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Improvement Nutrient Digestibility and Production Performance of Cattle Through Restricted Amino Acid and Organic Minerals Addition on Fermented Palm Oil Waste-Based Feed

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ABSTRACT

The objective of this research was to evaluate the effect of branched-chain amino acid and organic mineral addition on fermented palm oil waste based-feed to the nutrients digestibility and cattle performance. The research was done using nine Ongole crossbred cattle by applying randomized block design with three treatments and three replications. The first treatment (R0) was fermented palm oil waste-based feed; and the second treatment (R1) was R0 with 13% cassava leaves addition; and the third treatment (R2) was R1 with organic minerals (40 ppm Zn; 10 ppm Cu; 0.1 ppm Se; and 0.3 ppm Cr) addition. The result showed that R2 gave a significant effect ($P<0.05$) on crude protein, crude fiber, and ether extract digestibility, but showed no significant effect on dry matter and organic matter digestibility and cattle production parameters. The research concluded that fermented palm oil waste-based feed with 13% cassava leaves and organic minerals addition gave the best result based on the digestibility and cattle production parameters.

Keywords: Branched-chain amino acid, Cattle production, Nutrient digestibility, Organic mineral

Introduction

The improvement of livestock feed quality can be done by enhancing structural carbohydrate digestibility through chemical (ammoniation), physical, and biological (fermentation) treatment. The treatment then should be combined with a branched-chain amino acid, macro, and micro-organic minerals addition to further improve mineral absorption, rumen, and post-rumen bioprocess, while also improve other nutrients metabolism.

Branched-chain fatty acids (BCFA), which include isobutyric acid, 2-methyl butyric acid, and isovaleric acid, should be provided for microbial protein synthesis. BCFA on the rumen is a product from decarboxylation and deamination of branched-chain amino acids (BCAA), which are valine, isoleucine, and leucine. On the other hand, the lysed microbial rumen is also known to contribute to BCFA pool in the rumen. A supplementation of BCFA or BCAA should be given to prevent deficiency and also to foster microbial growth which will improve feed digestibility and cattle growth (Zain, 1999).

One of the natural sources for BCAA is cassava leaf flour, which also has relatively high crude protein content, which is about 19.60% (Bakrie *et al*., 1995); 22% (Montagnac *et al*., 2009); 16.7 – 39.9% (Ravidran, 1991), with 9.64 g/16g N leucine, 5.66 g/16g N isoleucine, and 6.49 g/16g N valine (Fasuyi and Aletor, 2005; Montagnac *et al*., 2009).

Mineral plays a significant role in rumen bioprocess optimization and other nutrients metabolism. Micro and macro minerals in cattle digestibility could be positively or negatively interact, and other factors like phytic acid and crude fiber could reduce minerals availability. Theoretically, organic minerals have higher absorption value, thus the addition of organic minerals, whether macro (Ca, Mg) or micro (Zn, Cu, Cr, Se), are expected to increase the absorptivity, rumen, and post-rumen bioprocess, and nutrients metabolism, in which could improve cattle production.

Mineral supplementation could increase rumen and post-rumen bioprocess, and the addition in the form of organic minerals would increase the absorption of the minerals in cattle. Furthermore, minerals in the form of chelates could also increase minerals availability and absorption. Some substances such as carbohydrate, lipid, amino acid, phosphate, and vitamin could be used as minerals chelating agent. The bonds could be defined as proteinates, e.g., Cu-proteinate, Co-proteinate, Zn-proteinate, Zn-methionine, and Zn-lysinate. Some organic Zn that could be used as supplementation is Zn-lysinate (Prayitno *et al*., 2016), Zn-methionine (Shakweer *et al*., 2010) and Zn-sulfate (Zali *et al*., 2008). Chelates in the feed will facilitate penetration in intestines cell wall, thus resulting in higher minerals absorption.

Muhtarudin *et al*. (2003) reported that the addition of organic Zn (lysine-Zn-PUFA and proteinate Zn) could improve rumen bioprocess, nutrients digestibility, protein metabolism, and cattle performance. The Zn supplementation in the form of organic Zn would increase the absorbed Zn value, and the addition of polyunsaturated fatty acids would give positive effect to the cattle.

The research on organic mineral production and utilization has been done by Muhtarudin *et al.* (2003) and reported that Zn-lysate showed the best result compared with Zn-polyunsaturated fatty acids (Zn-PUFA), Zn-lysinate, lysine-Zn-PUFA combination, and Zn-proteinate. Muhtarudin *et al*. (2003) described that the supplementation of Zn-lysinate could increase livestock digestibility and performance. The in vitro and in vivo evaluation has been done in goat and cattle (Muhtarudin *et al.*, 2003). Organic macro (Ca, Mg) and micro (Zn, Cu, Se, and Cr) minerals addition showed significant improvement in the rumen bioprocess (Muhtarudin *et al.*, 2003). Fathul *et al.* (2003) reported that organic Cu, Zn, and Mn supplementation yield higher metabolism and nitrogen retention compared to the inorganic minerals ($CuSO_4$, $ZnSO_4$, and $MnSO_4$). The addition of micro minerals on ruminants become essential based on report by Khalil *et al.* (2015) which showed low micro minerals content on forages (31.5 mg/kg Zn; 143.89 mg/kg Mn; 13.17 mg/kg Cu; 613.83 mg/kg Fe; undetected Co under 0.005 mg/kg concentration standard and undetected Se under 0.002 mg/kg concentration standard), thus mineral supplementation should be given to meet the requirements.

Materials and Methods

Materials used in the research were 9 Ongole crossbreed cattle, in which every 3 cattle were fed according to determined treatments. The feed composition consisted of forages and treatments (R0, R1, R2) with the usage of palm oil waste (palm oil stem and meal), cassava leaves silage as the source for restricted amino acids and organic micro minerals.

Research design

The research was done by using randomized block design (RBD) with three treatments and three replications. The given treatments were:

R0 = Fermented palm oil waste-based feed
R1 = R0 + 13% cassava leaves silage
R2 = R1 + organic micro minerals (consisted of 40 ppm Zn, 10 ppm Cu, 0.10 ppm Se, and 0.30 ppm Cr) according to Muhtarudin dan Liman (2006).

The basal feed was made up from cassava wastes, palm oil stems and meals, coffee peels, molasses, urea, and premix. The feed formulation can be seen in Table 1.

Research procedure

A preparation was previously done before the research started. The preparation includes cleaning up the pen, equipment, and area around the pen, then followed by weighing the cattle and

Table 1. Feed composition

Ingredients	R0	R1	R2
-------------- (%dry matter) ---------------			
Cassava wastes	24	24	24
Fermented palm oil stems	13	13	13
Fermented palm oil meals	34	34	34
Coffee peels	10	10	10
Napier grasses	13	0	0
Cassava leaves	0	13	13
Molasses	4	4	4
Urea	1	1	1
Premix)	1	1	1
Total	100	100	100
Nutrients content			
Crude protein	11.26	11.19	11.19
Crude fiber	20.33	20.75	20.75
Ether extract	10.80	10.92	10.92
Ash	7.38	7.68	7.68
Nitrogen free extract	50.23	49.46	49.46
Total Digestible Nutrient	65.80	66.76	66.76

*Analyzed in the Laboratory of Animal Nutrition and Feed, Departement Of Animal Husbandry, Faculty of Agriculture, University of Lampung, 2016.

put them according to the determined pen based on the research design. The research was done through three steps, which were preliminary, first data collection, and second data collection step. The prelim step was to feed cattle according to the treatments for 14 days. The first data collection step was done by collecting feces for 5 days starting from day-9 of preliminary step and weighing the consumed and leftover feed. The collected feces and feed were used for proximate analysis. The third step, which is second data collection was done at the end of the research.

Palm oil wastes preparation

The palm oil wastes consisted of palm oil stems and meals. Palm oil stems were firstly dried to reduce the water content up to 30%. However, palm oil meals were not dried considering that the meals already had 10 % water content. Palm oil wastes were then sprayed/mixed with EM4 with the ratio of 1 liter to 100 kg feed. The ingredients were then pressed and kept in an anaerobic container to achieve optimum fermentation. The fermentation process was done for 20 days, and the finished products were used for feed.

Sample collection

The total collection method was used in this research, with feed in all research steps were used as a sample. The feces sample were collected as much as 2%, and feed sample was collected as much as 100 g from the given feed. The feed sample was weighed to measure its dry weight and weighed again after sun-dried to measure its dry air weight. The sample was then analyzed for its crude protein and crude fiber content.

Tillman *et al*. (1998) stated that the digestibility could be measured based on its dry weight following the formula:

$$\text{Digestiblity} = \frac{\sum \text{Consumed feed (g)} - \sum \text{Excreted nutrients(g)}}{\sum \text{Consumed feed (g)}} \times 100\%$$

The obtained data were then analyzed with analysis of variance (ANOVA), and any significant differences were tested with Least Significant Difference (LSD) test at the level of 5% or 1%.

Result and Discussion

Crude fiber and crude protein digestibility

The result of the analysis showed that the supplementation of organic mineral to the fermented palm oil waste-based feeds give significant effect ($P<0.05$) to the protein and crude fiber digestibility. However, the dry matter and organic matter of the feed did not show any significant differences. Furthermore, the LSD test showed that the protein and crude fiber digestibility in R2 showed significant differences ($P<0.05$) compared to R0 and R1, while R0 also showed significant differences with R1. The highest protein and crude fiber digestibility were achieved in R2, which is with the addition of cassava leaves (source of branched-chain amino acids) and organic minerals. The addition of cassava leaves could increase microbial rumen growth. The cassava leaves could provide valine, isoleucine, and leucine which are branched-chain amino acids (BCAA). Zain (1999) stated that BCAA supplementation could increase bacterial growth in which resulted in higher nutrient digestibility and cattle performance. A natural feed ingredient which could provide BCAA is cassava leaf flour, as it has high crude protein content with 6.7 g/16g N isoleucine, 10.9 g/16g N leucine, and 5.45 g/16g N valine (Devandra, 1979). Bakrie *et al*. (1995) reported that cassava leaf has 19.60% crude protein content and would be increased up to 25.60% after fermented with *Aspergillus niger*. The branched-chain amino acid is a microbial growth precursor by providing complete nutrients which will affect feed digestibility in cattle, especially in crude fiber digestibility, regarding that crude fiber digestibility in the rumen is based on the work of digestive enzymes produced by microbial rumen. Furthermore, crude fiber would stimulate rumination and rumen contraction which will lead to increased crude fiber fermentation. The main products of the crude fiber fermentation are acetic, propionic and butyric acid which provide energy for microbial rumen. An increase in microbial rumen population would lead to higher crude fiber digestive enzymes, thus resulted in better feed degradation, especially in crude fiber fraction.

The increase in microbial population would also imply to higher microbial protein. Microbial protein is a high-quality protein which could be utilized in post-rumen. An increase in microbial protein leads to higher amino acids balance and would affect to better protein absorption in small intestines. From Table 2, it could be seen that R2 showed highest protein digestibility compared to other treatments.

Muhtarudin *et al*. (2003) reported that the supplementation of organic Zn (lysine-Zn-PUFA and proteinate Zn) could increase the bioprocess in the rumen, nutrients digestibility, protein metabolism, and livestock performance. The supplementation of Zn in organic form could increase Zn absorption, and the addition of polyunsaturated fatty acid would give a positive result to the livestock. Other organic micro minerals supplementation, such as Cu, Cr, and Se also give a positive result to protein digestibility. Muhtarudin *et al.* (2016) reported that the dry matter, organic matter, crude fiber, and protein digestibility would be increased with the supplementation of organic minerals. Furthermore, Obeidat *et al*. (2009) reported that an increase in crude protein content would lead to higher feed digestibility.

Ether extract digestibility

Fat in would be digested into volatile fatty acids (VFAs) by microbial rumen, with the

Table 2. The effect of treatments on the observed parameters

Parameters	Treatments		
	R0	R1	R2
Crude protein digestibility (%)	62.49[a]	75.94[b]	79.29[c]
Crude fiber digestibility (%)	52.90[a]	58.05[b]	63.51[b]
Ether extract digestibility (%)	85.89[a]	84.73[a]	87.59[b]
Dry matter digestibility (%)	97.49[a]	95.97[a]	96.51[a]
Organic matter digestibility (%)	91.47[a]	91.24[a]	90.34[a]
Average daily gain (kg/day)	0.78[a]	0.80[a]	0.86[b]
Feed consumption (kg/cattle/day)	12.24[a]	11.70[a]	11.68[a]
Feed conversion (%)	15.69	14.62	13.58

[a, b]Different superscripts indicate significant differences (P<0,05)
R0 = Fermented oil palm waste-based feed
R1 = R0+13% cassava leaves
R2 = R1+organic micro minerals (40ppm Zn, 10 ppm Cu, 0.10 ppm Se, 0.30 Cr ppm).

increase of microbial rumen population, an increase in fat digestion would occur. The R2 treatment showed the highest fat digestion compared to R0 and R1. The increase in fat digestion on R2 was caused by the increase of microbial rumen as the result of BCAA and organic minerals altogether. On the R1, the addition of cassava leaves as the source of BCAA did not increase the fat digestibility; however, with the addition of organic minerals, the microbial metabolism would increase, thus resulting in higher microbial population. Research on feed fermentation with the addition of minerals was done by Febrina *et al*. (2016) and reported that fermentation of palm oil stemmed with *Phaneerochaete chrysosporium* and added with Phosphor, Sulfur, and Magnesium would improve the microbial protein synthesis and VFA concentrations.

Dry matter and organic matter digestibility

Dry matter and organic matter digestibility on all treatments in this research did not show a significant difference, indicating that the dry matter and organic matter digestibility on each treatment have relatively same quality. The most affecting components of the dry matter and organic matter digestibility are the nitrogen-free extract and ash content on the given feed. Despite the different microbial rumen population and cell metabolism caused by cassava leaves and organic mineral supplementation, the dry matter and organic matter digestibility remained the same because of the relatively same nitrogen-free extract value in each feed. Hernaman *et al*. (2007) stated that factors which affect dry matter digestibility were the total consumed feed, the flux of feed in the digestive system, and the nutrient content in the feed. Other factors that affect dry matter digestibility are feed proportions, chemical components, protein levels, fat percentages, and mineral content in the feed. On each isonutrient composed treatments, the nutrient contents are quantitatively equated. Fathul and Wajizah (2010) stated that organic matters are part of the dry matter, so an increase in dry matter digestibility would result in an increase in organic matter digestibility as well. Muhtarudin and Liman (2006) also stated that organic matter digestibility would follow the dry matter digestibility of the substrate.

The effect of feed on the production parameter

Treatments in this research did not show any difference to the feed consumption. On R2, the achieved average daily gain was 0.86 kg/cattle/day, significantly higher (P<0.05) compared to control (0.78 kg/cattle/day). Furthermore, R2 showed the highest average feed efficiency which was 0.08 (0.8 kg of meat yielded for every 10 kg of consumed feed each day). However, the statistical analysis showed no significant difference to other treatments. Suryitman *et al*. (2015) reported that the effect cassava leaves flour, sulfur, and phosphor addition as protein and minerals sources on ammoniated palm oil leaves-based feed would give better body weight of the livestock.

Based on the digestibility parameters, the best fermented palm oil waste-based feed was with the addition of 13% cassava leaves (as the source of BCAA), and organic micro minerals (40 ppm Zn, 10 ppm Cu, 0.10 ppm Se, and 0.30 Cr) according to NRC (2016) recommendation.

Conclusion

Based on the digestibility and cattle production parameters, the best result was shown on R2, which consisted of fermented palm oil waste based-feed, cassava leaf (for BCAA source), and organic micromineral (40 ppm Zn, 10 ppm Cu, 0.10 ppm Se, and 0.30 organic Cr).

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