The Nutritive Value of Cocoa Shell in Ruminants

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ABSTRACT: The nutritive value of cocoa shell was studied by *in vitro* and nylon bag technique and a feeding trial was also carried out in growing cattle. Cocoa shell contains 17.6% CP, 4.6% fat, 46.6% NDF,0.36% Ca, 0.61% P, 0.06% Na, 0.61% Mg and 1.6 % theobromine. The dry matter (DM) digestibility of cocoa shell was 63.5 % and within 48 hr 50 % of the DM disappeared from the rumen. Approximately 30 % of cocoa shell protein disappeared from the rumen after 12 h and there was small increase after that time. Whereas for fat, there was an increasing amount disappeared from the rumen after 12 hr but may reach the maximum value (73 %) at 48 hr. Cocoa shell is a good source of energy and minerals, P and Mg for ruminants. Five levels of cocoa shell (CS), 7, 17, 27, 37 and 47 %, were included in the concentrate to study (I) theobromine disappearance in the rumen, (II) its effect on growing cattle. In experiment I, 2 fistulated Ongole fed elephant grass *ad libitum* plus 2 kg concentrate (with 7 % CS) were used to suspend the nylon bag containing different levels of CS. Almost all of theobromine disappeared from nylon bag at 24 hr incubation, and there was no difference with 48 hr incubation. In experiment II, thirty Ongole (144 ± 12.2 kg) were randomly divided into 5 treatment groups recieving elephant grass ad libitum + concentrate (1.2% Live Weight) containing different levels of CS . The experiment lasted for 80 days. There were no differences in intake of dry matter (DM) and metabolisable enery (ME) between the treatments. Live weight gain was not affected by feeding less than 27 % CS in the concentrate (or 11% in the ration). However, at 37% CS (or 15 % in the ration), live weight gain started to decline. At this level the ration contains approximately 0.24 % theobromine which may be responsible for reduced utilisation of metabolisable energy.

Key Words: Cocoa Shell, Nutritive, *In Vitro*, Nylon Bag, Ruminants

Introduction

In Indonesia, the tropics in general, the ruminants basal diet consists of forage, which its protein and energy does not meet the requirements for high growth or milk production. For this reason, feed supplement needs to be added to the basal diet. However, the high demand of feeds by poultry industry forces farmers who raise cattle to find feed resources which does not compete with poultry industry.

There is a substantial production of cocoa bean shell in this country, estimated around 13500 ton in 1990 (BPS, 1991) but it had not been used widely as ruminant feed. The above figure is expected to increase as the plantation area is expanded since then. This by-product (from cocoa processing factory) could be used as source of feed without competing with human need (NRC ,1983).

Proximate analysis showed that cocoa shell has 14% - 22% protein and 3% - 9% fat (Gohl, 1980; NRC, 1983). Based on this data, cocoa shell may be used as feed supplement in ruminant diet. Furthermore, low level of inclusion of cocoa shell in the diet could act as appetite stimulant (Sutherland, et al., 1970; Zaomas, et al., 1976; Tarka, et al., 1978).

The limiting factor of cocoa shell as a feed may be the content of alkaloid theobromine (3,7-dimethylxanthine) which was suspected to have deleterious effect on animals (Wong, et al 1986). However, low level of inclusion in the diet were reported to be safe. In dairy cattle, 1 kg/h/d caused no ill effects (Weineger, et al., 1956), increased the resistance of milk from oxidative deterioration and increased fat content (Mueller and Blazys, 1955; Chase, 1989) or decreased milk yield (Haring and Kubliz, 1955). Flachowsky, et al., (1990) suggested to use cocoa shell up to 5% dry matter (DM) intake in ruminant diet as this level did not effect milk yield and milk fat content. Whereas detheobrominized cocoa shell may be used up to 30% in the ration

Table 1. The proximate analysis, DM digestibility, and protein, fat and theobromine disappearance of cocoa shell in the rumen

		Rumen fermentation (hr)		
		12	24	48
Dry matter (%)	94			
Crude protein (%)	17.6	29.6	31.0	32.2
Fat (%)	4.6	55.3	59.1	72.9
NDF (%)	46.6			
Ca (%)	0.36			
P (%)	0.61			
Na (%)	0.06			
Mg (%)	0.61			
Theobromine (ppm)	16000			
Level in Conc:				
7%		99.9	99.9	
17%		99.9	99.9	
27%		99.9	99.9	
37%		99.9	99.9	
47%		99.9	99.9	
DM digestibility (%)		39.2	40.9	49.6

The disappearances of DM, protein, fat and theobromine were determined by nylon bag tehnique.

Table 2. The *in vitro* dry matter digestibilities of cocoa shell, corn meal, broken rice, rice polishing, wheat pollard, coconut meal, palm kernel and kapok seed meal.

Feed	Dry matter digestibility (%)
Cocoa shell	63.5
Corn meal	65.5
Broken rice	81.1
Rice polishing	76.9
Wheat pollard	75.1
Coconut meal	58.0
Palm kernel	71.9
Kapok seed meal	50.0[a]

[a]Adapted from Fflouks and Bamualim (1989)

without affecting milk yield, pulse rate and liveweight changes (Bonadonna, et al., 1963). In sheep Tarka, et al. (1978) and Hamzah, et al. (1989) found that liveweight gain tended to decrease as the level of inclusion of cocoa shell in the ration were increased. The inclusion of cocoa shell above 14 %, the value which was equivalent to 0.24% theobromine in the diet reduced liveweight gain and was thought to be due to decrease in feed intake (Tarka, et al., 1978). However, Hamzah, et al. (1989) did not find any differences in feed intake between the treament and control diet.

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Table 3. The composition of experimental diets

Treatment	CS in the conc (%)	CS in the diet (%)	Conc	EG (%)
I	7	2.8	37.2	*ad lib*
II	17	6.8	33.2	*ad lib*
III	27	10.8	29.2	*ad lib*
IV	37	14.8	25.2	*ad lib*
V	47	18.8	21.2	*ad lib*

CS = cocoa shell, Conc = concentrate, EG = elephant grass

Table 4. The chemical composition of elephant grass (EG), and the treatment diets, I, II, III, IV and V.

Feed	NDF (%)	CP (%)	Fat (%)	Ca (%)	P (%)	Na (%)	Mg (%)
EG	68.6	8.3	2.5	0.40	0.36	0.06	0.38
I	42.1	16.4	6.1	1.09	0.89	0.66	0.45
II	42.9	15.9	6.0	0.97	0.85	0.51	0.47
III	42.1	16.9	6.2	0.91	0.83	0.44	0.50
IV	45.6	16.7	5.7	0.76	0.78	0.34	0.50
V	46.5	16.6	5.3	0.78	0.76	0.37	0.51

NDF = Neutral Ditergent Fibre CP = Crude Protein, I = 7%, II = 17%, III = 27%, IV = 37 % and V = 47% cocoa shell

Table 5. The average daily gain (ADG), feed intake/LW, digestible energy and estimated metabolisable energy intake (MEI) each with the standard error of mean

	Treatment diet						
	I	II	III	IV	V	SEM	P
ADG[a] (kg/d)	0.72	0.63	0.7	0.54	0.51	0.09	<0.05
DM Intake (g/kg LW)	0.031	0.028	0.029	0.030	0.031	0.0001	NS
DE (MJ/kg)	11.5	11.5	11.5	11.3	11.2	0.38	NS
MEI[b] (MJ)	46.3	46.2	44.6	48.5	44.1	3.49	NS

[a]ADG is calculated based on regression analysis of LW over times
[b]MEI is calculated as 0.82 DE x DM Intake

Table 6. The precentage of cocoa shell (CS) in the diet, the theobromine concentration and the efficiency of metabolisable energy (MEI/LWG)[a]

Tretament diet	% CS in the diet	% Theobromine	MEI/LWG
I	2.8	0.04	64.3
II	6.8	0.11	73.3
III	10.8	0.17	63.7
IV	14.8	0.24	89.8
V	18.8	0.30	86.5

[a]Cocoa shell contains 1.6% theobromine

The following was a preliminary experiment designed to evaluate the nutritive value of cocoa shell in ruminants.

Materials and Methods

Nylon bag experiment

Two fistulated Ongole were used to measure nutrient disappearance of cocoa shell in the rumen. They were offered chopped elephant grass (*Pennisetum purpureum*) *ad libitum* plus 2 kg concentrate containing 7 % cocoa shell (made by local dairy cooperative). Water is available at all times. Triplicate sample of cocoa shell (100%), each of 10 g were suspended in the rumen for 12, 24 and 48 h using nylon bag tehnique. On a separate test triplicate sample of five different levels of cocoa shell in the concentrate, 7 , 17 , 27 , 37 and 47 % were also suspended in the rumen for 24 and 48 h. The residues obtained after incubation in the rumen were dried at 40°C and analysed for theobromine, fat and protein content. Whereas for the determination of DM disappearance, the residues were dried at 100°C.

Feeding trial

Animals and feeding. Thirty Ongole cattle with a mean live weight of 144.4 ± 12.2 kg were randomly divided into 5 treatment groups, based on the amount of cocoa shell inclusion in the concentrate. The concentrate was made by the local dairy cooperative consisting of wheat pollard (50%), coconut meal (8%), corn meal (11.5%), palm kernel cake (6%), cocoa shell (7%), soybean meal (4%), kapok seed meal (5.5%), fish meal (3%) and mineral mix (5%). The treatment groups were: I concentrate (conc), II conc + 10% CS, III conc + 20% CS, IV conc + 30% CS and V conc + 40% CS. The composition of the experimental diets are shown in Table 3. This feeding trial lasted for 80 days. The animals were kept in individual pens and fed chopped elephant grass (*Pennisetum purpureum*) *ad libitum* plus concentrate (1.2 % LW) containing different levels of cocoa shell. The concentrate was offered at 9.00 before the elephant grass in order to get all consumed. Water was available at all times. The animals were weighed every second week before feeding.

Digestibility measurement. Three animals in each group were randomly assigned for digestibility trial which was carried out in the 4th week after the onset of the experiment. During this time sample of feces were taken daily for dry matter (DM) and energy content measurment. At the end of the 10 days collection, subsamples were taken for DM and proximate analysis. This measurement was repeated 3 weeks after the first measurement.

A comparative study in *in vitro* digestibility of cocoa shell and other common feeds used in dairy concentrate was also carried out using rumen fluid from 3 fistulated buffaloes as described by Tilley and Terry (1963). The buffaloes were fed chopped elephant grass *ad libitum* + 1 kg concentrate similar to that used in Treatment I. Triplicate sample of cocoa shell and of six other feed ingredients were used.

Statistical analysis. Data were subjected to the analysis of variance based on a Fully Randomized Design. Differences between treatment means were examined using LSD.

Results and Discussion

Proximate analysis and rumen disappearance

Data on the proximate analysis (Table 1) showed that both values of NDF (neutral detergent fibre) and crude protein of cocoa shell were in the range of that reported by Gohl (1983) and NRC (1983).

The sodium (Na) content of cocoa shell was similar to that of elephant grass (0.06%) a value which is below the requirment of dairy but marginal for the requirement of beef cattle. While the calcium content of cocoa shell is slightly lower than elephant grass, it would meet the requirements of beef and dairy cattle.

Cocoa shell is a good source of phosphorus (P) and magnesium (Mg) as the concentration of these minerals were high.

Almost 50 % of the dry matter (DM) was digested in the rumen after 48 h incubation (see Table 1), indicating that approximately 14 % of the DM was digested in the lower digestive tract as the *in vitro* DM digestibility was 63.5% (see Table 2).

When the value of *in vitro* digestibility of cocoa shell was compared to that of other feedstuffs, the value was similar to corn meal, higher than coconut meal and kapok seed meal, but lower than broken rice, wheat pollard, rice polishing or palm kernel (see Table 2). Since *in vitro* dry matter digestibility is only a rough measurement of dry matter being digested, it does not reflect the nutrient available in the animal, a further study on approximate nutrient availabilty was done through nylon bag tehnique.

Nylon bag experiment showed that approximately one third of the protein of cocoa shell by-passed the rumen after 12 h incubation, and there was little increase after that time (see Table 1). This value is lower than protein sources such as fish meal, cotton seed meal, linseed meal, soybean meal or ground nut meal (see Orskov, 1982). The high rumen-degraded protein of cocoa shell can be used as a source of N for microbial synthesis. It is thus anticipated that supplementation of cocoa shell would improve the digestibility or intake of low quality basal diet. A low level of cocoa shell in the diet however, has been reported to act as appetite stimulant (Sutherland, et al., 1970; Zaomas and Tarka, 1976; Tarka, et al. 1978).

A considerable amount (73%) of the fat of cocoa shell is protected against fermentation in the rumen (see Table 1), suggesting that the inclusion of cocoa shell in the concentrate would improve the energy available for the animal and in particular for milk production.

Using different levels of cocoa shell in the concentrate, nylon bag experiment revealed that there were very little theobromine left in nylon bag after being suspended in the rumen for 24 h (see Table 1), almost all of the theobromine by-passed the rumen. Wheather theobromone forms other substance in the rumen, or wheather theobromine by-passes the rumen and forms other compound in the small intestine was not known and this should be further investigated.

Feeding trial

There was no different ($P<0.05$) in liveweight gain of animals in Treatment I, II and II. Similarly, the liveweight gain of animals in Treatment IV and V were not different ($P<0.05$), but there was a significant reduction ($P<0.05$) in liveweight gain in those animals as compared to that in animals in Treatment I, II, and III (see Table 5).

The decrease in liveweight gain in the animals recieving 37% and 47% cocoa shell in the concentrate (14.8 % and 18.8% in the diet respectively) was in agreement with the result found by Tarka, et al. (1978). At the level of 14.8% cocoa shell in the ration which approximately contained 0.24% theobromine (see Table 6), the live weight gain started to decline.

The DM intake, DM digestibility and ME intake were not different ($P<0.05$) between treatments (see Table 5). Similar results were also found by Hamzah, et al. (1989). Tarka, et al. (1978) found that at a lower level (<9.2 %) cocoa shell in the ration stimulated feed intake, but this was observed only at the last 2 weeks of the experiment. However, in the study by Tarka, et al. (1978), the reduction of liveweight gain in the animals with higher level of cocoa shell inclusion in the ration was associated with lower intake. This was not the case in the present study. The lack of relationship between intake and liveweight gain in the animals recieving higher levels of cocoa shell in the diet suggested that the efficiency of metabolisable energy was low (see Table 6). Perhaps this was due to the high theobromine content in the diet. If this true, the use of cocoa shell as source of feed supplement for growing cattle is limited up to 11 % in the ration. However, further study is required to ensure maximum utilisation of this by-product for ruminant feed particularly for dairy cattle. At present the dairy cooperative uses 7% of cocoa shell in the concentrate.

The suspected theobromine as a limiting factor of cocoa shell for ruminant feed needs a thorough study. While nylon bag experiment revealed that almost 100% of theobromine by-passes the rumen, the mechanism in which theobromine affect the efficiency of utilisation of ME is not understood.

Certainly, the inclusion of cocoa shell could reduce the cost of concentrate, as it is a cheap source of supplement.

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