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Substitution of the Fermented Cocoa Pod Waste in to the Grass Based Diet on Performance of Bligon Goat

Engkus Ainul Yakin*, Sri Sukaryani, and Catur Suci Purwati

Program Study of Animal Science, Faculty of Agriculture, Universitas Veteran Bangun Nusantara, Sukoharjo, Indonesia

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* Corresponding author:
Telp. +62 878 3996 6222
E-mail: engkus_ainul@yahoo.com

ABSTRACT

This experiment was aimed to evaluate the effect of fermented cocoa pod as feed for Bligon goats. Sixteen Bligon goat with a body weight of 11-13 kg were put into individual cages which were equipped with feed and drink containers. The study design used a randomized block design, where initial body weight in as peragam with four treatments and four replications. Fermented cocoa pod used Trametes versicolor. The experimental treatments were T 1 = 30% of fresh king grass + 50% of dried king grass + 20% of concentrate; T2= 30% of fresh king grass + 30% of dried king grass + 40% of concentrate; T3= 30% of fresh king grass + 30% of cocoa pod + 40% of concentrate; and T4= 30% of fresh king grass + 30% of cocoa pod fermented + 40% of concentrate. Observed variables were feed intake, body weight gain and feed conversion. The result showed that fermented cocoa pod at the level of 30% had higher ($P<0.05$) in feed intake (560.33 g day^{-1}), body weight gain (101.79 g head^{-1} day^{-1}), and feed conversion (5.50) compared to other treatments. The conclusion of this study were the use of 30% cocoa pod fermented in the ration showed the best body weight gain and feed conversion on Bligon goat performance.

Keywords: Bligon goat, Cocoa pod, Fermentation, King grass, Trametes versicolor

Introduction

Cocoa pod was the by-product of cocoa plants with the proportion reaching 75% of fresh fruit. The use of cocoa pod as mulch spread around the plant can be a place to grow *Phytophthora palmivora* fungus which causes black pod diseases. This fact causes problems in handling the by-product of cocoa crops because it can directly reduce cocoa production. One possible alternative is the use of cocoa pod as feed ingredients.

Cocoa pod contains 7.75% of protein, 40.15% of crude fiber and energy as much as 3900 kcal/kg that exceed the composition of elephant grass which only contains 6.9% of protein and 3800 kcal/kg of total energy (Yakin *et al.*, 2017). According to this composition, cocoa pod was a potential source of fiber for ruminant feed. However, cocoa pod has low digestibility due to the lignin content in the material, which is about 35%. Hence, delignification was necessary to enhance its digestibility.

The effectiveness of cocoa pod utilization was limited by poor nutritional composition, especially the low protein content and high lignocellulosic component (Alemawor *et al*., 2009). The value of the benefits of agricultural by-products as feed ingredients can be increased by providing preliminary treatments, physically, chemically and biologically (Sun and Cheng, 2002). The preliminary treatment aims to eliminate, break or reduce the bond between cellulose and hemicellulose and lignin. Lignocellulose bonds can be broken by ligninases such as lignin peroxidase (LiP) and manganese peroxidase (MnP) (Takano *et al*., 2004). LiP and MnP enzymes are produced by several organisms including *Trametes versicolor*. *Trametes versicolor* in the process of bioconversion, among others, is able to degrade the lignin component first followed by the cellulose component (de Koker *et al*., 2003), has a fast lag phase of around 0-3 days (Shi *et al*., 2009), and able to grow optimal at 40°C (Singh and Chen, 2008), making it suitable for use in the fermentation process which produces a lot of heat.

Bioconversion with *Trametes versicolor* can reduce the bonding and lignin content which can improve the quality of cocoa pods. The total digestible nutrient (TDN) and protein content of cocoa pods are almost the same as king grass. This study aims to examine the use of fermented cocoa pods with *Trametes versicolor* on the performance of Bligon goats.

Materials and Methods

Cocoa pod was obtained from Wonogiri Regency, Central Java Province, Indonesia. Cocoa pod was chopped into 2 cm in size and sun-dried until the water content reached around 35% (Yakin *et al*., 2017).

Cocoa pod was chopped and dried until the dry matter content were estimated to reach 35%. Every 100 kg of dry cocoa pod placed on a plastic bucket and 100 ppm Mn and 1190 ppm Ca (base on dry matter) are added. Cocoa pod was inoculated with *Trametes versicolor* as much as 0.9% of the dry matter (Bonnen *et al*., 1994); and mixed evenly. Cultured starter molds were grown on cocoa pod for 7 days. A mixture of cocoa pod and mold were fermented for 7 days. Fermented cocoa pod was one of the ingredients making up the ration.

The instrument used in this study were a individual cage with plot measuring 60 cm x 100 cm were occupied by one goat. Each cage were equipped with a wooden tub where the feed were complete, while the drinking water container used a plastic bucket. Digital analytical scales with a sensitivity of 0.0001 g, a scale capacity of 10 kg with a sensitivity of 0.1 kg, a scale capacity of 1000 kg with a sensitivity of 0.5 kg, and a feed containers. The goats used sixteen male Bligon goats with initial body weights of 11.5±1.5 kg. The composition of the ingredients of the experimental goat ration is shown in Table 1. The mineral content of the ration was enriched by the addition of $MnSO_4.H_2O$ and $CaCl_2$. The ration was arranged to achieve 100 grams of body weight gain per day, with protein requirements of 50 grams and TDN of 359 g $days^{-1}$ (NRC, 1985). Estimation of the ability of dry matter intake by goats is 645 g $head^{-1}$ day^{-1}. The food given is in the form of fresh king grass, dried king grass, fermented cocoa pod and concentrate. The study was conducted in three periods, namely adaptation, introduction and data collection. The adaptation period was to adapt goats to the experimental environment. The adaptation period was 30 days, 15 days preliminary period and 28 days data collection period. Feed in the data collection period was given *ad libitum*, the amount of which is determined based on free feed intake in the introduction period. Drinking water were given *ad libitum*.

Sixteen Bligon goat with a body weight of 12.72-13.88 kg were put into individual cages equipped with feed and drink containers. The third stage of the study design used a randomized block design, where initial body weight in as peragam with four treatments and four replications. The treatment of cocoa pod as feed as follows : T1 = 30% of fresh king grass + 50% of dried king grass + 20% of concentrate, T2 = 30% of fresh king grass + 30% of dried king grass + 40% of concentrate, T3 = 30% of fresh king grass + 30% of cocoa pod + 40% of concentrate, T4 = 30% of fresh king grass + 30% of cocoa pod fermented + 40% of concentrate.

Variables measure were : feed and nutrient intake (g $head^{-1}$ day^{-1}), body weight gain (g day^{-1}), and feed conversion.

Analysis of the data obtained due to treatment was tested with Analysis of Variance (ANOVA) with an unidirectional study design, if there were differences in variables because the treatment was continued with Duncan's multiple range test (DMRT) to determine differences between treatments (Astuti, 2007).

Results and Discussion

Feed and nutrients

Feed intake can be expressed in units of head g^{-1} day^{-1} (van Hao and Liden, 2001), g kg^{-1} body weight day^{-1} (Van et al., 2005), or g kg^{-1} metabolic body weight ($BW^{0.75}$) day^{-1} (Mandal *et al*., 2005). The average of dry matter intake (Table 2) during the study ranged from 434-560 g $head^{-1}$ day^{-1} or 60-78 g kg^{-1} $BW^{0.75}$ day^{-1}. The dry matter intake reported by several researchers varies, namely 41.5 g kg^{-1} $BW^{0.75}$ day^{-1} (Kondo *et al*., 2004), 54.94 g kg^{-1} $BW^{0.75}$ day^{-1} (Katongole *et al*., 2009), 61.8 g kg^{-1} $BW^{0.75}$ day^{-1} (Aregheore, 2006), and 78.1 g kg^{-1} $BW^{0.75}$ day^{-1} (Abdou *et al*., 2011). Differences in the dry matter intake are caused by

Table 1. Composition, and nutrient content of diet (% DM)

Variable	T1	T2	T3	T4
Type of feed (%)				
Forage				
Fresh king grass	30.00	30.00	30.00	30.00
Dried king grass	50.00	30.00	0.00	0.00
Cocoa pod	0.00	0.00	30.00	0.00
Fermented cocoa pod	0.00	0.00	0.00	30.00
Concentrate				
Cassava waste	4.00	16.00	13.00	13.00
Pollard	6.00	8.00	10.00	10.00
Soybean meal	4.00	6.00	5.00	5.00
Rice bran	6.00	10.00	12.00	12.00
	100.00	100.00	100.00	100.00
Nutrient composition				
Crude protein (%)	13.42	13.36	13.14	13.54
Crude fiber (%)	22.55	24.26	24.34	23.76
TDN (%)	64.07	68.65	68.35	71.22

T1 = 30% of fresh king grass + 50% of dried king grass + 20% of concentrate, T2 = 30% of fresh king grass + 30% of dried king grass + 40% of concentrate, T3 = 30% of fresh king grass + 30% of cocoa pod + 40% of concentrate, T4 = 30% of fresh king grass + 30% of cocoa pod fermented + 40% of concentrate.

Table 2. Average of feed intake of Bligon goat (g head^{-1} day^{-1})

Parameter	Treatments			
	T1	T2	T3	T4
Dry matter	434.65±0.81	499.23±0.59	538.55±0.24	560.71±0.57
Organic matter	368.29±0.72^{b}	428.33±1.51^{ab}	467.45±0.21^{ab}	492.01±1.50^{a}
Crude Protein	45.98±0.11^{b}	59.61±0.74^{ab}	63.27±1.32^{a}	72.11±1.7^{a}
Crude Fat	24.36±1.04^{b}	46.84±1.55^{a}	47.22±0.26^{a}	47.29±0.53^{a}
Crude Fiber	120.41±1.28^{bc}	109.11±0.13^{c}	154.52±1.70^{ab}	130.76±1.13^{abc}
TDN	274.20±1.58^{b}	344.91±1.41^{ab}	351.59±1.16^{ab}	388.23±0.40^{a}
NDF	250.31±1.53	270.77±0.32	305.27±1.14	281.09±0.30
ADF	173.33±0.32^{b}	162.52±1.19^{b}	232.44±1.10^{a}	215.23±0.22^{ab}
Cellulosa	111.59±1.22^{b}	102.02±0.12^{b}	117.28±0.54^{b}	135.66±0.14^{ab}
Hemicellulosa	77.23±0.16^{b}	108.54±1.13^{a}	73.11±1.36^{b}	66.42±0.75^{b}

^{a,b,c}Different superscripts on the same line show significant differences (P<0.05). T1 = 30% of fresh king grass + 50% of dried king grass + 20% of concentrate, T2 = 30% of fresh king grass + 30% of dried king grass + 40% of concentrate, T3 = 30% of fresh king grass + 30% of cocoa pod + 40% of concentrate, T4 = 30% of fresh king grass + 30% of cocoa pod fermented + 40% of concentrate.

nutrient content, especially protein content and feed energy (Negesse *et al*., 2001), physiological status (Fedele *et al*., 2002), sex of livestock (Lewis and Emmans, 2010), and constituent feed ingredients ration (Aregheore, 2006). The use of fermented cocoa pod (Table 2) plays a role in increasing the protein content of feed (Table 1) which has implications for increasing of dry matter intake (Table 2), but has not shown any difference.

Dry matter intake of T1 and T2 treatments was lower than other treatments. Coleman and Moore (2003) state that regulation of feed intake was an interaction between the characteristics of feed ingredients, rumen and livestock. Bulky king grass limits the ability of livestock to consume more food because the capacity of the rumen was limited. Yansari *et al*. (2004) state that feed intake can be limited by rumen capacity and length of digestion expenditure from the rumen. Toharmat *et al*. (2006) showed that the specific gravity of king grass (0.854 kg/dm^3) was smaller than cocoa pods (1.156 kg/dm^3). Feed material with a smaller specific so it requires a larger space in the rumen of livestock.

Dry matter intake ranged from 3.1% - 4.0% of body weight. The feed consumed were used for maintenance and growth or reproduction. The dry matter intake has fulfilled the maintenance needs, which is 2.4% - 2.8% of body weight (NRC, 1985) but has not fulfilled the need to increase body weight by 100 g head^{-1} day^{-1}. The need for dry matter to reach body weight gain 100 g head^{-1} day^{-1} was 360 g plus the need for maintenance which depends on the body weight of goats. Dry matter intake below the standard needs of goats often occurs because the feed were more resistant to breakdown during chewing (chewing) which will reduce the dry matter digestibility. Coleman and Moore (2003) states that digestibility has a close relationship with the dry matter intake.

The pattern of organic matter intake follows the pattern of dry matter intake. The average organic matter intake during the study ranged from 368-492 g head^{-1} day^{-1} or 51-69 g kg^{-1} BW$^{0.75}$ day^{-1}. Organic matter intake is lower than the results of research by van Hao and Liden (2001), which is 565 g head^{-1} day^{-1}. Tuah *et al*. (1995) reported that organic matter intake in rations by sheep was around 71.8-95.4 g kg^{-1} BW$^{0.75}$ days^{-1}. Organic matter intake in treatment T1 was lower (P<0.05) compared to other treatments. The low organic matter intake is due to the low of dry matter intake (434 g head^{-1} day^{-1}) and higher ash content (15.13%).

Protein intake was closely related to body weight gain. Protein were used for the fulfillment of maintenance, production, and reproduction. The average protein intake during the study ranged from 45-72 g head^{-1} day^{-1}. This amount of protein intake has the standard estimate the adequacy of crude protein requirements based on body weight to reach body weight gain 100 g day^{-1}, was 56-58 g head^{-1} day^{-1} except T1. Protein intake of T1 was smaller (P<0.05) compared T2, T3, and T4. Low of protein intake was caused by dry matter intake and organic matter and lower protein content compared to other treatments. Utilization of fermented cocoa pod increases ration protein content and feed intake.

The efficiency of nutrient utilization depends on the adequacy of energy and protein. The fulfillment of energy needs is directed at the energy needs for maintenance and energy needs for production. Energy intake ranges from 274 - 388 g head^{-1} day^{-1}. The standard requirement for TDN for goats with a body weight of 10 kg and body weight gain 100 g is 359 g (NRC, 1985) greater than the results of the study of Mandal *et al*. (2005), namely 331 g head^{-1} day^{-1}. Energy intake of T1 was lower (P<0.05) compared to other treatments. In line with the other nutrients intake, low dry matter intake causes low energy intake. The amount of energy intake were combination of dry matter intake and ration energy content. Lallo (1996) reports that energy intake increases with the increase in feed energy content.

Goats need crude fiber for normal rumen activity and function. Crude fiber were degraded by microbes that act as energy providers to support maintenance, growth, lactation and reproduction (Lu *et al*., 2005). The need for crude fiber in goat rations has not been clearly established in the guidelines and standards for nutritional requirements. Average of crude fiber intake ranges from 109-157 g head^{-1} day^{-1}. The lowest of crude fiber intake in T2 and T4 in the highest. This difference in consumption is due to the crude fiber content and the proportions of different ingredients. The reduction in crude fiber consumption of T1 was due to a partial substitution of king grass with the used of concentrates which had lower crude fiber content.

The role of crude fiber as an energy source was closely related to the proportion of constituent components of fiber such as cellulose, hemicellulose and lignin. The average of NDF intake is 284 g head^{-1} day^{-1} or 40 g kg^{-1} BB^{0,75} day^{-1}. Research conducted by Souza *et al*. (2009) produced 32 g kg^{-1} BW^{0,75} day^{-1} NDF intake by goats. The NDF content of the ration were illustrated the number of components of cell wall fiber fraction contained in the ration were hemicellulose, cellulose and lignin, and the amount in this study were estimated to be too high in supporting the optimum development of rumen microbes.

Increased body weight

Growth was an indicator of the process of nutrient deposition in body tissues. The ability of N protein retention into tissues is influenced by the supply of protein and ration energy. The average of goats is 81 g head^{-1} day^{-1}. This result has not reached the target of 100 g head^{-1} day^{-1}. This is due to energy intake that is still below standard. The protein intake that has met the needs of goats were not followed by the availability of energy for growth. The initial body weight of goats before treatment ranged from 12.72-13.88 kg (Table 3) requires energy ranging from 392-405 g head^{-1} day^{-1}, while the energy intake of feed ranges from 274-388 g head^{-1} day^{-1}.

The crude protein content and TDN treatment ration have the standard requirements. Dry matter intake which ranges from 57.95% - 75.26 from the need is the main cause of low protein and energy intake. Low dry matter intake is due to the high fiber fraction content. Lu *et al*. (2005) explain that the ADF content of 18% will produce the highest of dry matter intake and decrease in the ADF content of more than 18%. Dry matter intake and non-fiber carbohydrates (NFC) decreases linearly with an increase in feed NDF content (Zhao *et al*., 2011) because increased of fiber fractions intake will increase chewing activity (Lu *et al*., 2005). Treatment 4 consisted of 30% fresh king grass, 30% cocoa pod fermented, and 40% concentrate produced the highest body weight gain, which was 102 g. This result is better than the results of the study of Tuah *et al*. (1995), which is 55 g at the level of use of the cocoa pod 30% in the ration. Aregheore (2002) obtained goat body weight gain which was fed in the form of a mixture of several by-products of chocolate with 95 g of head^{-1} day^{-1}.

The use of fermented cocoa pod (T4) gives better results than the use of cocoa pod (T3) and king grass (T2). The three ingredients have the same proportion (30%) in the ration, but give a different daily body weight gain, which was 102; 84; and 77 g respectively for T4, T3, and T2. That was due to better consumption and chemical composition of T4 feed. T4 dry ration consumption of 560 g or 75.26% of the estimated dry matter needs were 745 g, higher than other treatments. Feed intake that were still below the requirement allows the substrate to stay longer in the rumen and gives the enzyme more time to make contact with the substrate.

Feed conversion

The biggest loss of dry matter intake especially those from forage and by-products agriculture occurs in faeces (Coleman and Moore, 2003). The proportion of lost feed and utilization others affect the efficiency of the feed. Feed conversion can be measured by the efficiency of feed use and feed conversion. Feed conversion was the amount feed consumed to produce one unit livestock production (Katongole *et al*., 2009). The smaller feed conversion value indicates the better of quality feed. Feed conversion of experimental ranges 5.50-7.38. This result was better than cocoa pod conversion in sheep from 12.23-17.74 (Lallo, 1996). Research on Aregoheore (2004) the results feed conversion of 14.90 in goats used with potato leaves. The magnitude of the feed conversion value was highly dependent on the digestibility and metabolism of nutrients in the body of livestock. Feed consumed by livestock will be used for maintenance and production. Feed conversion of T1 was greater ($P<0.05$) compared to other treatments. The smallest conversion (5.50) achieved by T4.

Table 3. Initial body weight, average daily gain and feed conversion of Bligon goat

Parameter	Treatments			
	T1	T2	T3	T4
Initial body weight (kg)	13.88±0.58	12.72±1.14	13.50±0.91	13.73±1.06
Final body weight (kg)	15.53±0.67	14.88±1.29	15.85±0.95	16.58±1.11
Metabolic body weight (kg)	7.19±0.23	6.73±0.45	7.04±0.36	7.13±0.41
Average daily gain (g head^{-1} day^{-1})	58.95±3.09^{d}	77.38±5.46^{c}	83.93±1.79^{b}	101.79±1.79^{a}
Feed conversion	7.38±0.51^{a}	6.45±0.63^{ab}	6.42±0.41^{ab}	5.50±0.47^{b}

^{a,b,c} Different superscripts on the same line show significant differences ($P<0.05$). T1 = 30% of fresh king grass + 50% of dried king grass + 20% of concentrate, T2 = 30% of fresh king grass + 30% of dried king grass + 40% of concentrate, T3 = 30% of fresh king grass + 30% of cocoa pod + 40% of concentrate, T4 = 30% of fresh king grass + 30% of cocoa pod fermented + 40% of concentrate.

Conclusions

Utilization of 30% cocoa pod fermented combined with king grass and concentrate results in dry matter intake (560 g head^{-1} day^{-1}), body weight gain (102 g head^{-1} day^{-1}) and feed conversion (5.50) and which is better compared to rations containing only king grass and cocoa pod without fermentation.

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