飼糧添加大豆油對努比亞閹公羊生長性能及屠體性狀之影響（1）

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摘要

本試驗旨在探討飼糧添加大豆油對肉羊生長、屠體、血液性狀及羊肉共軛亞麻油酸（conjugated linoleic acids, CLA）含量之影響。試驗選用 18 頭 10 月齡努比亞閹山羊（體重約 35 kg），逢機分配至 0%、2.5%及 5%大豆油三個飼糧處理組，試驗期為 5 個月。試驗期間每日紀錄採食量，每兩週採血測定血液性狀及增重。肥育結束每組逢機選取 5 頭羊屠宰測定屠體性狀。試驗結果顯示，飼糧處理對生長及屠體性狀無顯著影響。在血液方面，三酸甘油酯與膽固醇濃度以添加 5.0%大油組顯著較對照組為高（P＜0.05）。羊肉中的 CLA 濃度於各組間並無顯著差異，但添加大豆油組之羊背脂中的 CLA 濃度顯著（P＜0.05）較對照組為高，且飼糧添加大豆油也使羊肉之脂肪酸組成含有較高的多元不飽和脂肪酸，有益人體健康。本試驗結果顯示，飼糧添加大豆油雖無法改善生長及屠體性狀，但可以增加羊皮下脂肪 CLA 含量，可以做為生產品牌化產品的方法。

關鍵語：屠體性狀、共軛亞麻油酸、努比亞山羊、大豆油。

緒言

國人對羊肉之需求頗高，尤其在冬季。羊肉價格提高而目前國民所得提高，消費型態越趨精緻化，因此對食肉品質的要求逐漸高於量的要求。共軛亞麻油酸（conjugated linoleic acid, CLA）為一群具有共軛雙烯基（conjugated dienoic）、十八碳之多元不飽和脂肪酸，是亞麻油酸之幾何（geometric）與位置（positional）異構物。反芻動物乳、肉製品是我們飲食中 CLA 之主要來源，CLA 的攝取和健康息息相關，因此如何增加肉品中 CLA 的含量已成為動物營養研究的主要目標。

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Bauman *et al.*（1999）發現反芻動物食物中 CLA 主要來源是亞麻油酸在瘤胃生物氫化過程中產生之 CLA。另一種來源是動物組織利用 *trans-11C18:1* 合成 CLA，而 *trans-11 C18:1* 是不飽和脂肪酸在生物氫化過程中之另一個中間產物。因此來自反芻動物食物產品中之 CLA 與不完全之生物氫化作用有密切的關係。

研究指出 CLA 可降低癌症發生的風險（Parodi, 1994），降低動脈硬化（Lee *et al.,* 1994）及抗肥胖（Pariza *et al.,* 1996）的作用。同時也發現對免疫功能和人體都有正面的影響（Miller *et al.,* 1994），且有降低體脂肪達到減肥的功效。由於 CLA 具有潛在的健康價值，因此過去的研究主要著重在提高乳中 CLA 含量(Dhiman *et al.,* 2000; Bu *et al.,* 2007; Bernard *et al.,* 2009; Gómez-Cortés *et al.,* 2011），鮮少著重在於肉質上面。本試驗預期於羊隻日糧中餵食大豆油可間接的將亞麻油酸轉變成 CLA，因此，本試驗探討大豆油添加於努比亞閹山羊日糧中對羊隻生長性能與屠體組成之影響，並了解添加大豆油後血液中三酸甘油酯及膽固醇含量之變化，期望能夠生產高品質且具機能性健康羊肉，提高畜產品附加價值。

材料與方法

本研究涉及之動物試驗於屏東科技大學執行，動物之使用、飼養及實驗內容係依據屏東科技大學實驗動物管理委員會批准之試驗準則進行。

Ⅰ. 試驗設計與飼糧配製

試驗使用 18 頭努比亞（Nubian）閹山羊，年齡在 9~12 個月之間，以圈飼進行肥育，逢機將閹山羊分成三組，每組 6 頭，分別添加不同量之大豆油進行試驗，每組羊的初始平均體重約為 35 kg。試驗日糧依 NRC（1981）所推薦山羊營養需要量並滿足其維生素與礦物質需求，飼糧為等蛋白不等能量，調配成三種不同處理組之完全混合日糧（total mixed ration, TMR），分別為 0%大豆油（對照組）、2.5%大豆油（soybean oil）及 5.0%大豆油。各組之 TMR 配方組成列於表 1。TMR 於每日 9：00 及於 15：00 餵飼，每二週採血及測定體重一次，試驗期 150 天，結束後每組逢機屠宰 5 頭，於台東縣肉品市場之屠宰場依屠宰程序進行屠宰。

Ⅱ. 生長與屠體分析

（ⅰ）生長性能：試驗期間每兩週秤重一次，並記錄每日攝食量。分別計算平均日增重、平均採食量及飼料轉換率。

（ⅱ）屠體性狀測定

1.屠宰體重：肥育羊隻屠宰前禁食 16~24 小時，僅提供飲水，於屠宰前所測得之重量。

2.屠體長：屠宰吊掛後，以皮卡尺測量第一頸椎至恥骨末端之距離即為屠體長。

3.屠體重：羊隻經屠宰流程（放血、脫毛、去頭部及內臟）後，並蓋上防檢標章，所秤取之體重，稱為空屠體重。

4.屠宰率：屠體重除於屠宰體重即為屠宰率。

Ⅲ. 血液採集與分析

血液採集以每兩週早上餵飼前採血一次，採取後靜置 2~3 小時待血液凝固後，且經離心機 1700 × g 離心 15 分鐘，所得血清儲存於-20℃，測定三酸甘油酯及總膽固醇濃度。三酸甘油酯與總膽固醇之測定是以 Human（Germany）生化公司出品之測試套組測定。

表1. 試驗飼糧組成

Table 1. Composition of experimental diets (dry matter,%)

Ingredients	Control	2.5% soybean oil	5.0% soybean oil
Bermudagrass hay	30.0	30.0	30.0
Corn	55.7	52.8	49.8
Soybean meal	13.1	13.5	14.0
Soybean oil	0	2.5	5.0
Dicalcium phosphate	0.4	0.4	0.4
Limestone, pulverized	0.4	0.4	0.4
Salt	0.2	0.2	0.2
Premix*	0.2	0.2	0.2
Total	100.0	100.0	100.0
Calculated values			
TDN	75.7	77.4	78.9
CP	13.8	13.8	13.8
ADF	16.5	16.5	16.5
NDF	29.3	29.0	28.7
NSC	48.4	46.4	44.4
TEE	3.4	5.8	8.2
Calcium	0.47	0.46	0.46
Phosphorus	0.42	0.41	0.40

TDN: total digestible nutrient; CP: crude protein; ADF: acid detergent fiber; NDF: neutral detergent fiber; NSC: non-structrual carbohydrate; TEE: total ether extract; Ca: calcium; P: phosphorus

* Provided per kilogram of diet: Vitamin A, 6,000 IU; Riboflavin, 4 mg; Pyridoxine, 1 mg; Vitamin B12, 0.02 mg; Vitamin D3, 800 IU; Vitamin E, 20 IU; Vitamin K3, 4 mg; Biotin, 0.1 mg; Folic acid, 0.5 mg; Niacin, 30 mg; Pantothenic acid, 16 mg; Fe, 140 mg; Cu, 7 mg; Mn, 20 mg; I, 0.45 mg.

Ⅳ. 羊肉與羊背脂脂肪酸測定

羊肉測定為後腿肉、腹脇肉及背最長肌三個部位採樣混合後之樣品，而羊背脂以第 1 肋骨、最後肋骨及最後腰椎三點背脂採樣混合後分析脂肪酸含量。

共軛亞麻油酸與脂肪酸含量則是依 Folch *et al*.（1957）之方法修改後萃取粗脂肪並經甲基化後，以氣相層析儀（Hitachi gas chromatography, Model 263-50, Hitachi, Ltd, Tokyo, Japan）分析，條件為注入口溫度 240℃、檢出器溫度 240℃、管柱（SP-2330 packed column, Supelco, Bellefonte, PA）初溫為 170℃，終溫為 200℃，升溫速度 2℃/min。

Ⅴ. 統計分析

試驗所得資料以統計分析系統（SAS, 2002）之一般線性模式（general linear models procedure,

GLM）進行變方分析。再以鄧肯氏新多變域測定法（Duncan's new multiple range test）比較處理組平均值之差異顯著性。

結果與討論

餵飼不同濃度大豆油對閹公羊生長性狀列示於表 3。依處理組別分群飼養，每日定時定量餵予 0%、2.5%、5%大豆油之三組羊群，其全期平均日增重分別為 105.2、87.3、98.2（g/day），每日平均採食量分別為 1233、1105 及 1135 g/day，以及飼料轉換率分別為 0.085 ± 0.02、0.079 ± 0.05、0.087 ± 0.10（gain/feed）。三組羊隻之平均日增重、每日平均採食量及飼料轉換率均無顯著差異。Dhiman *et al.*（2000）於飼糧中添加不同來源之油脂，結果發現含 3.6% 大豆油處理組或含 4.4% 亞麻籽油（linseed oil）之飼糧對於牛隻採食量仍無負面之影響與本試驗結果相似。然而 Mohamed *et al.* (1988) 之研究指出含 4.0%油脂飼糧對於採食量有負面之影響，可能原因為未保護油脂（free oil）會降低瘤胃內乾物質之消化率，使牛隻乾物質採食量下降。飼糧中添加過量不飽和脂肪酸之油脂，則會降低纖維及有機物之消化率，甚至降低微生物蛋白質之合成 （Jenkins, 1993）。添加脂肪對微生物之影響有：(1)脂肪覆蓋在飼料微粒上，延緩微生物和酵素的分解作用，因而降低消化率；(2)長鏈脂肪酸與微生物細胞膜結合，改變細胞膜的功用，使微生物喪失活力；(3)高量不飽和脂肪酸對某些微生物有毒害作用；(4)脂肪酸與瘤胃中陽離子形成化合物，使微生物不易獲得陽離子而影響微生物生長（Jenkin, 1993）。本試驗於羊隻飼糧中添加 2.5%、5%大豆油，過量之油脂可能對瘤胃內乾物質消化率有負面之影響，造成平均日增重及飼料轉換率略低於對照組之結果。

表 2. 試驗所用大豆油之脂肪酸組成

Table 2. Fatty acid composition of the soybean oil used in the experiment

Fatty acid	%
C14:0	0.1
C16:0	11.5
C16:1	0.2
C18:0	3.9
C18:1	23.0
C18:2	52.9
C18:3	6.8
Others	1.52

比較飼糧中添加不同濃度大豆油（0%、2.5%、5%）之羊隻屠體性狀，如表 4 所示。屠體體重、屠宰率、精肉率、骨骼及內臟比例等並未受試驗處理之影響。但是 Santos-Silva *et al.*（2004）在羊飼糧中添加 8%大豆油發現，雖添加大豆油未提高屠體重，但可顯著提高屠宰率。Awawdeh *et al.*（2010）於每公斤羊飼糧中額外添加 32 g 大豆油發現，可顯著提高羊隻屠重，但是有減少屠宰率之趨勢。由以上研究結果發現，添加大豆油造成不同屠體性狀的結果可能是受到品種、飼糧組成、環境溫度、餵飼方式及生長速度等因素影響。

表 3. 飼糧添加大豆油對閹山羊生長性狀之影響

Table 3. Effect of dietary soybean oil supplementation on growth performance of castrated goats

Items	Control	2.5% soybean oil	5.0% soybean oil
ADG*(g/day)	105.2 ± 33.1	87.3 ± 21.4	98.2 ± 30.7
ADFI (g/day)	1233 ± 98.0	1105 ± 65.0	1135 ± 101
FCR (gain/feed)	0.085 ± 0.02	0.079 ± 0.05	0.087 ± 0.10
Days on test (days)	150	150	150

*ADG: average daily gain; ADFI: average duily feed intake; FCR: feed conversion rate.

表 4. 飼糧添加大豆油對閹山羊屠體性狀之影響

Table 4. Effect of dietary soybean oil supplementation on carcass characteristics of castrated goats

Items	Control	2.5% soybean oil	5.0% soybean oil
Carcass length (cm)	81.3 ± 2.7	80.1 ± 0.9	80.5 ± 2.7
Carcass weight (kg)	56.5 ± 3.9	54.0 ± 2.3	56.3 ± 4.3
Dressing percentage (%)	53.1 ± 2.2	54.7 ± 1.7	50.9 ± 2.1
Meat percentage (%)	41.2 ± 2.0	42.8 ± 1.9	39.7 ± 1.7
Bone percentage (%)	11.9 ± 1.1	11.8 ± 0.8	11.1 ± 0.7
Organ percentage (%)	9.6 ± 0.6	9.8 ± 1.1	9.5 ± 0.3

餵飼不同濃度大豆油對閹山羊血液性狀之影響，列於表 5。發現血液中三酸甘油酯及膽固醇含量以添加 5%大豆油顯著高於對照組（$P<0.05$）。此結果與 Fébel *et al.*（2002）結果相同，飼糧添加大豆油，會增加血液中膽固醇及三酸甘油酯的濃度。

表 5. 飼糧添加大豆油對閹山羊血脂與膽固醇之影響

Table 5. Effect of dietary soybean oil supplementation on blood lipids and cholesterol composition of castrated goats

Items	Control	2.5% soybean oil	5.0% soybean oil
Triglyceride (mg/dL)	20.5 ± 2.55^{b}	25.6 ± 3.28^{ab}	31.6 ± 7.78^{a}
Cholesterol (mg/dL)	68.7 ± 11.3^{b}	79.2 ± 13.7^{ab}	94.0 ± 28.0^{a}

[ab]Means in the some row with different letters differ significantly ($P < 0.05$).

餵飼不同濃度大豆油對羊肉與羊背脂的脂肪酸組成之影響如表 6 和表 7。共軛亞麻油酸異構物以 *cis-9, trans-11* 和 *trans-10, cis-12* 為主，*trans-10, cis-12* 之異構物在肉中與脂肪酸組織中含量較少（Pariza *et al.*, 2001）。各組羊肉之脂肪酸組成均以油酸（C18:1）含量為最高，在羊肉中約佔 37~41%（fatty acid methyl esters）；而在背脂中佔 39~41%，其次為棕櫚酸（C16:0），在羊肉中約佔 15~19%；在背脂中佔 22~26%。在羊肉中亞麻油酸（C18:2）佔 11~13%；在背脂中佔 3~4%。硬脂酸（C18:0）在羊肉中 9~11%；背脂中佔 19~22%。Santos-Sliva *et al.* (2004)在羊飼糧中添加大豆油，及 Bessa *et al.* (2005)餵食紫苜蓿、精料與 Knott *et al.* (2003) 於飼糧中添加紅花油籽，

經過一個月的肥育後，其羊肉中含有脂肪酸比例與本試驗羊肉之脂肪酸比例相似。CLA (*cis-9,trans-11*)在羊肉中佔 0.87~0.91％；在背脂中佔 1.00~1.41％。Bolte *et al.* (2002)發現，在羊飼糧中添加含 78％亞麻油酸之紅花油籽與含 76％之紅花油籽，經肥育 5 個月後發現，背脂中所含 CLA 量比背最長肌含量高與本試驗之結果相似。

表 6. 飼糧添加大豆油對閹山羊羊肉之脂肪酸組成

Table 6. Effect of dietary soybean oil supplementation on fatty acid composition (% fatty acid methyl esters) of raw lamb loin chops of castrated goats

Fatty acid	Control	2.5% soybean oil	5.0% soybean oil
C14:0	1.57 ± 0.22[a]	1.20 ± 0.28[b]	1.48 ± 0.07[a]
C15:0	4.45 ± 0.62[a]	4.38 ± 0.27[a]	3.25 ± 0.27[b]
C16:0	18.0 ± 0.76[b]	15.47 ± 0.82[c]	19.18 ± 0.72[a]
C16:1	2.39 ± 0.10[a]	1.90 ± 0.13[b]	2.29 ± 0.29[a]
C17:0	1.01 ± 0.04[a]	0.66 ± 0.17[b]	0.68 ± 0.05[b]
C18:0	9.47 ± 0.68[b]	11.17 ± 0.57[a]	9.05 ± 0.88[b]
C18:1(trans-11)	0.61 ± 0.11[a]	0.38 ± 0.06[b]	0.25 ± 0.05[c]
C18:1	41.15 ± 0.98[a]	37.16 ± 0.96[c]	39.9 ± 0.69[b]
C18:2	11.17 ± 0.59[b]	13.19 ± 0.90[a]	12.62 ± 0.91[c]
C18:3	0.43 ± 0.02[a]	0.46 ± 0.07[a]	0.30 ± 0.03[b]
CLA(C18:2,cis-9,trans-11)	0.87 ± 0.13	0.90 ± 0.18	0.91 ± 0.08
C22:0	0.49 ± 0.13[a]	0.45 ± 0.08[a]	0.28 ± 0.06[b]
C20:3n6	0.47 ± 0.16	0.42 ± 0.03	0.44 ± 0.11
C20:4n6	6.56 ± 1.08[b]	8.65 ± 0.44[a]	6.95 ± 0.75[b]
C20:5n3	0.54 ± 0.10[a]	0.47 ± 0.26[a]	0.25 ± 0.03[b]
C22:4n6	0.64 ± 0.11[b]	0.73 ± 0.13[b]	1.00 ± 0.15[a]
C22:6n3	0.68 ± 0.10[b]	3.48 ± 0.62[a]	2.90 ± 0.69[a]
Total SFA*	35.06 ± 0.41	33.34 ± 0.36	33.95 ± 0.34
Total MUFA	44.17 ± 0.54[a]	39.45 ± 0.54[b]	42.46 ± 0.49[a]
Total PUFA	20.63 ± 0.30[c]	27.22 ± 0.35[a]	24.52 ± 0.38[b]

*SFA, saturated fatty acids; MUFA, monounsaturated fatty acids (CLA excluded); PUFA, polyunsaturated fatty acids.

[abc]Means in the same row different letters differ significantly ($P < 0.05$).

反芻動物飼糧中食物改變會影響 CLA 在小腸的吸收與利用，但 Griinari *et al.*(1997)指出反芻動物脂肪中部分之共軛亞麻油酸是由內源性所產生的，內源性 cis-9, trans-11 CLA 是 trans-11 C18:1 經由Δ 9-去飽和酶(desaturase)之去飽和作用所形成的。雖飼糧中添加大豆油並未提高羊肉中 CLA 濃度，但可提高羊肉中多不飽和脂肪酸濃度（$P<0.05$）（表 6）。而飼糧中添加大豆油可提高羊背脂 CLA 及多不飽和脂肪酸濃度（表 7）。Beaulieu *et al.* (2002) 在牛飼糧中添加 5.0％大豆油經

肥育 28 天，結果顯出大豆油並不會顯著影響 CLA 在組織的沉積。Radunz *et al.*（2009）於 Hampshine 與 Dorset 雜交闉山羊飼糧中添加富含多不飽和脂肪酸（大豆油與亞麻仁油，比例為 2:1），發現添加富含多不飽和脂肪酸飼糧並未提高羊肉 CLA 濃度，但可提高羊背脂 CLA 濃度。Knott *et al.* (2003)和 Bolte *et al.*(2002)指出羊餵食 0%及 6%紅花油籽或餵食含量高濃度油酸鹽 (含 76%的 C18：1) 之紅花油籽及高濃度亞麻油酸(含 78%的 C18：2)之紅花油籽分別肥育 48 天與 4 個月，結果發現添加 6%紅花油籽與含油酸鹽或亞麻油酸之紅花油籽會增加羊肉之多元不飽和脂肪酸，同時會減少總單元不飽和脂肪酸於肉中的堆積。上述之研究結果與本試驗結果相似，即飼糧中添加大豆油會增加羊肉之多元不飽和脂肪酸的堆積，同時降低單元不飽和脂肪酸之濃度。在羊背脂方面，飼糧中添加大豆油會降低羊背脂飽和脂肪酸之含量，主要是因為棕櫚酸(C16:0)會因大豆油的添加而顯著的降低，故推測以適當的多元不飽和脂肪酸餵飼動物更能有效抑制棕櫚酸（C16:0）。Lough *et al.*（1991）於闉山羊飼糧中添加油菜籽（canola seeds），經肥育後亦會降低背脂中飽和脂肪酸濃度，尤其棕櫚酸(C16:0)合成含量顯著降低。

表 7. 飼糧添加大豆油對闉山羊羊背脂之脂肪酸組成

Table 7. Effect of dietary soybean oil supplementation on fatty acid composition (% fatty acid methyl esters) of raw lamb subcutaneous fat of castrated goats

Fatty acid	Control	2.5% soybean oil	5.0% soybean oil
C14:0	2.92 ± 0.20[b*]	2.20 ± 0.29[b]	3.40 ± 0.37[a]
C15:0	1.03 ± 0.23[ab]	0.80 ± 0.11[a]	1.09 ± 0.21[a]
C16:0	26.14 ± 0.98[a]	21.96 ± 1.36[c]	23.72 ± 1.40[b]
C16:1	1.33 ± 0.33[b]	2.16 ± 0.29[b]	2.27 ± 0.26a
C17:0	1.89 ± 0.19[a]	1.44 ± 0.29[b]	1.75 ± 0.33[ab]
C18:0	19.10 ± 1.96[b]	21.86 ± 0.61[a]	19.28 ± 1.69[b]
C18:1(trans-11)	0.52 ± 0.11[b]	0.56 ± 0.08[b]	0.88 ± 0.11[c]
C18:1	39.01 ± 1.17[b]	40.73 ± 1.34[c]	40.61 ± 0.97[a]
C18:2	3.16 ± 0.11[b]	3.90 ± 0.32[a]	4.06 ± 0.38[a]
C18:3	0.46 ± 0.11[b]	0.62 ± 0.14[a]	0.56 ± 0.11[ab]
CLA(C18:2,cis-9,trans-11)	1.01 ± 0.11[b]	1.28 ± 0.36[a]	1.41 ± 0.11a
C22:0	ND	ND	ND
C20:3n6	0.77 ± 0.12	0.64 ± 0.11	0.81 ± 0.11
C20:4n6	ND	ND	ND
C20:5n3	ND	ND	ND
C22:4n6	ND	ND	ND
C22:6n3	ND	ND	ND
Total SFA*	51.11 ± 0.71[a]	48.29 ± 0.53[c]	49.28 ± 0.80[b]
Total MUFA	40.88 ± 0.54[c]	43.46 ± 0.57[b]	43.78 ± 0.44[a]
Total PUFA	4.39 ± 0.11[c]	5.16 ± 0.19[a]	5.43 ± 0.19[a]

*SFA, saturated fatty acids; MUFA, monounsaturated fatty acids (CLA excluded)；PUFA, polyunsaturated fatty acids.

[abc]Means with in the some row the different letters differ significantly ($P < 0.05$).

結論

飼糧中添加大豆油並無法提高生長性能及改善屠體性狀，但會顯著提高血液中三酸甘油酯及膽固醇濃度。雖然添加大豆油可增加羊背脂 CLA 的濃度，但顯著減少羊背脂中總飽和脂肪酸含量，且顯著提高總單元不飽和脂肪酸及總多元不飽和脂肪酸的濃度。

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Effects of dietary soybean oil supplementation on growth performance and body fatty acid composition of castrated Nubian goats[1]

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Absatract

A total of eighteen castrated Nubian goats (initial body weight; BW = 35 kg) were individually housed to study the effects of dietary supplementation of soybean oil on the growth, carcass, blood characteristics, and conjugated linoleic acids (CLA) concentrations in muscle and subcutaneous fat. Goats were randomly assigned to one of three dietary treatments: without added soybean oil (control), 2.5% soybean oil, or 5.0% soybean oil. When the experiment was finished, 5 goats from each group were randomly selected for slaughtering and determining their carcass characteristics. Results of the study showed that the dietary supplementation of soybean oil did not significantly affect the growth and carcass characteristics. The concentrations of triglyceride and cholesterol in blood of goats fed with 5% soybean oil supplementation were significantly ($P<0.05$) higher than those of the control group. There was no difference in muscle CLA concentrations of goats meat among treatments. However, the concentration of CLA in the subcutaneous fat of goats fed soybean oil was significantly higher ($P < 0.05$) than that of the control. In addition, higher concentration of polyunsaturated fatty acids was found in the fatty acid composition of the goats fed with the soybean oil supplement. In conclusion, the dietary soybean oil supplementation did not improve the growth and carcass characteristics of the goats. Nevertheless, it significantly increased the CLA concentration in goat subcutaneous fat.

Key Words: Carcass traits, Conjugated linoleic acids, Nubian goat, Soybean oil

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