Evaluation of Nutrient Digestibility of Goats Fed on Biofermented Cocoa Pods Using *Phanerochaete chrysosporium* Supplemented by Mangan (Mn) and Calsium (Ca)

Suparjo [1)], E.B. Laconi [2)], K. G. Wiryawan[2)], & D. Mangunwidjaya[3)]
[1)] Department of Animal Production, Faculty of Animal Science, University of Jambi
[2)] Department of Nutrition and Feed Technology, Faculty of Animal Science, Bogor Agricultural University
[3)] Department of Agricultural Industrial technology, Faculty of Agricultural Technology, Bogor Agricultural University

Abstract

An in vivo experiment was conducted to evaluate biofermented cocoa pods to substitute forages for goats. The experiment was carried out using a Randomized Block Design on a total of 15 goats with 5 treatments and 3 blocks. Ration was designed iso-protein (50 g/day) and TDN (359 g/day) using cocoa pod (CP) or napier grass (NG) as forages and concentrate. The treatments consisted of concentrate plus : 80% NG (R1); 60% EG (R2); 30% EG and 30% untreated CP (R3); 30% EG and 30% bio fermented CP supplemented Mn and Ca (R4), and 30% NG and 50% biofermented CP supplemented Mn and Ca (R5). Variables measured were feed consumption, nutrient digestibility and average daily gain. Data were analyzed with analysis of variance and followed by Duncan`s multiple range test. Results showed that ration contained 30% biofermented CP supplemented by 100 ppm Mn and 1 190 ppm Ca, 30% napier grass and 40% concentrate resulted in a better goat performance and more profitable than other rations. Goats receiving such ration had more advantage on dry matter consumption (560.33 g/day/head), dry matter digestibility (70.48%), organic matter digestibility (74.31%), feed conversion (5.50), average daily gain (101.79 g/day/head) and income over feed cost (Rp 1 192.80) compared to the other treatments. It was concluded that cocoa pod biofermented with Phanerochaete chrysosporium supplemented by Mangan (100 ppm Mn) and Calsium (1 190 ppm Ca) is potential to be used as forages for substituting napier grass for feeding goats during growing period.

Keywords: cocoa pod, biofermented, Phanerochaete chrysosporium fungi, nutrient digestibility

Introduction

Cocoa pod is a biggest cocoa by-product. Some researchers utilized cocoa pods as animal feed for cows (Smith *et al.* 1988; Amirroneas 1990; Laconi 1998), sheep (Smith and Adegbola 1985), broiler (Donkoh *et al.* 1991; Sobawima and Longe 1994; Olubamiwa 2002; Tequia 2004), layer (Osei *et al.* 1991) and rabbit (Ridwan *et al.* 1993). Utilizing cocoa pods on ruminant decrease feed digestibility and animal performance (Smith and Adegbola 1985; Smith *et al.* 1988).

Constrains utilizing cocoa pods as animal feed are low protein and high fiber contents. High lignin content and hard structure of cocoa pods can reduce feed consumption, digestibility and animal performance.

Utilizing cocoa pods as feed can improve by pretreatment with *Phanerochaete chrysosporium*. *P. chrysosporium* bioconversion can reduce tightness lignocellulose bond and feed lignin content. Fermentation cocoa pods with *P. chrysosporium* and supplement Ca and Mn for 10 days result better digestibility and cellulose lignin ratio.

Materials and Methods

Main materials used were cocoa pods, manganese sulfat ($MnSO_4 \cdot H_2O$), calsium chloride ($CaCl_2$) and *P. chrysosporium* fungi. *P. chrysosporium* fungi IFO 31249 were obtained from Pusat Penelitian Kimia-LIPI Kawasan PUSPIPTEK Serpong. Fungus were maintained on millet for 10 days.

Diet composed to fulfill nutrient requirement goats with weight 10kg and daily gain 100 g day^{-1}. Nutrient requirement base on 50g day^{-1} total protein and 359g day^{-1} total digestibility nutrient (NRC 1981). Feed dry matter consumption estimated as big as 645g day^{-1}.

Fresh cocoa pods chopped and dried (dry matter $\pm$35%). Dried Cocoa pod was supplemented with 100 ppm Mn dan 1190 ppm Ca and inoculated with 0.9% *P. chrysosporium* (Bonnen *et al.* 1994). Cocoa pod was fermented for 10 days.

Fifty goats with an average live weight of 11.60±1.54 kg were used to compared utilization of cocoa pods in randomized complete design. Treatment did in 3 periods were adaptation period for 30 days, preliminary period for 15 days and data collection for 28 days. Diets for data collection period were ad libitum based on voluntary feed intake on preliminary period. Measured and analyzed variables were feed and nutrient consumption (g kg^{-1} $BW^{0.75}$ day^{-1}), average daily gain (g day^{-1}), nutrient digestibility (total collection method) and feed conversion.

Data on feed intake, growth, feed conversion, feed digestibility were analyzed statistically by analysis of variance (ANOVA) and Duncan's multiple range test was used to separate the means.

Table 1. Composition diet experiment (%)

Feedstuffs	Treatment				
	A	B	C	D	E
Napier grass (NG)	80.0	60.0	30.0	30.0	30.0
Cocoa pod (CP)	0.0	0.0	30.0	0.0	0.0
Fermented cocoa pod	0.0	0.0	0.0	30.0	50.0
Rice bran	9.5	29.5	29.5	29.5	9.5
Corn	2.0	2.0	2.0	2.0	2.0
Coconut Meal	2.0	2.0	2.0	2.0	2.0
Soybean Meal	2.0	2.0	2.0	2.0	2.0
Molasses	3.2	3.2	3.2	3.2	3.2
Salt	0.5	0.5	0.5	0.5	0.5
Feedmix	0.8	0.8	0.8	0.8	0.8
Total	100.0	100.0	100.0	100.0	100.0
Diet Nutrient (% DM)					
Dry matter	84.88	86.31	86.29	86.25	84.78
Crude protein	10.18	11.29	11.32	12.89	12.86
TDN	58.93	62.37	61.59	62.59	59.29

Results and Discussion

Feed Intake

The level of intake and the characteristics of digestion depend closely on the feeding behaviour in goats reared in the goat house (Morand-Fehr 2005). Feed intake can expressed in g day^{-1} (Lallo 1996), g BW^{-1} day^{-1} (Aregheore 2000) or g kg^{-1} $BW^{0.75}$ day^{-1} (Ananda *et al.* 1996; Mandal *et al.* 2005). Dry matter intake (Table 2) were 433.92 - 560.33 g $days^{-1}$ or 60.40 - 78.49 g kg^{-1} $BW^{0.75}$. Some researches had been reported that dry matter intake by goats were 41.5 (Kondo *et al.* 2004), 46.0 (Ananda *et al.* 1996), 57.1 (Santra *et al.* 1998) and 61.8 g kg^{-1} $BW^{0.75}$ day^{-1} (Aregheore 2006). The variation of feed intake caused nutrient content, particularly feed protein and energy (Lallo 1996), sex (Aregheore 1995) and feed composition (Aregheore 2006). Dry matter intake increased with increasing feed protein. However, no significant ($P>0.05$) differences were obtained among treatments. Lallo (1996) reported dry matter intake by goats increased in step increasing feed protein content.

Feed Digestibility

Dry matter digestibility range from 55.36 to 70.48% (Table 3). Tuah *et al.*

Table 2. Average nutrient consumption (g day^{-1})

Nutrient	Treatment				
	A	B	C	D	E
Dry matter	433.92^{a}±8.40	499.29^{a}±59.05	537.93^{a}±24.04	560.33^{a}±57.07	549.83^{a}±21.15
Organic matter	368.27^{b}±7.13	427.69^{ab}±50.59	467.41^{ab}±20.89	492.31^{a}±50.14	481.82^{a}±16.16
Crude protein	45.17^{b}±0.87	58.92^{ab}±6.97	63.48^{a}±2.84	71.55^{a}±7.29	66.09^{a}±14.56

Means within each treatment for each variable of different superscript differ (P<0.05).
A: 80% NG + 20% concentrate; B: 60% NG + 40% concentrate; C: 30% NG + 30% CP + 40% concentrate; D: 30% NG + 30% Fermented CP + 40% concentrate; C: 30% NG + 50% Fermented CP + 20% concentrate.

Table 3. Nutrient digestibility (%) experimental diet

Nutrien	Treatment				
	A	B	C	D	E
Dry matter	55.36^{b}±7.01	66.99^{a}±5.82	64.13^{a}±6.21	70.48^{a}±2.47	68.32^{a}±2.80
Organik matter	59.25^{b}±6.74	70.27^{a}±5.24	68.37^{a}±5.66	74.31^{a}±2.17	71.28a±2.55

Means within each treatment for each variable of different superscript differ (P<0.05).
A: 80% NG + 20% concentrate; B: 60% NG + 40% concentrate; C: 30% NG + 30% CP + 40% concentrate; D: 30% NG + 30% Fermented CP + 40% concentrate; C: 30% NG + 50% Fermented CP + 20% concentrate.

(1995) reported that dry matter digestibility of cocoa pods on sheep range from 44.67 to 59.02%, tend to decrease with increasing level of cocoa pods in the diet. The difference was caused by goat capability in digest fiber fraction compare sheep.

There were difference (P<0.05) ini dry matter digestibility of goats fed napier grass. The digestibility of dry matter of diets of B, C, D and E were not different (P>0.05). Diet contain 30% fermented cocoa pod had highest digestibility value, about 70.48%. Diet D contain higher crude protein but lower fiber content. Tuah et al. (1995) reported that digestibility of cocoa pods with level 30% in sheep diet as big as 49.37%. This difference is caused by change of characteristic of fermented cocoa pods and ability of livestock in digesting fibrous feed. Fermentation of cocoa pods with *P. chrysosporium* and addition of Ca and of Mn can decrease lignin content and improve crude protein. Degradation of lignin content give to access to microbe for the degrade of cellulose, hemiselulosa and other feed component.

Average Daily Gain

Average daily gain of goat was 81.19 g day^{-1} (Table 4) lower than target was 100 g day^{-1}. Lower feed protein and energy cause daily gain was low. Protein requirement for goat with body weight 13.47kg and daily gain 100 g was 85.99 g day^{-1}. Estimated dry matter, protein and TDN requirement are in Table 5.

Diet D contain 30% napier grass, 30% fermented cocoa pods and 40% concentrate give highest daily gain was 101.79 g. This result better than *et al.* (1995) that

Table 4. Initial body weight, daily gain, and feed efficiency

Nutrient	Treatment				
	A	B	C	D	E
Initial body weight (kg)	13.88±0.58	12.72±1.14	13.50±0.91	13.73±1.06	13.52±3.48
Final body weight (kg)	15.53±0.67	14.88±1.29	15.85±0.95	16.58±1.11	15.87±3.57
Daily gain (g)	58.95^{d}±3.09	77.38^{c}±5.46	83.93^{b}±1.79	101.79^{a}±1.79	83.93^{b}±3.09
Feed conversion	7.38^{a}±0.51	6.45^{ab}±0.63	6.42^{ab}±0.41	5.50^{b}±0.47	6.52^{ab}±1.20

Means within each treatment for each variable of different superscript differ (P<0.05).
A: 80% NG + 20% concentrate; B: 60% NG + 40% concentrate; C: 30% NG + 30% CP + 40% concentrate; D: 30% NG + 30% Fermented CP + 40% concentrate; C: 30% NG + 50% Fermented CP + 20% concentrate.

Table 5. Estimation of requirement of dry matter, protein and TDN for daily gain 100 g

Requirement	Treatment				
	A	B	C	D	E
Dry matter (g day^{-1})[a]	748.73	716.07	738.00	744.53	738.47
Protein					
Metabolic body weight (kg $BB^{0.75}$)	7.19	6.73	7.04	7.13	7.02
CPm (g day^{-1})[b]	41.92	39.24	41.04	41.57	40.93
CPg (g day^{-1})[b]	45.00	45.00	45.00	45.00	45.00
Total protein (g day^{-1})	86.92	84.24	86.04	86.57	85.93
Protein in diet (%)	11.61	11.76	11.66	11.63	11.64
Energy					
TDNm (g day^{-1})[b]	216.42	202.57	211.90	214.61	211.30
TDNg (g day^{-1})[b]	161.00	161.00	161.00	161.00	161.00
Kebutuhan TDN (g day^{-1})	377.42	363.57	372.90	375.61	372.30
TDN in diet (%)	50.41	50.77	50.52	50.45	50.42

CPm= Protein for maintainance (5.83 g kg-1 BB0.75); CPg= protein for gain (0.45 g for 1 g body gain); TDNm: TDN for maintainance (30.1 g kg-1 BB0.75); TDNg: TDN growth (1.61 g for 1 g body gain).
[a] 2.8 (%) x BW (kg) + 0.36 kg (NRC 1981); [b] Mandal *et al.* (2005).

obtain 55 g on 30% cocoa pods in diets. Utilizing fermented cocoa pods (D) give better result than nonfermented cocoa pod (C) and napier grass (A). However, these feed contain same proportion (30%) in the diet resulted different daily gain, 101.79, 83.93 dan 77.38 g for diet D, C and A, respectively.

Feed conversion influence body gain. Smaller feed conversion value indicated better feed quality. Feed conversion on this experiment range from 50 to 7.38. This result better than cocoa pod conversio on sheep was 12.23-17.74 (Lallo 1995). Feed conversion of diet A significantly ($P<0.05$) bigger than others.Diet contain 30% fermented cocoa pods result lowest feed conversion was 5.50. Lower feed conversion and higher body gain influence economical value of feed. Analysis of feed cost on benefit did calculated *Income Over Feed Cost* (IOFC). Better daily gain on diet that contain fermented cocoa pod menghasilkan highest income (Rp 1 192.80) than others.

Conclusion

Utilization 30% fermented cocoa pods that combination with 40% concentrate and 30% napier grass result dry matter consumption (560.33 g day^{-1}), dry matter digestibility (70.48%), organic matter digestibility (74.31%), feed conversion (5.50), daily gain (101.79 g day^{-1}) *income over feed cost* (Rp 1 192.80) is better and more profitable than napier grass and non fermented cocoa pods.

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