CARCASS PRODUCTION AND MEAT QUALITY OF SHEEP FED HIGH LEVEL OF RUMEN BYPASS FAT DIETS

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ABSTRACT

Fat content of ruminant diets has naturally restricted due to the rumen ecosystem, in which fibrous materials digested by rumen microbes. The presence of high amount of fat (>4%) in the diet has been reported to be detrimental to most rumen microbes and will reduce their cellulolytic activity. To correct such negative effect, fats/oils should be prepared in such a form to make them able to pass throughout the rumen safely and will be available to the animal in the small intestine. An experiment using 20 growing male Garut sheep was conducted to test the effect of 4 types of concentrate diets on carcass production and meat quality based on a randomized block design. The diets were made iso-nitrogen and iso-calory, basically composed of wheat pollard and soybean meal. Concentrate (C)-A was formulated without fat addition, C-B contained 10% free fatty acids, C-C and C-D contained 10% and 15% rumen bypass fat (in form of Ca-fatty acids), respectively. Fresh chopped King grass had been fed to each sheep 4 kg/day, while drinking water available every time. Results of the experiment showed no significant difference in total dry matter intake among treatments (varied from 847.42 to 875.90 g/d). Carcass production, however, was significantly higher (P<.05) on sheep fed rumen bypass fat (16.34 kg for diet C-C and 15.72 kg for diet C-D) as compared to the other diets (14.84 kg for diet C-A and 14.68 kg for diet C-B). There was no significant difference among dietary treatments on most quality parameters observed. Fat content of the mutton was 2.42% for sheep fed diet C-D, and it was significantly higher (P<.05) than that of sheep fed diet C-C (1.71%), which was not differ significantly compared to the sheep fed control diet (C-A). Feeding high level of rumen bypass fat to the sheep increased the proportion of total unsaturated fatty acids content of the meat fat, while total saturated fatty acids was significantly lower (P<.05). The whole data comparison shows that the concentrate diet containing 10% rumen bypass fat gave the best result on carcass production and meat quality.

Key words: Rumen bypass fat, Sheep, Carcass, Meat quality

INTRODUCTION

Most grains, which are used for food, have also been traditionally used for feed to fulfill nutrient requirements of livestock, especially protein and energy. In order to reduce such competitive utilization, other feed resources should be found and developed to be edible to the animals. Fats/oils are the alternative feed ingredients can be used as a source of energy. For ruminant animals, however, rumen fermentation pattern will be altered when fats/oils are fed at a relatively high concentration (> 4% in the diet), in which will reduce fiber digestion rate (Palmquist and Jenkins, 1980). To make them more valuable to ruminants and harmless to the rumen microbes, fats/oils should be protected so they can freely passing through the rumen. Calcium soap of fatty acids have recently been of interest to ruminant nutritionists and have been successfully tested and used as an energy supplement for lactating cows (Sklan *et al.*, 1994; Salfer *et al.*, 1994; Tomlinson *et al.*, 1994). It has also been reported that inclusion of Ca-tallowate (a rumen bypass fat) up to 8% in a complete mix for lactating cows feeding improved milk production and increased unsaturated fatty acids proportion of the milk fat (Lubis, 1986). However, there is restricted information available on the utilization of fat supplement for sheep and

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goats. This paper dealing with Ca-fatty acids feeding on growing sheep.

MATERIALS AND METHODS

Twenty growing male Garut sheep were used to test the effect of rumen bypass fat (in form of Calcium salt of long chain fatty acids) on carcass production and meat quality. Average initial body weight of the sheep ranged from 21.42 to 22.78 kg. The free fatty acids were derived from a frying oil company (PT Bimoli) as a waste of crude palm oil processing for frying oil. The fat was composed of myristic (1.15%), palmitic (54.30%), palmitoleic (0.15%), stearic (4.35%), oleic (32.70%), and linoleic acids (7.35%). The fatty acids were bond with Ca^{++} (of $CaCl_2$) through a two-step saponification process and oven-dried to be used as a main energy source component of concentrate diets. The sheep were basically fed with chopped fresh King grass (4 kg/d) and concentrate diets, which were formulated to be isonitrogen and isocalory. There were 4 types of concentrate diets offered to the sheep and were allotted based on a randomized block design with 5 replications. The concentrate (C)-A was made without fat supplementation and was used as a control positive diet, while C-B was supplemented with free fatty acids (as a control negative diet). The other two diets were C-C and C-D, which were supplemented with Ca- fatty acids as much as 10% and 15%, respectively. Feed ingredients and nutrient composition of the four diets are presented in Table 1.

The concentrate diets were fed at 7:00 am and the amount was gradually increased from 300 g/d up to an amount where the sheep could maximally tolerate the feed, in this case was 500 g/d, during three-week preliminary period. Fresh chopped King grass was then fed between 10:00 to 11:00 am as much as 4 kg/d. Concentrate feed refusals were weighed just before the forage was given and that of King grass was weighed the next morning before the first feeding. Drinking water was available continuously so they can drink anytime they need it. Each sheep was weighed once a week in the morning before feeding time during the preliminary period and the next 16 weeks fattening period. All sheep were then slaughtered and prepared for carcass

Table 1. Feed composition (kg/100kg) and nutrient content of the diets used for sheep fattening

Composition	Diet-A	Diet-B	Diet-C	Diet-D
Concentrate Ingredients:				
Wheat pollard	81.72	66.72	69.72	62.86
Soybean meal	14.57	19.43	18.57	21.14
Free fatty acids	-	10.00	-	-
Ca-fatty acids	-	-	10.00	15.00
Urea	0.71	0.71	0.71	0.71
Calcium carbonate	2.50	2.57	0.86	0.18
Iodized salt	0.50	0.57	0.14	0.11
Nutrient Content:*				
M.E. (Kcal/kg)	1668.43	1651.21	1672.63	1845.86
Crude protein (%)	17.00	17.00	17.00	17.00
Ether extractibles (%)	3.59	10.19	9.22	14.30
Crude fiber (%)	15.83	15.27	15.41	15.18
Ash (%)	6.96	6.81	6.94	6.93
Calcium (%)	0.80	0.80	0.80	0.80
Phosphorus (%)	0.26	0.24	0.24	0.24

*Calculations based on complete feed dry matter

Table 2. Feed dry matter intake (g/d) of sheep fed concentrate diets with or without free fatty acids or Ca-fatty acids

Dietary Treatments	Forage*	Concentrate*	Total*
Concentrate(C)-A (control+)	424.19 ± 54.14	451.71^b ± 11.08	875.90 ± 50.25
C-B (10% FFA, control -)	404.41 ± 25.12	450.80^b ± 8.24	855.21 ± 24.08
C-C (10% Ca-fatty acids)	399.40 ± 43.92	467.29^a ± 4.87	866.69 ± 42.89
C-D (15% Ca-fatty acids)	382.53 ± 32.03	464.89^a ± 3.96	847.42 ± 32.94

*Different superscripts in one column indicating significant difference (*P*<.05)

production and meat quality evaluation, i.e. marbling, pH, tenderness, ribeye area, subcutaneous fat thickness, fat and water content of the mutton. Transversal section of *longissimus dorsi* muscle cut between the 6th and 7th ribs was visually observed for degree of marbling and graded according to Handbook of Japan Meat Grading Association (JMGA, 1988). This section was also used for subcutaneous fat thickness (cm) and the ribeye area (cm^2) measurements using meat square. Meat tenderness was measured using penetrometer (mm/10sec/50g) and pH-meter was used to determine the pH value. Fat and water content of the meat was assessed using Soxhlet extraction and oven-dried, respectively. Fatty acid composition of the meat fat was determined using gas chromatograph. All data observed were statistically analyzed for analysis of variance and the mean comparison among treatments was tested using Duncan's multiple range test (Montgomery, 1984).

RESULTS AND DISCUSSION

Feed Intake and Carcass Production

Substitution part of dietary energy source with Ca-fatty acids increased concentrate dry matter intake significantly, but there was no significant difference on total feed dry matter intake among treatments (Table 2). Forage dry matter intakes tend to decrease along with the increasing amount of fat addition in concentrate diets. The higher dry matter intake of concentrate diets with Ca-fatty acids indicating no major disturbances in rumen fermentation process (especially fiber digestion) due to high fat intake and feed particles can normally passing through the lower digestive tract. It was reported by Jenkins and Palmquist (1984) that nutrient digestibility on dairy cows offered high fat diets can be improved with inclusion of calcium salt of fatty acids. Recently, Bayourthe *et al.* (1994) found that *in situ* fiber

Table 3. Carcass weight and dressing percentage of sheep fed concentrate diets with or without free fatty acids or Ca-fatty acids

Dietary Treatments	Live wght (kg)*	Carcass (kg)*	Dressing %*
Concentrate(C)-A (control+)	34.00^a ± 0.64	14.84^b ± 0.70	43.62^b ± 1.65
C-B (10% FFA, control -)	31.74^b ± 2.03	14.68^b ± 1.11	46.24^a ± 1.87
C-C (10% Ca-fatty acids)	34.58^a ± 1.86	16.34^a ± 0.93	47.28^a ± 2.07
C-D (15% Ca-fatty acids)	34.30^a ± 2.26	15.72^a ± 1.07	45.84^a ± 2.30

*Different superscript in one column indicating significant difference (P<.05) digestion of canulated sheep fed diets containing 12% Ca salt of fatty acids was improved and apparent energy digestibility was higher than that of the sheep fed control (low fat) diet. The effect of feeding high fat ration in form of free fatty acids and Ca-fatty acids on carcass weight and dressing percentage of the sheep are presented in Table 3. Non-significant differences in carcass yield of the sheep consumed control positive and control negative (with 10% free fatty acids) diets indicates no negative effect of relatively high free fatty acids feeding on carcass production although the final live weight of the control negative sheep significantly lower than the other treatment groups. As reported by Lubis *et al.* (1998) that Garut sheep fed concentrate diets with 10% free fatty acids had the lowest daily gain and final live weight (P<.05) compared to the control positive sheep and the other groups which received concentrate diets containing 10% and 15% Ca-fatty acids. Feeding Ca-fatty acids to the sheep resulted in higher (P<.05) carcass yield than the control groups. With lower concentrate dry matter intake, indicated that feeding high fat in form of its calcium salt more efficient than the other dietary treatments.

Dressing percentage of the sheep did not differ significantly among the control negative group and the other two treatment groups (concentrate with 10% and 15% Ca-fatty acids), while the control positive group had lower (P<.05) value. Fluctuation in the corresponding values of carcass weight and dressing percentage among dietary treatments was inconsistent and this result confirmed the findings of Rao *et al.* (1998) from their study using Mujaffarnagari rams. In this study, higher dressing percentage of control negative group than that of the control positive group with same carcass weight was simply due to significantly lower final live weight of the control negative sheep (31.74 kg) compared to the control positive sheep (34.00 kg).

Meat Quality

Visual observation on the degree of marbling of *longissimus* muscle according to its physical characteristics as compared to the standard graphs provided by Japan Meat Grading Association (JMGA, 1988), which ranged from the first to the sixth grade, all samples with four different treatments had same characteristics and were categorized to second grade. Although the degree of marbling could not exactly measured through this method, it was quite obvious to observe the difference on fat dispersion intramuscularly among grade categories. In addition, results from fat extraction could support the visual observation, in which all samples had low fat content with average values among treatments ranged from 1.71 to 2.42% (Table 4). The lowest fat content was determined in meat samples of the sheep consumed concentrate diet with 10% Ca-fatty acids and did not differ significantly with the control positive samples. Meat samples from the control negative group and the sheep fed concentrate diets with 15% Ca-fatty acids had relatively same fat content and were significantly higher than the control positive group. In general, fat percentage in sheep is higher than that in goat

Table 4. Meat quality of sheep fed concentrate diets with or without free fatty acids or Ca-fatty acids

Quality Parameters*	Dietary Treatments			
	Control	10% FFA	10% Ca-FA	15% Ca-FA
Degree of marbling	2nd grade	2nd grade	2nd grade	2nd grade
Tenderness (mm/10 sec/50 g)	88.07 ± 2.84	86.00 ± 3.70	88.27 ± 6.63	85.27 ± 3.66
pH	7.22 ± 0.98	6.96 ± 1.19	7.26 ± 0.82	7.28 ± 0.86
Subcutaneous fat (cm)	0.41 ± 0.14	0.54 ± 0.30	0.41 ± 0.09	0.54 ± 0.29
Ribeye area (cm^2)	9.90^{ab} ± 0.88	10.60^{ab} ± 1.26	10.90^{a} ± 1.52	9.70^{b} ± 0.95
Fat (%)	1.73^{b} ± 0.81	2.32^{a} ± 0.71	1.71^{b} ± 0.34	2.42^{a} ± 0.41
Moisture (%)	74.08 ± 0.97	74.12 ± 0.89	74.35 ± 1.07	73.97 ± 1.17

*Different superscripts in one row indicating significant difference (P<.05)

Table 5. Fatty acid composition (%) of meat fat from sheep fed concentrate diets with or without free fatty acids or Ca-fatty acids

Fatty Acids*	Dietary Treatments			
	Control	10% FFA	10% Ca-FA	15% Ca-FA
Myristic (C14:0)	15.79[a]	9.81[b]	9.21[b]	8.78[b]
Palmitic (C16:0)	30.85[a]	29.89[ab]	25.74[c]	27.91[bc]
Palmitoleic (C16:1)	5.93[ab]	8.03[a]	7.17[ab]	5.34[b]
Stearic (C18:0)	17.28[a]	17.30[a]	17.51[a]	15.09[b]
Oleic (C18:1)	22.16	25.85	25.29	24.94
Linoleic (C18:2)	5.02[b]	5.30[b]	6.52[ab]	9.11[a]
Linolenic (C18:3)	1.40[b]	1.26[b]	4.65[a]	4.30[a]
Arachidic (C20:0)	0.24[b]	0.26[b]	0.82[a]	0.80[a]
Behenic (C22:0)	0.11	0.21	0.22	0.29
Erucic (C22:1)	1.15[c]	1.97[bc]	3.88[a]	3.11[ab]
Total saturated acids	64.30[a]	57.55[ab]	53.86[b]	53.15[b]
Total unsaturated acids	35.70[b]	42.41[ab]	46.14[a]	46.85[a]

*Different superscript in one row indicating significant difference ($P<.05$)

(Owen *et al.*, 1978). In this study, where Garut sheep was used, the fat percentage was closer to goat meat. This finding implies that the fat derived from the diets was deposited more into adipose tissues, especially in abdominal cavity. Similar tendency also occurred in subcutaneous fat deposition. Subcutaneous fat thickness was relatively thin and did not differ significantly among dietary treatments. Growth coefficient value of fat depots differ between body parts and species (Wood, 1984). Major fat depots in ruminants occur in mesenterium and omentum, and less in subcutaneous. Contrastly, pigs have much more subcutaneous and less abdominal fat. It has also been reported by Broad and Davies (1981) in sheep that intramuscular fat (marbling) had the slowest relative growth coefficient of fat tissue and the value increased progressively for subcutaneous, intermuscular and in internal cavity

As evident from Table 4, there were no significant differences in tenderness, pH and moisture content among diet treatments. Almost similar tenderness values for all meat samples might be attributed to same grade according to degree of marbling. Meat tenderness is also related to pH and protein breakdown post mortem. It has been reported that tender meat had higher pH than tough/firm meat. Although meat pH declines gradually post mortem due to the release of carbon dioxyde by bicarbonate, the breakdown of creatine phosphate (from protein) releases phosphate that serves as a buffer to correct the pH (Pearson and Young, 1989). They also stated that proteolysis of desmin maybe involved in tenderization of meat during postmortem aging. Furthermore, recent study by Carpenter *et al.* (1996) found that elevated calpistatin level has a negative effect on meat tenderness and other sensory traits, concluded that higher calpistatin level inhibit protein breakdown and postmortem tenderization process. Clare *et al.* (1997) proved that different tenderness between leg, shoulder and the loin was highly related to its clpistatin level, and callipyge lambs had higher calpistatin in their muscle than normal lambs. The pH value is also closely related to water holding capacity and moisture content, in which water holding capacity increases as the pH increases (Pearson and Young, 1989). Water content determined in this experiment varied in normal range, i.e. 70 - 78% for skeletal muscle (Pearson and Young, 1989).

Feeding high level of rumen bypass fat (Ca-fatty acids) in concentrate diets significantly increased the unsaturation of meat fat. Total unsaturated fatty acid content was higher ($P<.05$) in the meat fat of the sheep consumed concentrate with 10% and 15% Ca-fatty acids than in the sheep fed control diets.

This unsaturation was mainly caused by tremendous increased in C 18:2 and C 18:3 fatty acids but no change in C 18:1 (Table 5). On the other hand, the decreased meat fat saturation of the sheep consumed control diets was primarily due to decreased ($P<.05$) in the proportion of C14:0 and C 16:0 fatty acids.

The saturation and unsaturation value of the meat fat of control negative sheep, which consumed concentrate diet with 10% free fatty acids, determined in between that of control positive sheep and the rumen bypass fat consumers ($P>.05$). These findings proved that Ca-fatty acids consumed by the sheep could safely passing through the rumen. The higher unsaturation of meat fat of the sheep consumed rumen bypass fat indicates less biohydrogenation of fatty acids in the rumen. The results found in this experiment, where the free fatty acids used are derived from palm oil, are in agreement with Enjalbert *et al.* (1994) who reported that biohydrogenation rate of fatty acids from palm oil and soybean oil in the rumen declined when fed in their Ca salts form, and could modify the absorption of unsaturated fatty acids through small intestine. Under usual condition, most fatty acids derived from the diet are hydrogenated by rumen microbes and this process causing fat of ruminant animals more reduced/saturated than that of non-ruminant animals. Harfoot (1978) found that free fatty acids from feed particles that adsorbed on rumen microbial cells were hydrogenated, which started with isomerization to make reduction process is possible under anaerobic condition. Moreover, Doreau and Ferlay (1994) reported that linolenic acid (C18:3) was often completely hyrdogenated to stearic acid (C18:0), while hydrogenation of linoleic acid (C18:2) was not complete. Under condition in this experiment, linoleic acid content of meat fat of the sheep fed concentrate with 10% Ca-fatty acids did not differ with that of the control positive and control negative sheep, but the sheep consumed concentrate with 15% Ca-fatty acids had significantly higher linoleic acid.

CONCLUSION

Feeding rumen bypass fat in form of Ca-fatty acids in isonitrogen and isocaloric diets to Garut sheep improved carcass production without altering mutton quality. Best performance under condition in this study was reached by inclusion 10 % Ca-fatty acids into concentrate diet. Moreover, feeding Ca-fatty acids resulted in less saturated meat fat, which is desired by present day health-conscious people.

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