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Research Article

Optimizing the Production of Beef Cattle Utilizing Palm Oil Leaf Sheet Ammoniation Supplemented by Sulfur Minerals, Phosphorus and Cassava Leaf Flour

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Abstract

Objective: This study was designed to explore the effects of supplementing processed leaf-based palm leaf rations with minerals [sulfur (S) and phosphorus (P)] and cassava flour on the optimization of bioprocess in the rumen and beef cattle growth performance. **Materials and Methods:** Simmental beef cattle were divided into 5 treatments and 4 replicates. The treatments consisted of A = Field grass+concentrate (60%: 40%, used as the control), B = Palm frond ammoniation + concentrate (60%: 40%), C = B + mineral supplementation S (0.4%) and P (0.27%), D = B + cassava flour (5%) and E = C + cassava flour (5%). The consumption of dry matter rations, dry matter digestibility, weight gain and feed efficiency was evaluated. **Results:** It is observed that the treatments had significantly different effects on Simmental cattle growth performance ($p<0.05$). The average dry matter ration consumption ranged from 11.25-11.76 kg/head/day, average dry matter digestibility ranged from 52.28-62.01%, average weight gain ranged from 0.84-1.01 kg/head/day and average feed efficiency ranged from 7.39-8.59%. **Conclusion:** Ammoniated palm oil leaves supplemented with the minerals [S (0.4%) and P (0.27%)] and cassava starch flour (5%) can replace 100% of the grass in beef cattle rations and resulted in better growth performance than was observed for control rations (grass feed) in terms of weight gain.

Key words: Palm leaf processing, beef cattle, ammoniation, mineral sulfur, phosphorus, cassava flour, rumen

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Palm leaf stem is available in high quantities and shows great potential as forage feed but its usefulness as feed remains very limited partially because of the low quality of palm leaves. A previous analysis of the nutrient content of palm leaves revealed its composition as follows: Dry matter: 54.12%, organic matter: 89.86%, crude protein: 8.51%, crude fibre: 28.48%, neutral detergent fiber (NDF): 59.11%, acid detergent fiber (ADF): 42.87%, cellulose: 24.69%, hemicellulose: 16.24% and lignin: 14.21%. Its high lignin content results in low digestibility and palatability[1]. Previous efforts to optimize waste feed utilization have focused on physical, chemical, biological and mixed processing techniques. However, processing alone provides only a small increase in digestibility. Therefore, efforts to increase the digestibility of fibrous feed should be combined with efforts aimed at optimizing bioprocess in the rumen by increasing the population of rumen microbes[2].

The rumen microbial population depends on the availability of nutrient precursors, such as carbohydrates, energy, nitrogen, amino acids and vitamins, to synthesize microbial proteins. Rumen cellulolytic bacteria require branched-chain fatty acids (BCFA), which are produced via the decarboxylation and deamination of branched-chain amino acids (BCAA). Low-quality waste feed contains very low amount of BCAA and therefore, requires supplementation with BCAA. One natural source of cheap and easy-to-obtain BCAA is cassava leaves, which contain the following BCAA: Isoleucine (4.4%), leucine (8.75%) and valine (8.43%)[3].

The specific objectives of this study were to study the effect of supplementing processed leaf-based palm leaf rations with the minerals sulfur and phosphorus with or without cassava flour on bioprocess in the rumen and beef cattle growth performance.

MATERIALS AND METHODS

Materials: Palm leaves were collected from Kelompok Tani Cerdas (Farmer's Groups) located at Block A Sitiung II, Jorong Koto Hilalang II, Nagari Sungai Langkok, Tiumang District, Dharmasraya Regency. Analyses of processed palm leaf stems, rations and faeces were performed at the Ruminansia Nutrition Laboratory of the Faculty of Animal Husbandry at Andalas University of Padang between January and June 2017. The research subjects included 20 Simmental bulls aged between 1 and 2 years with body weights (BWs) of approximately 350 kg. Simmental cattle were divided into 4 groups based on BW and then randomly assigned to one of 5 different treatment rations. The rations consisted of forages and concentrates, which were fed at a ratio of 60%: 40%. The concentrates were prepared from fine bran, tofu, mud (solid), premix and probiotics. The forage consisted of field grass (used as a control) and an ammoniac leaf bark that was supplemented with the minerals [sulfur (S) and phosphorus (P)] in addition to cassava. The equipment used in these experiments included cages, enclosure equipment, digital scales (1,500 kg capacity) and various laboratory equipment.

Methods: These experiments used a randomized block design consisting of 5 treatment rations and 4 groups of beef cattle, which were used as replicates. The cattle were grouped based on the initial BW of each individual bull and each replicate consisted of 1 beef cattle. The following 5 treatments rations were used:

A = Field grass+concentrate (60%: 40%) (used as the control)
B = Ammoniated palm leaf fronds+concentrate (60%: 40%)
C = B+mineral supplementation with S (0.4%) and P (0.27%)
D = B+cassava flour (5%)
E = C+cassava flour (5%)

This set up resulted in the following design model[4]:

$$Y_{ij} = \mu+P_i+K_j+€_{ij}$$

Where:

Y_{ij} = Value observed for treatment i and group j
μ = Common middle value
K_j = Group influence of j
P_i = Group influence of i
$€_{ij}$ = Influence of the rest of treatment i and group k

Parameters observed: The following parameters were analysed: The consumption of ration (g/head/day), the digestibility of food substances (%), weight gain (g/head/day) and ration efficiency (%).

Statistical analysis: The Duncan multiple range test was used to determine significance, which was defined as 0.01.

RESULTS AND DISCUSSION

Amber palm leaf blight did not affect the results of the present study because none of the beef cattle differentiated between leaves with or without blight.

Consumption of rations: Consumption is a benchmark of the palatability of a feed ingredient. Whether the feed ingredients are very palatable or not, it can be determined from the feed-consumption level. The amount of dry matter consumption observed during this study is presented in Table 1.

In this study, dry matter consumption ranged from 11.25 -1.76 kg/head/day and was not significantly affected by the treatments ($p>0.05$). However, dry matter consumption tended to be higher in the group fed rations supplemented with S & P and cassava flour (Treatment E, 11.76 kg/head/day). This result suggests that supplementing feed with the minerals S and P in combination with cassava flour increased the consumption rate because the feed was more palatable and easily digested.

In this study, the dry matter consumption rate was similar across all of the treatments, indicating that the treatments did not affect the palatability of the rations. This conclusion assumes that the composition and content of the food substances in each treatment were almost the same and is based on the results of previous studies[3,5] showing that the consumption of dry matter rations is influenced by several factors, including the palatability, quantity and quality or chemical composition of the available feed.

Other factors that affect the level of feed consumption include its physical form, the size of the feed particles and feeding frequency. In this study, the forage was cut first so that the physical shapes and sizes of the feed particles would be similar. The cattle were fed 3 times/day as follows: A morning concentrate and two afternoon feedings. The experimental cattle had the same amount of time as the controls to consume a given amount of feed. This approach is in line with the opinion that cattle eating habits are influenced by hunger, the amount of time the food is available, the physical form of the food and feeding frequency[6]. It has also been suggested that the nutrient content of the feed, the feed particle size and the number of calories contained in the feed affect feed consumption[7].

The cattle used in this study were 1-2 years old. This age corresponds to a growth period during which a typical BW between 350 and 400 kg is attained. Hence, the capacity of the digestive system and the need for food substances were equivalent across the groups. Previous evidence indicated that feed consumption depends on the age, the condition and the production of livestock[6]. Additionally, the level of feed consumption is thought to be influenced by the livestock strain, BW, age, production rate, body obesity, metabolism in both the blood and rumen and physiological conditions in addition to the protein content and digestibility values and calories in the feed[8].

In this study, dry matter consumption ranged from 11.25-11.76 kg/head/day or 3.02-3.15% of BW. The results of this study were not very different from the results of a previous study, in which the consumption of dry matter in beef cattle fed palm leaf rations was estimated to be 3.02% of BW[9].

Digestibility of feed substances: In ruminants, the digestibility of feed is closely related to the amount and activity of the microbes in the rumen. The digestibility of all food substances used in this study is shown in Table 2.

The quality of a ration is determined by the digestibility of the dietary substances contained in the ration. Quality can be determined by comparing the percentage of ingested substances to the percentage of substances excreted in the faeces. The substances contained in the ration are not all fully bioavailable to the livestock. Some will, for example, be excreted in the faeces. Table 2 shows that the digestibility of ammonia leaf (B) is significantly lower than that of the other treatments. This illustrates that the activity and number of microbes in the rumen are reduced by the insufficient availability of nutrients required for microbial growth. Additionally, in ruminants, the digestibility of feed is determined by the population of bacterial microbes in the rumen. In these experiments, while ammonia production was quite high, it was not able to increase bacterial growth in the rumen. This finding shows that bacterial growth requires not only nitrogen but also other nutrients, such as energy, minerals and amino acids.

S and P mineral supplementation (Treatment C) only slightly increased the digestibility of food substances and did not match the digestibility of grass (ration A). This was because supplementation with S and P improved rumen conditions and thereby enhanced the quality of the rumen microbes. Both S and P are important components for the synthesis of amino acids and microbial proteins[10].

Table 1: Average dry matter consumption during the study

	Treatments					
Consumption of dry material	A	B	C	D	E	SE
Kg/head/day	11.25	11.37	11.54	11.55	11.76	1.02
BW (%)	3.02	3.03	3.04	3.05	3.15	0.07

SE: Standard error, A: Control (grass), B: Leaves of ammoniated palm, C: Leaves of ammoniated palm+mineral S and P, D: Leaves of ammoniated palm+cassava flour, E: Leaves of ammoniated palm+mineral S and P+cassava flour

Table 2: Digestibility of dietary substances research values (% dry matter)

	Treatments					
Parameters	A	B	C	D	E	SE
Dry material	62.01[a]	52.28[c]	57.67[bc]	61.05[a]	61.89[a]	1.78
Organic materials	65.51[a]	55.14[c]	59.97[b]	61.31[ab]	63.06[a]	1.59
Crude protein	71.58[a]	49.68[c]	56.76[b]	58.96[b]	70.98[a]	0.24
Rough fibre	55.17[a]	48.23[b]	51.57[ab]	53.96[a]	54.97[a]	0.37
NDF	53.38[a]	42.75[d]	45.68[c]	48.86[b]	51.92[a]	0.49
ADF	39.76[a]	22.97[d]	27.85[c]	34.67[b]	38.54[a]	0.97
Cellulose	52.98[a]	43.88[c]	46.97[bc]	48.69[b]	52.34[a]	0.15
Hemicellulose	78.89[a]	75.64[a]	75.97[a]	76.84[a]	77.58[a]	0.21

Different superscripts in the same line indicate a significant difference ($p<0.05$)

The dry matter digestibility in Treatment C increased by 10.31% compared to Treatment B, while the digestibility of NDF, ADF and cellulose fibre fractions increased by 6.85, 21.25 and 7.04%, respectively. However, hemicellulose digestibility was not increased. S and P mineral supplementation had a positive effect on fibre fraction digestibility and especially on ADF. This finding supports a previous proposal that S is important for fibre digestion in the rumen[10] and that a greater supply of S optimizes cellulose digestion by stimulating cellulolytic bacteria and the activity of ciliate protozoa and anaerobic rumen fungi.

Rumen microorganisms require P for cellulose digestion but it has not been easy to demonstrate that P stimulates the production of VFA[2]. P is specifically required to digest the major elements of cell walls and is especially important for cellulolysis, which requires more P than is required by hemicellulolysis or amylolysis. In most studies, *in vivo* deficiency in P exhibits a negative effect on both the digestibility of fibre fractions and the ability to digest organic matter[10].

In Treatment C, S and P mineral supplementation increased the S and P content of the ration. The amount of S and P in this feed was much higher than the standard mineral requirement for beef cattle[11]. However, a previous study estimated that the S requirement for intensive ruminant livestock is 0.4% of the total dry matter ration[12]. While this proportion is higher than the standard requirement, it may be because some minerals have low bioavailability in rations. This may have led to differences in the digestibility of food substances. For example, digestibility was lower in the Treatment C group than in the Treatment D and E groups. In addition, the mineral forms and types of mineral supplementation that were used also affected the results of this study.

In Treatment D, supplementation with cassava flour significantly increased digestibility. In this group, there was a significant increase in dry matter digestibility and NDF, ADF and cellulose but not hemicellulose digestibility. Cassava flour is a source of BCAA. BCAA are a source of the carbon framework required to stimulate cellulolytic growth. Without a carbon skeleton, neither urea nor ammonia nitrogen can be used to synthesize rumen microbial proteins. The increased digestibility of ADF and cellulose rations indicates that the population and activity of these cellulolytic bacteria were also increased, in agreement with the findings reported in previous studies[13]. These data demonstrate that cellulolytic bacteria are highly responsive to the addition of branched-carbon skeletons.

In this study, it is observed that rumen microbes were more responsive to the addition of BCAA than the addition of the minerals S and P. This responsiveness was indicated by the fact that the digestibility of food substances was higher in Treatment D than in Treatment C. The higher digestibility observed in Treatment D was due to an increase in the availability of nutrients for microbial growth. If minerals S and P had not been supplemented in this group, the mineral content in Treatment D would have been 0.32% for S and 0.45% for P, both of which are higher than the recommended mineral requirement reported in other studies[11].

In Treatment E, supplementing with minerals and cassava flour increased the digestibility of the ration to a level that matched the results in the Treatment A (grass) group. The increases in dry matter digestibility, NDF, ADF and cellulose observed in this treatment group were highly significant, indicating an increase in the population and activity of rumen microbes, which itself is caused by an increase in the availability of nutrients to a sufficient and balanced level. The results of this study suggest that the amounts of certain nutrient supplements should be adjusted based on the availability of other nutrients. The best increase in digestibility is achieved in rations that contain all of the nutrients needed by rumen microbes. In this study, nitrogen was derived from the ammonia in ammoniated palm leaves, the minerals S and P came from mineral supplementation and branched-carbon frameworks were derived from the BCAA contained in cassava

Table 3: Increase in body weight and ration efficiency

	Treatments					
Parameters	A	B	C	D	E	SE
Weight gain (kg/head/day)	0.91[ab]	0.84[b]	0.86[b]	0.89[b]	1.01[a]	0.04
Efficiency ration (%)	8.09[ab]	7.39[b]	7.45[b]	7.74[b]	8.59[a]	1.27

Different superscripts in the same line indicate a significant difference (p<0.05)

flour. These data show that mineral supplementation with S and P and cassava flour had a positive effect on digestibility, especially of ADF.

When analyzed according to the consumption of dry matter rations (Table 1), the increase in ration digestibility was not accompanied by an increase in dietary intake because the digestive flow rate in the digestive tract was low. Although ruminants have a large gastric capacity, the amount of food they can consume is limited by the speed of digestion and the rate at which food waste is removed from the gastrointestinal tract. Foods containing a high proportion of coarse fibre are difficult to digest, resulting in a low flow velocity[14].

In this study, dry matter digestibility ranged from 52.28-62.01%. This figure is lower than the figures reported in a previous study (69%)[9], in which palm oil leaves were used as a basal feed in beef cattle rations. The ADF digestibility values obtained here ranged from 22.66-41.02%, in agreement with the results of another study (10.98-51.09%)[15], in which ammonite palm coir was supplemented with an analogue of hydroxy methionine and BCAA in sheep defaunation. Research resulting from the use of fermented empty fruit bunches in cattle and sheep obtained dry matter digestibility ranging from 60.12-70.97% and ADF digestibility ranging from 36.44-56.47%[16].

Addition of body weight and ration efficiency: BW is a reflection of feed quality. The weight gain and feed efficiency data obtained during this study are presented in Table 3. In this study, ammoniated palm leaves (Treatment B) resulted in the same rate of weight gain as that observed in the Treatment C (mineral supplementation) and D (cassava flour supplementation) groups. The highest BW gain was observed in animals fed Treatment E (supplementation of S and P and cassava flour), which resulted in an average gain of 1.01 kg/head/day, while the lowest rate was observed in the Treatment B group (oil palm leaves, 0.84 kg/head/day). The high weight gain observed in Treatment E reflected the high consumption and digestibility of these rations, as shown in Table 1 and 2. Conversely, the low weight gain observed in Treatment C reflected the low consumption of dry matter rations, which ultimately decreased the availability of food substances to the livestock. The overall average weight gain observed in this study was higher than that reported in another study[9], in which growth of 0.76 kg/head/day was observed in beef cattle fed oiled palm leaves.

The efficiency of a ration is defined as the increase in BW produced/unit of dry ration ingredients consumed. A higher value indicates that the ration is more efficiently consumed, resulting in more weight gain. As shown in Table 3, the treatments had significantly different effects (p<0.05) on ration efficiency. The ration efficiency values in Treatments A, B, C and E were not significantly different from one another but the ration efficiency of Treatment B was significantly lower than that observed in the other treatments. The low ration efficiency observed in Treatment B is reflected by the low weight gain in this group. The best ration efficiency was obtained in Treatment E (8.59%) which was, followed sequentially by Treatments A, D, C and B. The differences in ration efficiency observed in this study were caused by differences in weight gain and the consumption of dry matter rations. This finding supports the conclusions reported in another study[2] in which it was proposed that the magnitude of ration efficiency depends on the amount of dry matter consumed, which is associated with weight gain. It is possible that as the weight gain caused by a given ration increases, the ration becomes more efficient to use.

The ration efficiencies observed in this study ranged from 7.39-8.59%. These values are lower than those obtained in another study (13.6%)[9] in which palm leaves were used as a basal feed in beef cattle rations and those for rations fed to goats (palm leaf rations and palm oil processing, 12.71-16.11%)[17]. The results of this study are not very different from the results of another study[16] in which empty, fermented fruit bunches had a ration efficiency of 6.34%-13.41%.

CONCLUSION

The results of this study show that ammoniated palm leaves supplemented with the minerals (S and P) as well as cassava flour can replace 100% of field grass in rations provided to beef cattle and out-performed the control rations (grass) in terms of weight gain and ration efficiency.

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