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Research Article
The Effect of Rations Based on Palm Oil By-products on Rumen Parameters and Digestibility in Ongole Cattle

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Abstract

Background and Objectives: Palm oil waste can be used as an alternative feed for ruminants. Optimizing the utilization of palm oil waste for ruminant feed can be accomplished through feed processing, such as fermentation. The objectives of this research were to determine the best effect of a fermented palm by-product-based ration on rumen parameters [ammonia (NH_3) and volatile fatty acids (VFAs)] and feed digestibility [total digestible nutrients (TDN)] and digestibility of dry matter, organic matter, protein and crude fibre, in Ongole cattle. **Methodology:** This study utilized a random block design and was based on weight gain. The design included 3 treatments and 3 replicates; thus, nine cattle were included. The treatments tested in this research were a control ration (R0; rice straw, cassava waste, coconut meal, rice bran, molasses, urea and premix), non-fermented palm oil by-product-based ration (R1; cassava waste, rice bran, molasses, urea and premix+palm leaves and palm kernel meal) and fermented palm oil by-product-based ration (R2; cassava waste, rice bran, molasses, urea and premix+palm leaves and palm kernel meal). **Results:** Rumen liquid VFA and NH_3 concentrations were highest at 110 and 6.74 mM, respectively, after treatment with non-fermented palm oil waste. Feed digestibility parameters (TDN and digestibility of dry material and organic material) were highest after treatment with fermented palm oil waste, with values of 82.94, 69.75 and 75.69%, respectively. The highest digestibility of protein was obtained with the control ration. **Conclusion:** Palm oil waste-based rations significantly increased rumen liquid NH_3, rumen liquid VFA, the digestibility of dry and organic material and TDN. The R2 treatment had the best effect on TDN and the digestibility of dry matter, organic matter and crude protein.

Key words: Palm oil by-product, rumen liquid ammonia, rumen liquid VFA, dry matter, organic matter digestibility, protein digestibility, raw fibre digestibility, total digestible nutrients (TDN)

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

INTRODUCTION

The availability of forage is important for supporting ruminant production. In developing countries, forage crop availability for cattle has decreased in quantity and quality due to land use changes and climate change. One of the solutions to the forage crop problem is the integration of livestock and agriculture. An optimized agricultural by-product could increase feed availability for ruminant cattle. Agriculture and plantation by-products have potential as feed for cattle[1]. One agricultural by-product that can be used as feed is palm oil. The by-products of palm oil include palm leaves, palm sludge and palm kernel meal. These palm oil by-products contain dry matter, crude protein and crude fibre that can be used as feed for ruminant cattle[2].

However, the by-product, including palm leaves, palm sludge and palm kernel meal, can be problematic as base material for feed since it has high crude fibre content but a low crude protein content; this combination can decrease digestibility. To improve the nutrition value of palm oil by-products, leaf blades were used in the fermentation process[3,4]. Fermentation is a biological feed processing technology that utilized microorganism activity to reconstruct the nutrition of low-quality food materials. It is expected that this fermentation process will increase the nutritional value of feed material and increase its digestibility.

Based on previously published data, researcher were interested in conducting studies on the effect of a fermented palm waste-based ration on rumen parameters [ammonia (NH_3) and VFA] and feed digestibility [total digestible nutrients (TDN)] and digestibility of dry matter, organic matter, crude protein and crude fibre in Ongole cattle. This study was designed to determine the best effect of a fermented palm by-product-based ration on rumen parameters [ammonia (NH_3) and volatile fatty acids (VFA)] and feed digestibility [total digestible nutrients (TDN), digestibility of dry matter, organic matter, protein and crude fibre], in Ongole cattle.

MATERIALS AND METHODS

The research study used a randomized block design and was based on weight gain. Nine cattle were included to evaluate 3 treatments in triplicate. The treatments tested in this study were as follows:

Control ration (R0); ration based on non-fermented palm waste (R1) and ration based on fermented palm waste (R2) (Table 1). The data were analyzed using one way ANOVA, with a 5% and/or 1% confidence level followed by the LSD (least significant difference) test[5].

The palm oil by-product fermentation process began with chopping the palm oil leaves. Effective microorganism (EM-4) obtained from Songgolangit Persada Company was sprayed evenly on the chopped palm oil leaves and fronds and palm kernel meal, which were then placed into a container for fermentation. Then, the materials were placed in anaerobic conditions for approximately 21 days. Every 1 milliliter of EM-4 (effective microorganism) contains 1.5×10^6 cfu/mL of *Saccharomyces cerevisiae* and 1.0×10^6 cfu/mL of *Rhodopseudomonas spalustris*[6].

The NH_3 concentration in rumen liquid was measured by the Conway micro diffusion method[7]. Volatile fatty acid (VFA) production in rumen liquid was measured by a steam *distillation* method. The research parameters of nutrient digestibility (digestibility of dry material, organic material, crude protein and crude fibre) were measured using the total collection method[8].

TDN was calculated using the following formula: total digestible crude protein + total digestible crude fiber + total digestible nitrogen free extract (NFE)+2.25$\times$(total digestible ether extract)[8].

RESULTS AND DISCUSSION

Rumen parameters: Rumen liquid NH_3. NH_3 is one of the final product generated by rumen microbes during the fermentation of feed protein. Subsequently, generated NH_3 is used by microbes as an N source to synthesize body proteins. The effect of treatment on NH_3 levels in Ongole cattle rumen liquid is presented in Table 1.

Based on ANOVA, the treatment significantly increased ($p<0.05$) rumen NH_3 concentration. Increasing rumen NH_3 level is recommended to aid in protein degradation.

According to the statistical analysis, rumen NH_3 levels were lower in the R0 group (control rations). The calculated protein content in R0 was lower than that in R1. The crude protein contents of R0 and R1 were 14.17 and 14.83%, respectively.

Increasing the dietary protein content supported an increase in protease activity and therefore, protein was converted to NH_3. The generated NH_3 could be used by rumen microbes to build microbial proteins after the formation of peptides and amino acids[9]. The optimal concentration for supporting microbial protein synthesis varies from 6 to 21 mM[10]. The NH_3 concentration generated in the R1 group was optimal for supporting microbial growth (6.94 mM). On the other hand, the lower production of rumen NH_3 effected

Table 1: The effect of rations on rumen and digestibility parameters

	Ration		
Parameter	R0	R1	R2
Rumen liquid NH_3 (mM)	4.41±0.21[a]	6.94±1.13[b]	5.38±0.36[a]
Rumen liquid VFA (mM)	71.67±2.89[a]	110.00±9.01[b]	77.50±2.5[a]
Dry material digestibility (%)	47.66±10.76[a]	55.01±8.47[b]	69.75±6.47[c]
Organic material digestibility (%)	61.40±8.52[a]	62.23±13.01[a]	75.69±4.16[b]
Crude protein digestibility (%)	84.43±5.31[b]	73.72±2.16[a]	70.29±4.44[a]
Crude fibre digestibility (%)	58.66±14.78[a]	58.10±16.11[a]	59.92±14.62[a]
Total digestible nutrients (TDN) (%)	72.82±8.61[b]	68.51±1.34[a]	82.94±7.94[b]

Different subscripted lowercase letters on the same line indicate a significant difference (p<0.05), R0: Control ration (15% rice straw, 22% palm kernel meal, 32% cassava waste, 25% rice bran, 4% molasses, 1% urea and 1% premix), R1: Ration based on non-fermented palm waste (15% palm leaves and frond, 35% palm kernel meal, 18% cassava waste, 25% rice bran, 4% molasses, 1% urea and 1% premix) and R2: Ration based on fermented palm waste (15% palm leaves and frond, 35% palm kernel meal, 18% cassava waste, 25% rice bran, 4% molasses, 1% urea and 1% premix)

microbial protein synthesis[11]. The growth of rumen microbes is interrupted when the NH_3 concentration in rumen liquid falls to approximately 3.57 mM[12].

Volatile fatty acid (VFAs) are the last product of carbohydrate fermentation and are the energy reserves for ruminants. According to ANOVA, the treatments R1 significantly increased rumen VFA. The LSD test showed that the highest rumen VFA level was in the non-fermented palm oil by-product (R1) group and the lower rumen VFA level in the R0 group was caused by the reduced organic consumption in R0 compared to R1. Organic matter accounted for 77.82% in the R0 treatment and 81.95% in the R1 treatment; thus, the organic matter consumption rate was 2.68 kg/day, in the R0 group and 3.20 kg/day in the R1 group. Organic matter consumption affected rumen VFA content[8]. Lower crude fibre content in the R0 and R2 treatments could have caused the lower VFA content; the percentage of crude fibre in the R0, R2 and R1 treatments was 12.16, 15.25 and 19.05%, respectively. The lower crude fibre content in these rations tended to decrease the rumen VFA concentration and rumen pH, thereby decreasing the activity of rumen bacteria that digest cellulose. The rumen VFA values in this study ranged from 70 to 117 mM. A previous study[10] found that the VFA requirement for rumen microbial synthesis ranges from 70 to 150 mM. Supplementation of ammoniated palm fronds with direct feed microbes in vitro can increase the concentration of digestible VFA and NH_3-N and result in a relatively more stable rumen pH[13]. Supplementation of palm fronds fermented by *Phanerochaete chrysosporium* with P, S and Mg resulted in the highest microbial protein synthesis and VFA concentration[3].

Nutrient digestibility: According to ANOVA, the treatments R3 significantly (p<0.05) increased dry matter digestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD) and TDN but did not have a significant effect on crude fibre digestibility (CFD). According to the LSD test, the best results for DMD (69.75%) and OMD (73.69%) were obtained with the R2 treatment. Fermentation of the R2 ration was suggested to increase DMD and OMD. The ration fermentation process decreased the crude fibre content of palm oil by-products. The crude fibre content was 19.05% before fermentation and then decreased to 15.25%. The fermentation process decreased the crude fibre content to 4%[14]. Therefore, the fermentation process degraded complex components to simple components.

The rate of nutrient passage is affected by crude fibre content; thus, increasing crude fibre would decrease DMD[15]. One component of the inoculants in EM-4 is *Saccharomyces cerevisiae* (SC). Microbial cellulose has the ability to remove fibre by breaking down cellulose into glucose[16]. This cellulose enzyme is secreted into the extracellular environment and has considerable ability to degrade organic waste, especially in agricultural and industrial waste[17]. The three species of bacteria that degrade cellulose are *Ruminococcus flavefaciens, Fibrobacter succinogenes* and *Ruminococcus albus*; cellulose digestion generates succinate and acetate[17]. Supplementation with SC in substrates containing ammoniated rice straw and concentrate influenced rumen fermentability and nutrient degradability[18].

In addition to the cellulose enzyme, a glucoamylase enzyme has been reported to be produced by SC[19]. This enzyme behaves similar to exo-beta-1,4 glucanase; these enzymes can degrade the B1-4 glucosidase bond in cellulose. Factors that affect DMD include feed consumption, rate of feed passage in the digestive tract and nutrient content in rations. A previous study[20] showed that the digestibility of dry matter, organic matter, crude fibre and crude protein increased with the addition of organic minerals. As dry matter contains organic matter, the organic matter portion increases as the dry matter portion increases[21]. The increase in OMD accompanies an increase in DMD.[22]

According to the LSD test, the R0 treatment significantly decreased CPD ($p<0.05$), where as the R1 and R2 treatment had no significant effects ($p>0.05$). CPD was higher in R0 treatment group than that of the R1 and R2 treatment groups. The increase in crude protein content indicated an improved growth response, namely, an improvement in the availability of amino acids that pass through post-ruminal digestion[23].

The results of another previous report[24] on ration digestibility values and protein content showed that an increase in crude protein in rations was followed by an increase in DMD. Supplementing ammoniated palm leaves with mineral sulphur, phosphorous and cassava leaf meal led to better performance in terms of body weight gain[4].

The treatments had no significant effect on CFD (ANOVA, $p>0.05$). The CFD value was better for the R2 treatment than for the R0 and R1 treatments. These results might have been caused by the palm oil by-product fermentation process, which was improved by the addition of the many microbes in EM-4; these microbes play a role in processing many substrates, including palm oil by-products.

The ANOVA results showed that the treatments had significant effects ($p>0.05$) on TDN. The fermented rations (R2) improved the TDN. The LSD test results showed that the R2 treatment had a significant effect compared to the R0 and R1 treatments. The improvement in the TDN value in the R2 group was caused by the fermentation process, which decreases the crude fibre content and increases nutrient digestibility. Therefore, the TDN value increased.

CONCLUSION

Palm oil waste-based rations had increased rumen liquid NH_3, rumen liquid VFA, the digestibility of dry and organic material and TDN. The fermented palm oil waste treatment had the best effect on TDN and the digestibility of dry matter, organic matter and crude protein.

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