Response of Sheep Fed on Concentrate Containing Feather Meal and Supplemented with Mineral Chromium

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ABSTRAK

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Penelitian dilakukan untuk mengevaluasi pengaruh substitusi protein konsentrat dengan tepung bulu ayam dan disuplementasi dengan mineral kromium (Cr) terhadap penampilan domba anak lepas sapih. Dua puluh lima ekor anak domba diberi pakan dasar cacahan rumput gajah segar *ad libitum* dan disuplementasi dengan salah satu dari lima pakan konsentrat perlakuan yang terdiri dari: Kontrol (C); 10% protein konsentrat disubstitusi dengan tepung bulu ayam (FM); 10% protein konsentrat disubstitusi dengan tepung bulu ayam dan disuplementasi dengan Cr organik pada level 1.5 mg (FMCrOrg); 10% protein konsentrat disubstitusi dengan tepung bulu ayam dan disuplementasi dengan Cr anorganik yang setara dengan 1.5 mg Cr yang terikat pada fermentasi tepung beras (FMCr); Konsentrat control disuplementasi dengan Cr anorganik (CCrOrg). Kromium organic disintesa dengan cara mengikorporasikan mineral CrCl3 pada tepung beras yang difermentasikan dengan kapang *Rhizopus* sp. Mineral dicampurkan dengan tepung bulu sebagai pembawa mineral. Domba pada semua perlakukan menerima pakan konsentrat yang disusun secara iso energi. Parameter yang diamati adalah perubahan bobot badan, konsumsi pakan, kecernaan pakan. Hasil dari pengamatan menunjukkan bahwa tidak ada pengaruh nyata pengaruh perlakuan pakan pada pertambahan bobot badan harian, konsumsi bahan kering dan konversi pakan, dengan nilai rataan secara berurutan adalah 75,4 g/h; 74,9 g/BW^{0,75} dan 9,9. Akan tetapi perlakuan pakan kombinasi antara kromium organik dan substitusi protein dengan tepung bulu (FMCrOrg) mempunyai kecenderungan mempunyai PBBH yang lebih tinggi (83,57 g/e/h). Rataan kecernaan bahan kering, bahan organic dan NDF secara berurutan adalah 68,7; 69,6 and 60,9%. Akan tetapi kecernaan NDF pada FMCrOrg cenderung lebih tinggi dibanding perlakuan yang lain (67,0%). Dari penelitian ini dapat disimpulkan bahwa substitusi sebagian dari protein konsentrat dengan tepung bulu dan disuplementasi dengan 1,5 mg kromium organic tidak berpengaruh pada penampilan anak domba.

Kata Kunci: Kromium, Domba, Tepung Bulu, Suplementasi

ABSTRACT

Yulistiani D, Puastuti W, Mathius IW. 2013. Response of sheep fed on concentrate containing feather meal and supplemented with mineral Chromium. JITV 18(1): 9-16.

A study was conducted to evaluate the effect of substitution of protein concentrate with feather meal supplemented with organic chromium mineral on performance of lambs. Twenty five male lambs were fed basal feed of fresh chopped king grass *ad libitum* and were allotted to either one of five different supplements (five dietary treatments): Control (C); 10% of protein in concentrate was substituted by feather meal (FM); 10% of protein in concentrate was substituted by feather meal supplemented with Cr yeast at 1.5 mg (FMCrOrg); 10% of protein in concentrate was substituted by feather meal supplemented with Cr inorganic which equal to the amount of Cr bound in yeast (FMCr); Concentrate control supplemented with 1.5 mg Cr yeast (CCrOrg). Cr-organic was synthesized by incorporating CrCl3 in fermented rice flour by Rhizopus sp. The mineral is mixed with feather meal as a mineral carrier. Sheep in all treatments received iso protein concentrate. Parameters observed were body weight change, feed consumption and nutrient digestibility. Results shows that there was no significant effect of diet treatments on average daily gain (ADG), dry matter consumption and feed conversion, with the average value of 75.4 gr/day; 74.9 g/BW$^{0.75}$ and 9.9 respectively, However diet treatment of organic chromium and protein substitution with feather meal (FMCrOrg) showed tendency of having higher ADG (83.57 g/h/d). Average nutrient digestibility of dry matter, organic matter and NDF were 68.7; 69.6 and 60.9%, respectively. However NDF digestibility of FMCrOrg tended to be higher than other treatment (67.0%). It is concluded that partial substitution of protein concentrate by feather meal and 1.5 mg Cr-organic supplementation did not affect sheep performance.

Key Words: Chromium, Sheep, Feather Meal, Supplementation

INTRODUCTION

Ruminant animals in high productivity state (growth, pregnancy and lactation) cannot meet their protein requirement from rumen microbial protein supply (Henson et al. 1997). Therefore, to achieve optimal productivity they must be offered diet containing rumen undegradable protein sources that are digestible (Mustafa et al. 2000; Saricicek 2000) such as feather meal. Unprocessed feather meal has low digestibility, about 5.8% (Wahyuni 2001) and therefore as a protein source, it needs processing such as by using low or high steam pressure or by using chemical such as hydrochloric acid or sodium hydroxide. The product of hydrolyzing process called hydrolyzed feather meal (Aderidigbe and Church, 1983). This product is high in un-degradable protein content. Processing of broiler feather by hydrolyzing with hydrochloric acid of 12% concentration can produce feather meal with 47% by-pass protein (Puastuti and Mathius 2007).

Beside the need of extra protein supplement, high productive ruminants also need high energy from carbohydrate source. In addition this animnals also frequently face physiological stress due to physiological change in the body and also environmental stress. In stress condition the requirement of chromium (Cr) also increase, due to mobilization of stock Cr in the body as a result of the increasing mobilization of glucose from pheripheral tissue to meet the need of glucose in the brain, which in turn Cr will be excreted through urine (Burton, 1995). Cr is an essential micro mineral which has important role in nutrient (carbohydrate, protein and fat) metabolism (Anderson 1987) and important part of glucose tolerance factor (GTF). GTF is responsible in regulating glucose level in the blood and its homeostatic which is related to fat and protein synthesis. Previous study reported that supplementation of organic-Cr increased growth rate, feed efficiency and milk production (Lindemann 1997). Whereas Gentry et al. (1999) reported that there was interaction effect between Cr and protein content of the diet on growth of lambs, feed consumption, and feed conversion ratio only at first 5 weeks of experiment. Cr supplementation in high protein diet increased growth rate, feed consumption and feed conversion, in contrast, supplementation in low protein content decreased those parameters. During next 6-12th weeks of experiment no significant effect was observed. In contrast, Mathius et al. (2005) reported that Cr organic supplementation during late pregnancy and lactation did not have any effect on ewe production. The reports on the utilization of Cr in concentrate to improve growth rate is limited and from previous study the effect of Cr supplementation was inconsistent. In order to further increase the productive ability of ruminants in the utilization of feather meal as by-pass protein source, supplementation of Cr is expected to be able to improve feed efficiency. Therefore, the objective of this study was to evaluate the effect of substitution of protein concentrate with feather meal and supplemented with organic chromium mineral on sheep performance.

MATERIALS AND METHODS

Feeds

Feather meal was obtained from Anwar Sierad Co a commercial feed mill, the feather was processed using high pressure steaming at temperature 105ºC, with 40% moisture content for 8 hours, and continued by grinding to be made into powder.

Chromium organic (Cr-organic) was synthesized using inoculants *Rhizopus* spp. that had faster growth and able to compete with other contaminant and had ability to bind Cr from CrCl3. In brief the procedure of synthesizing Cr organic were done by mixing rice flour 100 g as substrate with 140 ml CrCl3 solution with concentration 1000 ppm and 10 ml mineral solution. The mixture was then sterilised by autoclaving for 20 minutes and cooling down at room temperature. Then the substrate was inoculated with *Rhizopus* spp. as inoculants and fermented for 3-5 days at room temperature and dried prior to grinding before being used in the feeding trial.

Animal management and feeding experiment

The study used 25 male Sumatera Composite lambs of an average initial body weight of 18.0 $\pm$ 2.2 kg. In growth trial, lambs were kept in individual pen for 12 weeks (including 1 week adaptation period) and fed on fresh chopped elephant grass (*Penisetum purpureum*) *ad libitum* as a basal diet and supplemented with 400 g of one of concentrate treatments. Concentrates were formulated in iso-nitrogenous and iso-energetic (CP 18% and 73% TDN) levels. Grass and concentrate were offered separately at the same time and fed twice daily (at 09.00 and 15.00 hours). The lambs were divided into 5 groups based on body weight, each lamb in each group were fed on one of five dietary treatments. Five concentrate treatments were: 1) concentrate control (C); 2) 10% of protein in concentrate control was replaced by protein from feather meal (FM); 3) Concentrate in FM was supplemented with 1.5 mg of bound Cr in mold (fermented substrate) (FMCrOrg); 4) Concentrate in FM was supplemented with Cr inorganic with amount equal to Cr bound in Cr mold supplemented in concentrate (FMCr); 5) concentrate control supplemented with 1.5 mg of bound Cr in Cr mold (CCrOrg). Before the study, lambs were dewormed using commercial de-wormer (valbazen). For estimating nutrient digestibility at the end of growth trial, lambs were moved to metabolism cages for 2 weeks: comprising of a week each for adaptation and collection periods.

Parameters recorded

Parameters recorded were feed consumption, growth rate, nutrient digestibility, feed efficiency, N balance and rumen characteristics. Feed consumption was measured daily by calculating the difference between feed offered and refused.

Daily feed offered and refusal were weighed in the morning before feed was given. Feed digestibiity was measured using total collection method by daily weighing feed offered, refusal and fecal excreted for 7 days. For measuring nitrogen (N) balance, N in the feed, feces and in urine were analysed. Urine production was measured daily: urine was collected in a bucket containing 5 ml concentrated H_2SO_4. Feaces, feed offered and refusal were sub-sampled (100 g) and dried in an oven for 7 days. Samples from each animal in each day were taken 10% and bulked for each animals and ground for chemical analysis. After 8 days of collection period, rumen fluid of each lamb was collected using stomach tube. Rumen fluid was collected 3 hours after morning feed. Rumen fluid was analysed for pH and ammonia (NH_3-N) concentration. Growth rates of lambs were obtained by bi-weekly weighing in the morning before feeding. Nitrogen balance was measured by calculating the difference between N intake with N in urine and feces.

Sample analysis

Crude protein, dry matter, organic matter analyses were done according to the method of AOAC (1990), while NDF and ADF analyses were carried out according the method of Van Soest et al. (1991). Rumen ammonia was analysed using Conway's method.

Statistical analysis

Experiment was conducted in randomised complete block design. Data were analyzed using GLM for randomized complete block design (SAS, 1989) and those differences among means were compared using Duncan's multiple range test.

RESULTS AND DISCUSSION

Data on DM, CP and energy consumption are presented in Table 2. It shows that there was no effect of diet treatment on feed consumption (DMI, CP and energy). In diet FMCrOrg where the protein concentrate was partly substituted by feather meal protein and also supplemented with Cr organic was only slightly increased but not significantly. The nutrient intake was not affected by diet treatment with the average DMI intake of all treatment was 3.51%. These levels of DM intake were in the range suggested by (Kearl 1982) for growing ruminant animals.

The CP required for maintenance by sheep in the current experiment was estimated to be 45 g/d and for moderately growing sheep, growing at 100 g LW/d, the requirement was estimated to be 72 g CP/day (Kearl 1982). The average CP intake was 104 g/day indicating that CP intake was higher than that suggested by Kearl (1982). Intake of CP was not significantly ($P > 0.05$) different between treatments due to the concentrate was formulated in iso-protein.

Nutrient digestibilities in lambs fed on diet treatment are presented in Table 3, it shows that DM, OM or energy digestibility were not affected by treatments. However, NDF digestibility was significantly affected by diet treatments. Lamb fed on diet FMCrOrg had significantly higher NDF digestibility than that of CCrOrg. Crude protein digestibility in treatment CCrOrg was signicantly lower than those of C, FM, FMCrOrg, but was not significantly different to FMCr. However, among treatment C, FM, FMCrOrg, and FMCr were not significantly different.

Though, overall protein digestibility was high (> 60%) (Table 3), however, the N retention was low, with the average only 18.16% of N intake was retained in the body indicating that the protein utilization was low. Table 4 shows that more N intake was excreted in the urine. It seemed that partial replacement of protein with protein from feather meal did not alter its degradation in the rumen. Feed protein in the rumen

Table 1. Chemical composition of the feeds used in experimental diet

Parameter	Chemical composition (% DM)			GE (Cal/kg)
	OM	CP	NDF	
Concentrate control	93.2	16.4	36.1	3687
10% of protein concentrate replaced by feather meal	94.7	16.3	36.6	3680
Elephant grass	87.5	10.0	68.0	3706
Feather meal	98.1	69.8	ND	5037

degraded into amino acid, NH_3-N formed in the rumen from amino acid breakdown is absorbed from the rumen and converted into urea in the liver and excreted in the urine. The similar degree of protein degradation of the diet indicating that protein from feather meal which was expected to be undegradable was degraded in the rumen this could be due to heat treatment applied in feather meal processing was not strong enough to protect protein from degradation in the rumen. The similar degree of degradation was also can be observed from the similar concentration of rumen NH_3-N of all lambs fed different diet treatments (Table 5). Feather meal is one of feed protein sources with high content of undegradable but digestible protein. LEE and MOON (1997) reported that feather meal obtained commercially contained 63% UDP in which 42.3% of them was available in the intestinal. The different of processing affect the quality of hidrolised feather meal produced, as mentioned by El Boushy et al. (1990) who reported that in raw feather though its protein content was high (94.38%) but its digestibility in pepsin HCl digestion was only 16%. Processing feather meal using steam pressure at 621 kPa for 6 minute increased protein digestibility into 74%. In this study the feather meal was obtained from commercial animal feed factory using steam process. The differences quality of the feather meal in this study from previous study (Lee and Moon 1997; El Boushy et al. 1990) may be caused by different of processing method and resulted in different protein value of processed feather meal which can be observed from its biological value. In this study the biological value (N retained/N digested) of the

Tabel 2. Feed consumption of lamb fed on different feeding treatment

Parameter	Treatments					SEM
	C	FM	FMCrOrg	FMCr	CCr Org	
Dry matter intake (DMI):						
Grass	368.8	386.3	424.9	388.5	391.7	12.61
Concentrate	356	356	356	356	356	
Total	724.8	742.3	780.9	744.5	747.7	12.61
% DMI/BW	3.31	3.43	3.61	3.60	3.63	0.07
$DMI/BW^{0,75}$	71.5	73.9	77.9	76.8	77.4	1.34
CP intake	101.6	103.4	107.3	103.6	104.2	1.26
CP intake/$BW^{0,75}$ (g/day)	10.0	10.3	10.5	10.5	10.6	0.15
Gross energy intake (kCal)	2677.7	2834.1	2908.2	2765.6	2772.0	48.0
Gross energy intake/$BW^{0,75}$	264.2	282.0	290.0	285.2	290.0	4.79

C = Concentrate control
FM = Partly feather meal replacement
FMCrOrg = Partly feather meal replacement and supplemented with Cr organic
FMCr = Partly feather meal replacement and supplemented with Cr inorganic
CcrOrg = Concentrate control supplemented with Cr organic

Table 3. Nutrient digestibility of lambs fed on different diet treatments

Parameter	Treatments					SEM
	C	FM	FMCrOrg	FMCr	CCr Org	
Dry matter	70.2	68.6	66.4	70.8	67.6	0.62
Organic matter	71.8	69.5	66.8	71.8	68.2	0.77
NDF	62.6^{ab}	62.2^{ab}	67.0^{a}	59.6^{ab}	52.9^{b}	1.57
Crude protein	71.4^{a}	70.2^{a}	72.7^{a}	65.1^{ab}	60.1^{b}	1.20
Energy	69.9	69.1	63.8	70.4	66.1	0.94

Different supersript in the same row indicating significanly different ($P < 0.05$)
C = Concentrate control
FM = Partly feather meal replacement
FMCrOrg = Partly feather meal replacement and supplemented with Cr organic
FMCr = Partly feather meal replacement and supplemented with Cr inorganic
CcrOrg = Concentrate control supplemented with Cr organic

Table 4. Nitrogen balance of lambs fed on different diet treatments

Parameter	Treatments					SEM
	C	FM	FMCrOrg	FMCr	CCr Org	
N intake (g/day)	14.2	15.0	15.4	15.2	14.4	0.34
N excretion						
Faecal (g/day)	4.0	4.3	4.0	5.08	4.71	0.14
% of intake	29.1	28.7	29.1	32.0	32.7	1.01
Urine (g/day)	6.6	7.3^{ab}	8.37^{a}	8.0^{ab}	7.85^{ab}	0.34
% of intake	46.5^{b}	48.7^{ab}	54.8^{ab}	61.9^{a}	57.9^{ab}	1.84
N retention (g/day)	3.49	3.39	3.08	2.13	1.87	0.28
% of N intake	24.4	22.5	17.0	14.1	12.8	1.79

Different supersript in the same row indicating significanly different ($P < 0.05$)
C = Concentrate control; FM: Partly feather meal replacement
FMCrOrg = Partly feather meal replacement and supplemented with Cr organic
FMCr = Partly feather meal replacement and supplemented with Cr inorganic
CcrOrg = Concentrate control supplemented with Cr organic

Table 5. Average of pH and ammonia nitrogen in the rumen fluid of lamb fed on

Parameter	Treatments					SEM
	C	FM	FMCrOrg	FMCr	CCr Org	
PH	6.63	6.58	6.61	6.6	6.54	0.047
NH_3-N (mg/d1)	24.65	33.5	30.7	28.2	32.5	2.00

C = Concentrate control
FM = Partly feather meal replacement
FMCrOrg = Partly feather meal replacement and supplemented with Cr organic
FMCr = Partly feather meal replacement and supplemented with Cr inorganic
CcrOrg = Concentrate control supplemented with Cr organic

diet containing protein feather meal were 0.29, 0.27 and 0.21 for FM, FMCrOrg and FMCr respectively. These values slightly were lower than that of control diet (BV = 0.34) and slightly higher than that of CCrorg (0.19). Eventhough the rumen undegradable protein of commercial feather meal used in this study was low but it has high protein digestibility, therefore this protein source did not show over protection and can be used for protein source. The higher protein degradability in the rumen, indicates that commercial feather meal might be more suitable to be used as protein source for non ruminant animals.

The optimum concentration of NH_3-N suggested by Satter and Slyter (1974) was 5 mg NH_3-N/dl for rumen microbial synthesis, but higher values (10-20 mg/100ml) had been recommended (Preston and Leng, 1987; Perdok and Leng, 1990) to optimize degradation of fibrous feed. The average of concentration of rumen NH_3-N in this study for all treatments was 33.5 mg/dl. The higher rumen ammonia concentration indicates higher protein degradation as well as inefficiency of ammonia utilization by rumen microbes. Ammonia in excess of this concentration will probably traversing the rumen wall and converted in the liver into urea in turn excreted in urine. Even though, in this study the ratio between protein and energy intake (NI: DOMI) was in optimal condition (0.03-0.04) for rumen microbial activity, but the weight gain was not optimal. The low growth rate may be caused by the potential genetic of the breed of the lamb.

Considering the effect of Cr-organic supplementation in this study, it shows that there was no significant effect neither on nutrient intake (Table 2) nor nutrient digestibility and lamb performance. Supplementation with Cr has been reported to have an impact on blood metabolites (i.e. glucose), alter of some endocrine variables (i.e. insulin) and influence immune status (i.e. IgG), growth rate, and carcass characteristics in finishing pigs (Wang et al. 2007). On the other hand Dominguez-Vara et al. (2009) reported that Cr-yeast supplementation at 0.25 mg did not have any effect on growth rate of newly weaned lambs. However, when the supplementation was combined with Se yeast, this supplementation increased live weight gain and improve feed conversion. Insulin has potentiated insulin action by enhancing its binding to target cell receptor and also by improving its post receptor signaling. Debski et al. (2004) reported that insulin has increased protein synthesis, efficiency of amino acid transport, reduced protein degradation rate and increased carbohydrate and lipid utilization. Therefore, supplementation of Cr yeast at 0.25 mg reported by Dominguez-Vara et al. (2009) increased carcass protein content and fat free carcass. In contrast, in this study Cr supplementation did not affect average daily gain as well as feed efficiency (Table 6). Similarly Yan et al. (2008) also reported no significant effect of Cr yeast supplementation on growth rate of lamb.

The average daily gain was not significantly different between treatments (Table 6) with the average of 75.45 g/day. However, combination of feather meal replacement and Cr organic supplementation resulted in slightly higher ADG (83.57 g/day) and tended to have better feed conversion (9.66), protein conversion (daily protein intake/ADG) and energy conversion (daily energy intake/ADG) ratio.

DMI and CP and energy intake were not significantly different. Similarly ADG was also not significantly different among treatment diets. These results indicated that supplementation of Cr organic and its combination with protein source from feather meal did not give significant improvement in sheep performance (ADG). Gentry et al. (1999) also reported that Cr-picolinat supplementation did not have significant effect on ADG of sheep. Bunting et al. (1994) obtained no increase in ADG and feed efficiency of calves fed on Cr-picolinate supplementation. On the other hand, in stress condition due to transportation, Cr supplementation at 3 ppm reduces transportation stress in beef cattle by reducing weight loss, shortening recovery time, increasing body weight during one week of recovery process (Santosa et al. 2012), while Yang et al. (1996) reported that Cr supplementation tended increased milk production by 13% on first calving heifer. This was due to heifer in the first calving experience was in more stress condition than cows. In this study it seems that growth period of the lamb was not considered at stress condition, and this may be the reason of no response of lamb performance from Cr organic supplementation. Similarly, Mathius et al. (2005) also reported that supplementation of Cr yeast at 4 ppm to late pregnancy and lactation ewes did not affect preweaning lamb growth rate. Though, Lindemann (1997) reported that Cr is needed in stress condition in order to prevent the interference of production, but growth stage of lamb in this study ajusted the condition. It might be considered as non stress condition. Moreover Swanson et al. (2000) reported that Cr yeast supplementation at up to 400μg per kg diet in non-stress growing beef steer did not affect ADG and gain efficiency, eventhough the minor changed in blood glucose kinetics was observed. They suggested that ruminants had less sensitive to insulin, while at the same extent of change blood glucose kinetics in pig could result in increase feed efficiency and improve carcass characteristics (Lindemann, 1997). Moreover, Swanson et al. (2000) suggested that in non stress growing calves supplementation of organic Cr may not be beneficial. Similarly results from this study also found that Cr supplementation did not increase body weight gain as well as feed efficiency, therefore supplementation of Cr organic to non stress sheep at growth stage was not beneficial.

Table 6. Lamb performance fed on different dietary treatments

Parameter	Treatments					SEM
	C	FM	FMCrOrg	FMCr	CCr Org	
Initial weight (kg)	18.5	18.1	18.4	17.7	18.1	
Final weight (kg)	25.0	24.9	25.4	24.1	23.7	0.30
ADG (g/day)	70.2	81.2	83.6	75.7	75.7	4.51
FCR	11.5	9.94	9.66	10.05	9.77	0.46
Protein conversion ratio	1.62	1.39	1.33	1.40	1.36	0.07
Energy conversion ratio	42.6	37.8	36.0	37.4	36.1	1.73

C = Concentrate control
FM = Partly feather meal replacement
FMCrOrg = partly feather meal replacement and supplemented with Cr organic
FMCr = Partly feather meal replacement and supplemented with Cr inorganic
CcrOrg = Concentrate control supplemented with Cr organic

CONCLUSION

It can be concluded that partial replacement concentrate protein with feather meal and its combination with 1.5 mg Cr-organic supplementation in diet of growing sheep did not affect their performance.

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