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The Effect of Garlic Flour and Organic Chromium Supplementation on Feed Intake, Digestibility of Feed and Growth Performance of Goat

Agustinah Setyaningrum[1], Munasik[2], Nur Hidayat[3] and Caribu Hadi Prayitno[4*]
[1,2,3,4]Faculty of Animal Science, Jenderal Soedirman University, Indonesia
*Corresponding: caribuunsoed@gmail.com

ABSTRACT

This study was aimed to evaluate garlic flour and organic chromium on feed intake, digestibility of feed and growth performance (ADG) on goats. The study was conducted for 70 days using 24 Ettawa crossbred goats and 3 PE replacement stock goats aged 8 months which were divided into three treatments which were repeated seven times. The treatments consisted of R0 : 40% native grass + 60% concentrate (CP 14.36 %; TDN 66.32 %), R1 : R0 + 250 ppm garlic flour, R2 : R1 + 1,5 ppm organic Chromium. Data were analyzed using Completely Randomized Design (CRD) with further test using Orthogonal Contrast. Results showed that Supplementation of 250 ppm garlic flour and 1,5 ppm organic chromium mineral had an effect ($P<0.05$) on the consumption of dry matter (CDM) and crude fiber (CCF), digestibility of crude protein (DCP) and crude fiber (DCF), increase in average daily gain (ADG) and body condition score (BCS), but had no effect ($P>0.05$) on consumption of organic matter (COM) and crude protein (CCP), dry matter of digestibility (DDM) and organic matter (DOM), mean rumen pH, blood glucose and total VFA of Ettawa crossbreed goats. The combination of 250 ppm garlic flour supplementation and 1.5 ppm organic chromium (R2) had the same effect as the 250 ppm (R1) garlic flour supplementation treatment in increasing CDM, CCF, ADG and BCS, but tends to reduce DCP goat feed. Hence, the supplementation of 250 ppm garlic flour (R1) and the combination of 250 ppm garlic powder supplementation and organic chromium (R2) had the same effectiveness in increasing consumption and digestibility, glucose metabolism, and growth performance of goats.

Keywords: Goat, Consumption, Digestibility, Organic chromium, Glucose metabolism, Performance, Garlic flour

Introduction

In Indonesia, goat farms are generally owned and operated by smallholder farmers, hence low production owing to poor feed quality is a common issue (Prayitno & Suwarno, 2017). On the other side, the presence of rumen microbial activity, especially methanogens, results in an inefficient use of feed nutrients by livestock. Methanogens will change rumen fermentation results into methane gas, which reflects the loss of feed energy (Busquet et al., 2006). Antibiotics and antimethanogens have been widely utilized to promote growth in ruminants (Yang et al., 2015), however their usage is currently limited due to the fact that they can cause resistance in pathogenic bacteria and residues in meat and milk. In past few years, extensive research has examined the use of plant bioactive compounds and minerals as substitutes for methanogen inhibitors.

Garlic (*Allium sativum*) and organic chromium (Cr) minerals can act as anti-methanogenic and growth promoters. Garlic has various bioactive compounds, including organosulfur compounds, phenolic compounds, saponins, and polysaccharides (Szychowski et al., 2018). The active compounds of garlic that act as antibiotics are organosulfur compounds, namely diallyl thiosulfonate (allicin), diallyl sulfide (DAS), diallyl disulfide (DADS), diallyl trisulfide (DATS), E/Z-ajoene, S-allyl-cysteine (SAC), and S-allyl-cysteine sulfoxide (alliin)

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(Shang et al., 2019). In vitro research showed that the addition of 0.27 g/l garlic oil reduced the number of Archae bacteria by 3.87% and reduced methane gas by 23.94% (Patra & Yu, 2015), while supplementation in the form of 125 mg/l garlic flour reduced methane gas to 15.34% (Prayitno & Suwarno, 2017). The decrease in methane gas can occur because the organosulfur compounds contained in garlic can affect the stability of methanogenic cell membranes by inhibiting HMG-CoA reductase which is a catalyst for the synthesis of isoprenoid cell membranes of methanogens (Prayitno et al., 2013). Meanwhile, Cr mineral plays a role in increasing glucose absorption and tissue protein synthesis through increasing insulin activity in the body which plays a role in providing cell glucose. The addition of Cr increases the entry of glucose into the cells of the body. GTF (Glucose Tolerance Factor)-Cr increases insulin binding by receptors on cell membranes that play a role in the transport of glucose and amino acids as raw materials for protein synthesis so that entry into cells increases. The results showed that Cr supplementation increased the average daily gain of Bengal goats (Haldar et al., 2009) and beef cattle (Bernhard et al., 2012) but did not affect dry matter consumption and final weight. Recent studies on the addition of Cr showed varying results on dry matter consumption and daily body weight gain (ADG).

The combination of garlic flour supplementation with mineral Cr aims to maximize the production of PE goats while reducing the risk of environmental pollution by suppressing the production of methane gas. Prayitno et al. (2014) found that in male Brahman Cross cattle the combination of supplementation of 250 mg/kgDMI garlic flour, 1,5 ppm Cr, and 40 ppm Zn-Lysinate increased the consumption of DM 15.71% and ADG to 32.45%, and decreased the number of protozoa and bacteria by 5.07% and 11.01%, respectively. Prayitno et al. (2019) showed that supplementation of garlic flour combined with several organic minerals (Se, Cr, Zn-Lysinate) increased dry matter consumption by 7.69% and energy consumption by 7.92% in PE dairy goats. In general, the results of the above study indicate that the combination of garlic and organic Cr supplementation can increase livestock productivity in terms of ADG and consumption levels. This combination of garlic flour and organic Cr has never been tested on PE beef goats in order to increase their productivity, so it is necessary to evaluate the effectiveness of the combination on nutrient consumption and digestibility, glucose metabolism, and growth performance of PE goats.

Materials and Methods

Ethical Approved

Using animal and scientific procedures in this study has been approved by Animal Ethics Committee in the Faculty of Animal Science, Jenderal Soedirman University, Indonesia

Livestock, experimental design, livestock treatment and treatment design

The livestock used were male Ettawa crossbreed goats (PE) with an average age of 8 months totaling 21 heads with 3 replacement stock with an average body weight of 20.93 ± 3.80 kg. The design used is a completely randomized design. The treatments consisted of R_0 : 40% native grass + 60% concentrate (CP : 14.36%; TDN : 66.32 %), R_1 : R_0 + 250 ppm garlic

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flour, R_2 : R_1 + 1.5 ppm organic Cr which was repeated as much as seven times. Feed is given as much as 4% of body weight and drinking water is given ad libitum. Feeding was done twice, namely in the morning and afternoon and the treatment feed was given after 14 preliminary days, namely for 40 days. Garlic flour preparation followed the method of Prayitno et al. (2013) and the manufacture of organic Cr minerals based on Prayitno & Widyastuti (2010).

Table 1. Nutrient composition of the experiment

No	Type	R0	R1	R2
1	Native grass (%)	60	60	60
3	Concentrate (%)	40	40	40
4	Garlic Flour (%)	0	0.025	0
5	Seaweed Flour (%)	0	0	3.6
6	Organic Cr Minerals (%)	0.00015	0.00015	0.00015
	Total	100.00015	100.02515	103.6002

Table 2. Results of Native grass and Concentrate Analysis

Feed Ingredients	Nutrient Content				
	Dry Matter (%)	Ash (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)
Native grass*	34.31	9.64	7.05	32.42	0.38
Concentrate*	95.70	6.96	19.24	11.54	7.48

Source : *Proxymate Analysis at the Animal Feedstuffood Laboratory, Jenderal Soedirman University (2019)

Table 3. Experimental Feed Table (R_0)

Feed Ingredients	Nutrient Content					TDN
	Dry Matter (%)	Ash (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	
Native grass 40%	13.72	3.86	2.82	12.97	0.15	43.6
Concentrate 60%	57.42	4.18	11.54	6.92	4.49	72.3
Total 100%	71.14	8.03	14.36	19.89	4.64	

The concentrate ingredients consist of pollard, soybean meal, coconut meal, corn gluten feed (CGF), soybean groats, kleci (outlayer of soy), salt, mineral mix, and amino acid lysine.

Animal feeding and management

The goats were raised in individual pens. The feeds were given 4.0% of body weight and the water were given ad libitum. The diet was offered to the animal twice every day at

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07.00 AM and 04.00 PM. The refusal was collected and weight in the morning before new feed was given.

Digestion trial, chemical, analysis and growth measurement

The feed digestion experiment was carried out for 7 days using the total collection method. The feed given, the rest of the feed and the feces of each experimental unit were weighed and recorded every day. In the total collection, the feed given and the remaining feed were collected for each experimental unit of 100 grams each, while the feces samples were 250 grams. Samples of feed and the rest of the feed were dried in an oven at 60^{o}C, while the feces were stored at 18^{o}C.

Goat rumen fluid was taken through the stomach tube with the help of a vacuum pump. Rumen fluid was taken 3 hours after feeding in the morning, then the pH was measured and stored at -20^{o}C for chemical analysis. Measurement of dry matter, crude protein, crude fiber, crude fat and ash in feed and feces refers to the AOAC (2006). Measurement of feed and feces nitrogen refers to the Kjeldahl method.

Measurement of Nutrient Consumption and Digestibility

The recording of the amount of consumption and the rest of the feed was carried out for 4 weeks and in the last 7 days, samples were taken and the collection of feeding and leftover feed. The administration and the remaining forage were taken as much as 100 g and the administration and the remaining concentrate were taken as much as 10 g from the daily amount and then composited for 7 days of sampling. The sample was sun-dried, followed by baking at 70 °C for 2 days, and then reheated at 105 °C for a day. Dried samples are then ground down for analysis of feed ingredient composition according to AOAC (2006).

Measurement of Blood Glucose Levels, rumen pH, and total VF

Blood glucose measurement. Blood was taken from the jugular vein, 3 hours after eating. Rumen pH was measured 3 hours after eating. The rumen fluid collection point is 2 inches from the last rib and 2 inches from the vertebral column, or three fingers from the 13th rib. The point was wiped using an alcoholic tissue then pricked with a syringe and 7 ml of rumen fluid was taken, then the liquid was put into a glass bottle and stored in a cooler to be transferred to the laboratory. The rumen fluid was centrifuged and the supernatant was taken for analysis by VFA analysis using steam distillation technique (AOAC, 2006).

Growth Parameter Measuremen

Growth was measured by daily body weight gain. Daily body weight gain is the increase in body weight obtained from the difference between the final weight and the initial weight divided by the length of maintenance expressed in grams/head/day.

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Results and Discussion

Consumption and Digestion

Garlic flour supplementation of 250 ppm and organic Cr affected ($P<0.05$) dry matter consumption (CDM), crude fiber consumption (CCF), crude protein digestibility (CPD), crude fiber digestibility (CFD), but did not affect ($P >0.05$) consumption of organic matter (COM), consumption of crude protein (CCP), dry matter digestibility (DDM), and digestibility of organic matter (DOM). The average value of consumption and nutrient digestibility of PE goats supplemented with organic Cr and garlic flour which is presented in Table 2 as follows.

Table 2. Consumption and nutrient digestibility of PE goats supplemented with organic Cr and garlic flour

Parameter	R0	R1	R2	p-value
Dry matter (DM) consumption				
- DM consumption (g/head/hour)	820.29±95,99[a]	999.79±115,84[b]	933.25±82,40[b]	0.011*
- DM Consumption (% BW)	3.31±0.15	3.41±0.13	3.39±0.18	0.481
Organic matter (OM) consumption				
- OM consumption (g/head/hour)	521.90±70.81	589.29±34.89	585.44±57.65	0.067
- OM consumption (% BW)	2.04±0.11	2.10±0.22	2.08±0.11	0.779
Crude protein (CP) consumption (g/head/hour)	244.41±13.00	227.76±23.60	242.22±19.65	0.240
Crude fiber (SK) consumption (g/head/hour)	648.01±82.079[a]	781.27±106.2[b]	756.04±83.3[b]	0.032*
Digestibility				
- Dry matter (DM) Digestibility (%)	77.04±6.11	76.11±3.37	75.59±2.91	0.638
- Organic matter (OM) Digestibility (%)	69.17±10.25	62.23±6.04	66.61±3.05	0.225
- Crude protein (CP) Digestibility (%)	82.02±0.03[b]	72.71±3.2[a]	74.32±2.26[a]	0.000**
- Crude fiber (CF) Digestibility (%)	76.08±0.06[a]	82.42±2.03[b]	82.61±1.52[b]	0.021*

Description: R_0 = 40% native grass + 60% concentrate (CP 14.36 %; TDN 66.32 %), $R_1 = R_0$ + 250 ppm garlic flour, $R_2 = R_1$ + 1.5 ppm organic Cr, different superscripts on the same line shows significantly different, *significantly significant, **very significant effect

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Glucose Metabolism and Growth Parameters

Garlic flour supplementation of 250 ppm and organic Cr affected ($P<0.05$) average daily gain (ADG) and body condition score (BCS), but did not affect ($P>0.05$) the average rumen pH, blood glucose, and total VFA of PE goats. The average values of rumen pH, blood glucose, total VFA, ADG, BCS of PE goats supplemented with garlic flour and organic Cr are presented in Table 3.

Table 3. Average values of rumen pH, blood glucose, total VFA, ADG, and BCS of PE goats supplemented with organic Cr and garlic flour

Parameter	R_0	R_1	R_2	p-value
rumen pH	6.32±0.19	6.14±0.24	6.22±0.37	0.492
Blood Glucose (mg/dL)	21.64±2.30	23.49±2.33	20.37±2.65	0.080*
Total of VFA (mM)	276.17±18.62	201.71±19.06	226.00±12.13	0.050*
ADG (g/head/hour)	$337±22^a$	$405±33^b$	$395±47^b$	0,004**
BCS	$2.22±0.23^a$	$2.49±0.24^b$	$2.69±0.37^b$	0.020*

Description: R_0 = 40% native grass + 60% concentrate (CP 14.36 %; TDN 66.32 %), R_1 = R_0 + 250 ppm garlic flour, R_2 = R_1 + 1.5 ppm organic Cr, different superscripts on the same line shows significantly different, *significantly significant, **very significant effect

Discussions

Consumption and Digestion

Dry matter consumption in R_1 treatment was higher ($P<0.05$) than R_0, but tended to be the same as R_2 treatment. Meanwhile, consumption and digestibility of organic matter and dry matter digestibility of PE goats were not affected by supplementation of organic garlic and Cr flour. This indicates that the supplementation of garlic flour and organic Cr slightly affected the rumen microbial development of PE goats. Garlic flour and organic Cr stimulate the activity of feed-digesting bacteria so that the rate of feed exits the rumen faster and the rumen empty quickly so that livestock will increase dry matter consumption (Prayitno et al., 2014). This is related to the ability of garlic's organosulfur compounds to suppress the development of methanogens, so that the H2 formed in the rumen can be optimally utilized by acetogenic bacteria to produce acetate which is used as an energy source for livestock (Ahring et al., 2018). Organosulfur compounds in the sulfhydryl group of garlic can alter the metabolism of methanogens by interacting with the sulfhydryl groups of microbial proteins. The sulfhydryl group of methanogens contains enzymes that play a role in metabolism, so that its interaction with the sulfhydryl group of garlic can reduce the formation of methane gas (Gebhardt & Beck, 1996; Panthee et al., 2017)). Miller & Wolin (2001) stated that the inhibition of HMG CoA reductase by organosulfur garlic was specific for the Archaea bacteria group (methanogens) without disturbing other bacteria due to the different lipid composition of cell membranes.

Consumption and digestibility of Crude fiber (CF) treatment R1 was higher ($P<0.05$) than R0 but the same as treatment R2. Increased consumption and digestibility of Crude fiber (CF) in R1 treatment indicated that garlic flour did not tend to interfere with cellulolytic

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bacteria in digesting cellulose. Similar results were shown in the study of Prayitno et al. (2014) reveal that 0.25 ppm supplementation increased Crude fiber (CF) digestibility by 4.95% in dairy goats. Different results were shown in Prayitno et al. (2016) that 0.25 ppm garlic flour supplementation reduced the digestibility of Crude fiber (CF) and NDF by 9.01% in beef cattle and 5.10% in lactating dairy cows. Meanwhile, the combination of garlic flour and organic Cr supplementation also increased the consumption and digestibility of crude fiber. Cr plays a role in increasing insulin activity by increasing the ability of insulin to bind to target cell receptors. This insulin plays a role in increasing the use of carbohydrates and fats so that the digestibility of crude fiber can increase (Lashkari et al., 2018; Stoecker, 1999).

Garlic flour supplementation and organic Cr did not affect ($P>0.05$) Crude protein (CP) consumption although it tended to decrease compared to R0 but significantly decreased ($P<0.05$) Crude protein (CP) digestibility. Similar results were shown in the study of Prayitno et al. (2019) that supplementation of garlic flour and organic mineral mixture decreased the digestibility of Crude protein (CP) up to 14.24% and 11.87%, respectively. This is related to the organosulfur component that can reduce the activity of the gram-positive bacteria *Prevotella sp*. which plays a role in protein degradation and amino acid deamination. The low protein degradation and amino acid deamination (Mills et al., 2003; Prayitno et al., 2019) causes a lot of protein that is not utilized by microbes so that a lot of it is excreted through feces. Meanwhile, there was an increase in the Crude protein (CP) digestibility in the combination of garlic flour and organic Cr supplementation than only supplemented with garlic flour. This is related to the ability of organic Cr to increase insulin activity which plays a role in increasing protein synthesis, amino acid transport efficiency and reducing protein degradation (Lashkari et al., 2018).

Rumen pH and Blood Glucose

Garlic flour supplementation (R_1) and the combination of garlic flour and organic Cr (R_2) did not affect the rumen pH but tended to decrease compared to the control. However, the decrease in rumen pH was still within the normal range of rumen pH, which is 6-6.8 Blakely & Bade (1991). These results are similar to other studies where rumen pH was not affected by supplementation of garlic components (Ma et al., 2016) and garlic leaves (Panthee et al., 2017). The decrease in rumen pH due to garlic flour supplementation is due to the role of organosulfur in reducing methanogenic activity, causing H2 formed as a result of metabolism in the rumen to be utilized by other types of bacteria, including acetogenic bacteria that utilize H2 to produce acetic acid (Ahring et al., 2018). This is in line with the existence increase in total VFA in treatments R1 and R2 (Table 3). In addition to being used by acetogenic bacteria, available H2 in the rumen that is not used by methanogens is used for the creation of propionic acid, therefore it also has an effect on increasing total VFA, resulting in a reduction in rumen pH (Dijkstra et al., 2012).

Current blood glucose levels of PE goats (20.37-23.49 mg/dL) were lower than Marhaeniyanto et al. (2019) that the addition of different types of leaves in the concentrate resulted in blood glucose levels of 60.25-64.25 mg/dL. This difference is thought to be caused by different feeds, growth phases and environmental conditions.

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Garlic flour supplementation (R1) and the combination of garlic flour and organic Cr (R2) did not affect blood glucose levels. Supplementation of garlic flour and organic Cr in PE goats in this study was not effective in lowering blood glucose levels. The same findings are revealed by Panthee et al (2017) and Anassori et al. (2015) that supplementation of garlic leaves and garlic oil produced no different plasma glucose. The effectiveness of organic Cr in lowering blood glucose levels was less visible at R2, although it tended to decrease compared to R0. According to Lashkari et al (2018), Cr can increase the activity of cromodulin which is an insulin cofactor. This insulin hormone plays a role in absorbing blood glucose by attaching to receptor cells. It can increase the utilization of carbohydrates and fats, protein synthesis and amino acid transport, and energy use changes that have an impact on increasing dry matter consumption, average body weight gain, carcass parameters, and milk production. Although the supplementation of these two ingredients did not significantly reduce blood glucose levels, garlic flour and organic Cr could increase the average daily gain (ADG) and BCS at R1 and R2. Hence, garlic flour and organic Cr are still effective in increasing livestock productivity through the mechanism of increasing protein and tissue fat synthesis activity.

Average Daily Gain (ADG)

Garlic flour supplementation (R1) and the combination of garlic flour supplementation and organic Cr (R2) were higher ($P<0.05$) than the control treatment. This shows that the supplementation of these two types of ingredients is effective in increasing the productivity of PE goats. Garlic flour acts as an antimethanogen by directly inhibiting methanogenic activity, causing the diversion of utilization of H_2 compounds for the synthesis of propionate and acetate which play a role in the formation of body tissue and fat. Glucose, acetate, and propionate are needed by the body for intramuscular fat deposition. Propionic acid is a precursor of gluconeogenesis, namely the formation of glucose from non-carbohydrate compounds. Glucose from gluconeogenesis will be used for tissue fat deposition, especially intramuscular fat. Park et al. (2018) reprted that glucose is more dominantly required for intramuscular fat deposition than acetate, so the provision of propionate is needed to increase gluconeogenesis activity. Meanwhile, acetate is proven to play a role in external fat deposition (Lunn, 2018). This activity increased the average daily body weight gain of PE goats supplemented with garlic flour.

The combination of garlic flour and organic Cr supplementation resulted in higher average ADG and BCS than the control. Besides the role of garlic flour, the increase in ADG and BCS is also influenced by the role of organic Cr. Organic Cr increases insulin activity which can increase the activity of tissue protein synthesis and amino acid transport, shift the utilization of energy sources, and increase the utilization of carbohydrates and fats. This activity causes livestock to increase dry matter consumption and finally will increase daily body weight gain (Lashkari et al., 2018).

The supplementation of garlic flour (R1) and the combination of supplementation of garlic flour and organic Cr (R2) both increased ADG compared to the control treatment. However, there is a tendency that the R1 treatment resulted in a 3.97% higher ADG than R2. This result is in line with the results of the consumption of dry matter and crude fiber treatment R2 which is lower than R1 although not significant. The effectiveness of the combination of supplementation of these two ingredients on nutritional parameters and growth of PE goats was the same as that of garlic flour supplementation. This can be the basis that garlic flour supplementation alone is sufficient to increase goat productivity.

Conclusion

The supplementation of 250 ppm garlic flour (R1) and the combination of 250 ppm garlic powder supplementation and organic Chromium (R2) had the same effectiveness in increasing consumption and digestibility, glucose metabolism, and growth performance of goats.

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Conflict of interest
The authors have declared no conflict of interest

Authors' contribution
All authors contributed to conducting research and writing this manuscript

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