18:2 fatty acids. In contrast, in a trial with cattle, SOY increased the CLA *trans*-10, *cis*-12 but had no effects on CLA *cis*-9, *trans*-11[29]. Unsaturated fatty acids such as 18:2n-6 undergo extensive biohydrogenation in the rumen and involves the formation of 18:2 *cis*-9, *trans*-11 and 18:1 *trans*-11 as major intermediates with 18:0 being the final product[5]. Oil seeds such as soybean, sunflower and others mainly contain C18 PUFA and MUFA which are hydrogenated in the rumen and induce synthesis of conjugated and *trans* isomers[27].

These contradictions among results may support the idea that supplementation of high concentrate finishing diets, as that used in this study, with sources of linoleic acid is not an efficacious method for increasing the proportion of linoleic acid[2,30].

In this study both SES and SOY increased the C18:3 content. It was expected that supplementation of oils of similar C18:3 content would cause similar effects on C18:3 concentration, which was reduced by SUN supplementation. The lower concentration of C18:3 in SUN could be explained by the weak biohydrogenation process[2]. Bessa *et al*.[31] reported an increase in C18:3 proportions. This fact can be explained that it could be related to the biohydrogenation process within the rumen which may be enhanced when animals receive a high unsaturated lipid supplements[32,2,5]. Use of finishing diets supplemented with fats high in linoleic or oleic fatty acids (e.g. SUN and SES oil) can improve the concentration of CLAs and its positive impact on human health[33]. Supplementation of such oils is important in increasing the PUFA concentration in animal tissues[34].

The high level of linoleic acid in SUN altered the fatty acid synthesis and activation of some lipogenic enzymes were inhibited after SUN supplementation. The *cis*-9 *trans*-11 isomer is the most abundant CLA, *trans*-10, *cis*-12 CLA is capable of lowering body fat. Kids used in this study when fed the SES supplemented diets had a better feed conversion ratio than kids fed the SUN or SOY diets[3]. However, kids fed the SES supplemented diet had less mesenteric fat and lower total gastrointestinal tract weights compared to kids fed the SUN or SOY supplemented diets[3]. Shingfield *et al*.[35] reported that increasing ruminal outflow of 18:1*trans*-11 from sunflower seed oil was 10-times higher compared with 18:2 *cis*-9 *trans*-11, which suggests that, the metabolism of 18:2 *cis*-9, *trans*-11 to 18:1 *trans*-11 occurs at a faster rate than the conversion of 18:1 *trans*-11 to 18:0.

Fats of SES supplemented kids had high atherogenicity index value which is assumed to be more detrimental to the human health[36]. The depression in atherogenicity index value associated with SUN is in agreement with previous research[2,37].

Conflict of interest statement

We declare that we have no conflict of interest.

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