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# Effects of Soybean Oil or Probiotics on Meat n-6:n-3 Fatty Acid Ratio in Growing Goats

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**Abstract.** The objectives of this experiment was to study the effect of additional soybean oil together with probiotics on meat fatty acid profiles in growing goats fed with whole plant corn silage. The thirty growing crossbred (Thai native x Anglo-Nubian) goats were used to conduct experiment. They were allocated to 5 treatments according to factorial in Randomized Block Design with 6 goats in each treatment. The results showed that meat C18:c9, t11 and C18:t10,c12 conjugated linoleic acid (CLA) increased with highly significance ($P<0.01$). There were significant synergistic impact between soybean oil and probiotics on increase of CLA isomers. The ratios of PUFA/SFA and n−6/n−3 increased (PUFA/SFA: $P>0.05$; n−6/n−3: $P<0.05$). The C14:0 ($P<0.05$), C15:0 ($P<0.05$), C16:0 ($P>0.05$), C16:1 ($P>0.05$) and C17:1 ($P<0.05$) fatty acid composition decreased. All C18 fatty acids of the meat increased, particularly the C18:c9,t11 CLA increased 100 to 139.6% ($P<0.01$), the C18:t10,c12 CLA increased 100 to 300%($P<0.01$). There were significant synergistic effect of soybean oil and probiotics on CLA isomers was found ($P<0.05$). The total CLA isomers ($P<0.01$), total n-6 ($P<0.05$), and total poly-unsaturated fatty acids ($P<0.05$) significantly increased; total saturated (TSFA), total n-3, total mono-unsaturated, and desirable fatty acids tended to increased ($P>0.05$). Supplementation of 5.0% soybean oil significantly increased the ratios of poly-unsaturated fatty acids to total saturated fatty acids ($P<0.05$), whereas, significantly decreased the ratios of total n-6 fatty acids to n-3 fatty acids ($P<0.05$). A remarkable interaction between soybean oil and probiotics existed in total CLA isomers ($P=0.04$), total n-6 fatty acids (=0.03), total saturated fatty acids ($P=0.09$), and total n-3 fatty acids.

**Keywords:** soybean oil, n-6:n-3 ratio, fatty acid, conjugated linoleic acid, goat

## 1. Introduction

Recently, as the food safety and origin become the concern of the public, the chevon was preferred to many people due to it was looked as natural and low in fat and cholesterol. Furthermore, there is an interest in value-added goat meat that enriched with CLA, which could offer potential benefits in terms of human health, since CLA have been reported for wide range of beneficial effects such as anticarcinogenic, antiatherogenic, antidiabetic and immune stimulatory. In fact, biosynthesis of CLA happen in 2 ways [1] the first is the partial biohydrogenation of linoleic acid and linolenic acid in the rumen, and the second is the desaturation of trans-11 C18:1 (TVA; trans-vaccenic acid) by the action of Δ9-desaturase in gland and tissue [2]. Soybean oil contains about 52% linoleic acid [3], and sunflower oil contains 63%-70% linoleic acid normally [4]. This study selected levels of probiotics (2.5 and 5.0 g/h/d) and soybean oil (2.5 and 5.0% concentrate basis) were used in the present study to testify their synergistic effects on growth, ruminal metabolism, and plasma fatty acid profiles particularly CLA, on carcass quality, meat quality, meat fatty acid profiles particularly CLA in growing goats fed with corn silage.

## 2. Materials and Methods

### 2.1. Experimental Design and Treatments

The thirty growing crossbred (Thai native x Anglo-Nubian) goats that used to perform the second experiment were prepared for the present study. After the second experiment was finished, the animals was fed the concentrate 100 g/d/h and accessed to the whole plant corn silage *ad libitum* for 5 weeks to scavenge the possible difference that caused by the experiment. Subsequently, the animals were weighed and allocated to the present experiment. The weights of animals were (18.29 ± 2.7) kg, ages were about 9 months. They were allocated to 5 treatments according to factorial in Randomized Complete Block Design (RCBD) with 6 goats in each treatment. The blocks were mad by weight into heavy, medium, and light goats and each of the treatments contained 2 goats from each of the blocks (Table 5.1). Before the experiment, the animals were injected with Ivomic (Merial Ltd., Iselin, NJ) for anti-internal parasite, and housed in individual pens (0.9x1.4 m) where the animals could have an easy access to corn silage and fresh water *ad libitum*. And also, the pens were cleaned and disinfected with Ciber solution prior to the housing of the animals. During the experiment, animals in different treatments received the whole plant corn silage plus concentrate basal diet. The treatments included control, supplementations of 2.5 and 5.0% concentrate basis of soybean oil together with 2.5 and 5.0 g/h/d probiotics. The additional soybean oil and probiotics were mixed evenly with concentrate prior to feeding, and offered to animals by half at 9:00 am and the other at 3:00 pm, respectively. The concentrate was supplied with 1.5% *pro rata* body weight for each goat to ensure that the dietary intakes of crude protein, growth net energy, and dry matter in accordance with the Nutrients Requirements of Goats No.15 under the condition of maintenance plus lower activity and 50 g/d weight gain. All animals accessed to the whole plant corn silage and clean water *ad libitum*, and were cared for as described by the Ethics Committee on Animal and Human Experimentation of the UAB (Reference No. CEEAH 04/481) for the aim of respecting animal welfare and environmental protection. The experiment lasted 8 weeks, excepting 2 weeks for adjustment, 1 week for adaptation, and 1 week post-experiment for urinary and fecal samples collection.

## 2.2. Experimental Materials

The soybean oil and probiotics employed in this study were prepared at the same time as that used in the first and second experiment and with the same batch number. The soybean oil was purchased from Macro supermarket (Muang district, Nakhon Ratchasima province of Thailand). The probiotics was purchased from L. P. Feeds Tech Co., Ltd (Bangkok, Thailand), containing *Lactobacillus acidophilus* 2.0 x $10^{12}$ cfu/g and *Saccharomyces cerevisia* 5.0x$10^{11}$ cfu/g. The whole plant corn silage was purchased from Kornburee Cooperatives (Kornburee district, Nakhon Ratchasima province of Thailand). The pelleted concentrate that was the same as the second experiment was supplied by farm of Suranaree University of Technology (Nakhon Ratchasima province of Thailand), and it was composed of cassava chip (12.0%), cassava pulp (31.5%), rice bran with germ (10.0%), defatted rice bran (10.0%), molasses (8.0%), palm kernel expeller meal (18.0%), rapeseed meal (4.0%), corn meal (4.0%), urea (1.8%), mineral (1.5%) (Containing Ca 14.5%, P 17%, NaCl 18%, Mg 10%, and carrier), and additional binder (0.2%).

## 2.3. Sampling

The carcass scores, hot carcass weights, Kidney, pelvic and heart (KPH) fat weights, empty free fat tissue alimentary tract and internal organ weights were obtained at the time of slaughter. The carcass were scored by three persons individually and recorded as the means. The criterions for evaluating the carcass were as described by [5]. After chilling at 5 °C for 24 h, the carcasses were split along the vertebrae and the left side was separated between the 12th and13th ribs and used for all measurements and analyses. In each carcass, the following measurements were taken: longissimus dorsal muscle area between the 12th and 13th rib; body wall thickness between the 12th and 13th rib and 5 cm from the midline of the carcass. The longissimus dorsal muscle area was traced adopting the method that described by [6], measured using a LI-COR portable area meter (LI-3000A). Then the *semimembranosus* muscle, *Triceps humeralis* muscle, and *longissimus* dorsal muscle samples were taken from hindquarter, forequarter, and loin (from 12th rib counted backwards to 8th rib) of the left side of the carcasses. All samples were placed in plastic bags that air was expelled, and were frozen at -20 °C.

## 2.4. Analysis of Fatty Acids

The *semitendinosis* muscle, *Triceps humeralis* muscle, and *longissimus muscle* samples come from each animal were made a pool respectively for fatty acid profiles and CLA analysis, and the analyzing was done by GC. The preparation of meat samples for GC analysis was done by using a modified method explained by [7].

## 3. Results and Discussion

The very long chain saturated fatty acids C20:0 and C22:0 decreased significantly due to supplementations of soybean oil and probiotics in contrast to the control ($P<0.05$). On the contrary, presences of soybean oil and probiotics increased the very long chain unsaturated fatty acids C20:2 ($P<0.05$) and C20:3n ($P>0.05$). There were obvious interactions between soybean and probiotics on C20:0 ($P=0.08$), C22:0 ($P=0.05$), C20:2 ($P=0.09$) and C20:3n ($P=0.07$).

To sum up, administration of soybean oil and probiotics in goat feed significantly increased total CLA isomers ($P<0.01$), total n-6 ($P<0.05$), and total poly-unsaturated fatty acids ($P<0.05$); tended to increased total saturated (TSFA), total n-3, total mono-unsaturated, and desirable fatty acids ($P>0.05$). Supplementation of 5.0% soybean oil plus probiotics significantly increased the ratios of poly-unsaturated fatty acids to total saturated fatty acids (PUFA/SFA) ($P<0.05$), whereas, significantly decreased the ratios of total n-6 fatty acids to n-3 fatty acids (n6/n3) ($P<0.05$). A remarkable interaction between soybean oil and probiotics existed in total CLA isomers ($P=0.04$), total n-6 fatty acids ($P=0.03$), total saturated fatty acids ($P=0.09$), and total n-3 fatty acids (Table 1).

As shown in Table 2, when calculating the centesimal composition of fatty acids into fatty acid contained in per gram meat lipid (mg/g lipid), the statistical analyses were similar to those in percentage on total detected fatty acids. Collectively, total CLA isomers was 2.34 mg/g lipid for the control, and ranged from 5.36-8.17 mg/g lipid for administration of soybean oil and probiotics in feed, 5.0% soybean oil plus probiotics treatments were significantly higher than the control ($P<0.01$) and 2.5% soybean oil plus probiotics ($P<0.05$). The desirable fatty acids was 566.6 mg/g lipid for the control, and ranged form 597.6 to 665.5 for administration of soybean oil and probiotics in feed, in the same case as total CLA, 5.0% soybean oil plus probiotics treatments were higher than the control ($P<0.05$) and 2.5% soybean oil plus probiotics ($P>0.05$). The ratio of PUFA/SFA was 0.15 for the control, and ranged from 0.18 to 0.20 for the soybean oil and probiotics treatments. The n6/n3 ratio of the control was 0.15, and ranged from 2.09 to 2.78 for the soybean oil and probiotics treatments.

Wendell et al. [8] detected the similar PUFA/SFA ratios range (0.09-0.15), but much higher n−6/n−3 ratios range (9-14) for goat meat. Webb et al. [9] summarized the PUFA/SFA ratios of goat meat ranged from 0.16 to 0.49, and n−6/n−3 ratio 3.09 to 5.5. The results of the present study were lower than their summary. The presence of a lower n-6/ n-3 ratio associated with decreased risk of coronary diseases [10, 11]. The Health Department of England [12] recommends 4.0 as the maximum ratio of n-6:n-3. The findings of the present study in accordance whit the recommendation of [12].

Supplementations of soybean oil and probiotics significantly decreased C20:0 and C22:0, significantly C20:3n. There were obvious interactions between soybean and probiotics on C20:0, C22:0, C20:2 and C20:3n. Administration of soybean oil and probiotics in goat feed significantly increased total CLA isomers, total n-6, and total poly-unsaturated fatty acids; tended to increased total saturated, total n-3, total mono-unsaturated, and desirable fatty acids. Supplementation of 5.0% soybean oil significantly increased the ratios of poly-unsaturated fatty acids to total saturated fatty acids, significantly decreased the ratios of total n-6 fatty acids to n-3 fatty acids. A remarkable interaction between soybean oil and probiotics existed in total CLA isomers, total n-6 fatty acids, total saturated fatty acids, and total n-3 fatty acids (mg/g lipid).

## 4. Acknowledgements

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Table 1: Meat fatty acids centesimal composition profiles of growing goats supplemented soybean oil and probiotics under condition of feeding whole plant corn silage.

| %TFA | Control | SB (%) | 2.5 | | 5.0 | | SEM | P value | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | P (g/d) | 2.5 | 5.0 | 2.5 | 5.0 | | SB | P | SBxP |
| TCLA | 0.51$^{c}$ | | 1.01$^{b}$ | 0.99$^{b}$ | 1.13$^{ab}$ | 1.23$^{a}$ | 0.19 | 0.001 | 0.01 | 0.04 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TSFA | 54.24 | 53.28 | 54.32 | 56.61 | 51.85 | 1.53 | 0.01 | 0.69 | 0.09 |
| Tn6 | 5.30$^{b}$ | 6.91$^{b}$ | 8.96$^{a}$ | 6.33$^{b}$ | 6.72$^{ab}$ | 0.32 | 0.03 | 0.12 | 0.03 |
| tn3 | 1.78$^{b}$ | 2.06$^{b}$ | 2.82$^{a}$ | 2.85$^{a}$ | 2.71$^{a}$ | 0.30 | 0.05 | 0.85 | 0.08 |
| TMUSFA | 32.07 | 34.39 | 33.29 | 35.68 | 36.01 | 2.04 | 0.84 | 0.65 | 0.21 |
| TPUSFA | 8.35$^{c}$ | 10.23$^{b}$ | 12.42$^{a}$ | 10.31$^{b}$ | 10.90$^{ab}$ | 0.72 | 0.16 | 0.32 | 0.26 |
| DFA | 63.34 | 68.44 | 69.42 | 68.45 | 69.44 | 2.73 | 0.27 | 0.04 | 0.17 |
| PUFA/SFA | 0.16$^{b}$ | 0.19$^{b}$ | 0.24$^{a}$ | 0.20$^{ab}$ | 0.22$^{a}$ | 0.02 | 0.59 | 0.20 | 0.58 |
| *n*−6/*n*−3 | 3.03$^{ab}$ | 3.37$^{a}$ | 3.14$^{a}$ | 2.25$^{c}$ | 2.37$^{c}$ | 0.27 | 0.20 | 0.71 | 0.34 |

SB=soybean oil; P=probiotics; TSFA=total saturated fatty acid;TMUSFA=total mono-unsaturated fatty acid; TPUSFA= total poly-unsaturated fatty acid; DFA=desirable fatty acid; Tn6=total n6 fatty acid; Tn3=total n3 fatty acid; SEM=standard error of the mean of the SB and P treatments (except for the control); P value is for the SB and P treatments(except for the control); Means with different superscript letters in the same row differ significantly (P<0.05).

Table 2: Fatty acid and conjugated linoleic acid contents (mg/g lipid) in chevon of growing goats supplemented soybean oil and probiotics under condition of feeding whole plant corn silage.

| **mg/g lipid** | **Control** | **SB (%)** | **2.5** | | **5.0** | | **SEM** | **P-value** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **P (g/d)** | **2.5** | **5.0** | **2.5** | **5.0** | | **SB** | **P** | **SBxP** |
| C12:0 | 1.4$^{c}$ | | 1.6$^{c}$ | 1.8$^{bc}$ | 2.5$^{a}$ | 2.4$^{ab}$ | 0.08 | 0.003 | 0.06 | 0.02 |
| C14:0 | 28.3$^{a}$ | | 19.1$^{bc}$ | 17.5$^{bc}$ | 20.3$^{b}$ | 21.4$^{b}$ | 1.84 | 0.01 | 0.72 | 0.21 |
| C15:0 | 3.6$^{a}$ | | 2.7$^{b}$ | 3.0$^{b}$ | 3.2$^{ab}$ | 3.4$^{a}$ | 0.17 | 0.08 | 0.51 | 0.37 |
| C16:0 | 121.2 | | 114.2 | 117.2 | 117.9 | 119.6 | 4.65 | 0.73 | 0.53 | 0.73 |
| C16:1 | 3.4$^{a}$ | | 2.5$^{c}$ | 2.5$^{c}$ | 2.6$^{bc}$ | 3.1$^{ab}$ | 0.79 | 0.70 | 0.13 | 0.04 |
| C17:0 | 25.8 | | 24.7 | 25.5 | 27.9 | 28.7 | 1.82 | 0.15 | 0.83 | 0.22 |
| C17:1 | 5.7$^{a}$ | | 2.4$^{b}$ | 2.6$^{b}$ | 2.6$^{b}$ | 2.4$^{b}$ | 0.14 | 0.61 | 0.57 | 0.35 |
| C18:0 | 98.9$^{b}$ | | 112.8$^{b}$ | 140.8$^{a}$ | 144.4$^{a}$ | 145.6$^{a}$ | 8.46 | 0.15 | 0.33 | 0.10 |
| C18:1 | 183.9$^{c}$ | | 198.2$^{bc}$ | 195.0$^{bc}$ | 204.0$^{ab}$ | 225.2$^{a}$ | 11.26 | 0.04 | 0.56 | 0.17 |
| C18:2n6c | 24.5$^{b}$ | | 31.0$^{a}$ | 33.9$^{a}$ | 30.9$^{a}$ | 34.8$^{a}$ | 1.51 | 0.08 | 0.91 | 0.82 |
| C18:3n3 | 5.6$^{c}$ | | 7.9$^{b}$ | 8.7$^{b}$ | 12.4$^{a}$ | 14.4$^{a}$ | 0.84 | 0.01 | 0.48 | 0.08 |
| C18:c9,t11 | 2.22$^{d}$ | | 5.12$^{c}$ | 5.54$^{c}$ | 6.58$^{a}$ | 7.40$^{a}$ | 0.72 | 0.001 | 0.03 | 0.05 |
| C18:t10,c12 | 0.11$^{e}$ | | 0.22$^{d}$ | 0.30$^{c}$ | 0.43$^{b}$ | 0.52$^{a}$ | 0.09 | 0.001 | 0.05 | 0.03 |
| C20:0 | 1.6$^{a}$ | | 0.9$^{b}$ | 1.1$^{b}$ | 1.3$^{ab}$ | 1.3$^{ab}$ | 0.03 | 0.10 | 0.16 | 0.10 |
| C20:2 | 3.7$^{c}$ | | 5.2$^{b}$ | 5.8$^{b}$ | 6.4$^{a}$ | 6.7$^{a}$ | 0.34 | 0.07 | 0.65 | 0.87 |
| C22:0 | 0.8 | | 0.7 | 0.6 | 0.6 | 0.6 | 0.07 | 0.66 | 0.07 | 0.54 |
| C20:3n | 4.7$^{b}$ | | 3.4$^{c}$ | 5. 7$^{a}$ | 5.1$^{ab}$ | 5.2$^{ab}$ | 0.37 | 0.10 | 0.72 | 0.99 |
| TCLA | 2.34$^{c}$ | | 5.36$^{b}$ | 5.86$^{b}$ | 7.04$^{a}$ | 8.17$^{a}$ | 0.94 | 0.01 | 0.03 | 0.02 |
| TSFA | 274.9 | | 278.8 | 304.2 | 315.8 | 320.7 | 12.65 | 0.12 | 0.10 | 0.03 |
| Tn6 | 27.2$^{b}$ | | 33.7$^{ab}$ | 38.2$^{a}$ | 36.7$^{a}$ | 35.6$^{a}$ | 1.54 | 0.14 | 0.87 | 0.13 |
| tn3 | 10.1$^{c}$ | | 11.7$^{c}$ | 14.5$^{b}$ | 16.9$^{ab}$ | 17.5$^{a}$ | 1.14 | 0.14 | 0.07 | 0.04 |
| TMUSFA | 190.3 | | 202.0 | 194.4 | 208.1 | 190.7 | 10.16 | 0.67 | 0.25 | 0.77 |
| TPUSFA | 41.4$^{b}$ | | 49.3$^{b}$ | 59.6$^{a}$ | 62.8$^{a}$ | 61.0$^{a}$ | 4.54 | 0.12 | 0.80 | 0.83 |
| DFA | 566.6$^{b}$ | | 597.6$^{ab}$ | 637.3$^{a}$ | 665.5$^{a}$ | 658.2$^{a}$ | 16.18 | 0.04 | 0.01 | 0.23 |
| PUFA/SFA | 0.15$^{b}$ | | 0.18$^{a}$ | 0.19$^{a}$ | 0.19$^{a}$ | 0.20$^{a}$ | 0.04 | 0.18 | 0.45 | 0.33 |
| *n*−6/*n*−3 | 2.62 | | 2.78 | 2.69 | 2.17 | 2.09 | 0.61 | 0.63 | 0.83 | 0.61 |

SB=soybean oil; P=probiotics; TSFA=total saturated fatty acid;TMUSFA=total mono-unsaturated fatty acid; TPUSFA= total poly-unsaturated fatty acid; DFA=desirable fatty acid; Tn6=total n6 fatty acid; Tn3=total n3 fatty acid; SEM=standard error of the mean of the SB and P treatments (except for the control); P value is for the SB and P treatments(except for the control); Means with different superscript letters in the same row differ significantly (P<0.05).

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