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Rumen fermentation characteristics of Ongole crossbred bulls in response to different inclusion levels of dried cassava chips and palm kernel cake

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Abstract. This study determined the best proportion of dried cassava chips (local name: gaplek and palm kernel cake (PKC) with a fixed proportion of rice straw as assessed by rumen fermentation characteristics. Three rations were offered to 14 Ongole crossbred bulls (average liveweight at 200±20 kg). The rations were mixtures of rice straw, gaplek, and PKC at ratio of 20:70:10 (T1), 20:50:30 (T2), and 20:30:50 (T3).  and 2% urea was added to each ration. Ruminal fluid samples were obtained 0 hours before feeding at week 14 to measure pH and analyze VFA, NH₃-N, and microbial N concentrations. Rumen pH was not changing (range 7.1 - 7.5). The T2 and T3 treatments showed lower total VFA concentrations (P<0.05) than T1 treatment (71.6 and 70.3 vs. 88.4 mM, respectively). The highest NH₃-N concentration (P<0.05) was shown by T2 and there were no significant differences between T1 and T3 treatments. The greatest microbial N concentration was shown by T3 treatment, and was followed by T2 and T1. It can be concluded that a high inclusion of gaplek caused no adverse rumen digestion characteristics. A safe combination of rice straw, gaplek, and PKC was at a proportion of 20:30:50.

1. Introduction
Rumen microbes are able to form microbial proteins through the utilization of carbon chains, energy, and ammonia (NH₃). It is estimated that the contribution of microbial proteins reaches 60-70% of the total amino acids / proteins absorbed by livestock [1–2]. The contribution of microbial protein can even reach 100% in livestock with forage-based feed or agricultural waste [3]. Variability of energy and protein digestion in the rumen can affect rumen microbial protein synthesis.

Dried cassava chips (local name gaplek) is a potential feed ingredient for ruminants. Cassava production in 2015 was 22 million tons. Yogyakarta, especially Gunungkidul, is one of the potential cassava producing regions [4]. Cassava production in Gunungkidul was 800 tons. From those production, as much as 60% of cassava produced by farmers in the harvest season will be sold in the form of gaplek [5]. Previous study reported that an increase in cassava consumption resulted in an increase in curvilinear in the digestibility of organic matter and a linear increase in ADG (0.2 - 0.6 kg / day) [6].

In addition to energy sources, livestock also need protein sources in the diet. Previous study reported that Ongole cattle ADG was higher (0.52 vs 0.89 kg) when fed with the concentrate diet containing ongkok, copra meal and palm kernel cake than the bulls fed with regular diet. This ration
also significantly reduces the cost time needed to reach the target body weight [7]. Palm oil production in Indonesia in 2015 reached 31 million tons, so the palm kernel cake (PKC) as palm oil by-product is potentially available to be used as animal feed [8]. Based on previous research the crude protein content of PKC is quite high at around 14% with a crude fiber content of 21.7% [9].

The study of the rumen fermentation characteristics is necessary to determine the response of livestock to the dried cassava chips feeding. The characteristics of rumen fermentation is also important to determine the optimal combination of the cassava with palm kernel cake as energy and protein sources in the diet.

2. Material and methods

2.1. Materials

The materials used are Ruddweigh brand cattle scales that have a capacity of 1000 kg with 0.5 kg sensitivity, feed scales, analytical scales, ovens, Wiley mill, a set of proximate analysis tools, test tubes, test tube racks, centrifuges, waterbath, vortex, spectrophotometer, and micropipette.

2.2. Methods

2.2.1. General. This study used 14 male Ongole Breeds (PO) aged ± 1 year with a range of body weight 180 - 220 kg. The feed ingredients used are gaplek, PKC, rice straw, urea and mineral mix. The study was carried out for 112 days divided into 14 days of adaptation and 98 days of collection period. The first feed and feces collection was carried out on days 22th to 28th and the second collection was carried out on the 49th to 56th day. Bull’s liveweight measured every 7 days. Each bull is allotted in an individual pen. The bulls were divided into 3 feeding groups based on the treatment diet.

2.2.2. Preparation phase. The initial stage of the study was carried out by weighing the initial body weight of bulls to determine the amount of feed requirements, administration of ivermectin and allocation into the treatment group.

2.2.3. Adaptation and collection periods. Livestock were fed rice straw and concentrates based on their treatment. Feed is offered as much as 2.5% dry matter of the body weight, while water is available ad libitum.

Table 1. Feed formulation and nutrient composition

| Feed formulation (%) | T1 | T2 | T3 |
|----------------------|----|----|----|
| Rice Straw           | 20 | 20 | 20 |
| Gaplek               | 70 | 50 | 30 |
| PKC                  | 10 | 30 | 50 |

| Nutrient composition (%) | T1 | T2 | T3 |
|--------------------------|----|----|----|
| DM 78.99±0.19            | 82.06±0.08 | 82.21±0.19 | 83.67±0.17 |
| OM 77.51±0.63            | 97.19±0.08 | 96.33±0.40 | 96.00±0.69 |
| Ash 22.49±0.63           | 2.81±0.08  | 3.67±0.40  | 4.00±0.69  |
| CP 7.02±0.18             | 9.43±0.33  | 10.06±0.19 | 12.11±0.22 |
| SK 35.14±0.12            | 5.45±0.51  | 10.88±0.42 | 12.35±0.43 |
| EE 1.62±0.22             | 2.38±0.00  | 4.16±0.53  | 3.50±0.56  |
| BETN 33.17±1.00          | 79.68±0.89 | 71.11±1.99 | 67.93±0.69 |
| TDN 38.22±0.61           | 75.03±0.52 | 70.23±3.48 | 68.92±2.60 |

Source: Analysis in Laboratory of Feed Technology, UGM (2018)
Feeding was offered 3 times a day, namely at 8:30 a.m., 12:30 a.m., and 16:30 p.m. Rice straw was given first and followed by concentrate one hour later. The mineral mix was given as much as 20 mg/kg LW/head/day along with giving the concentrate in the morning. The urea was administered 2% of dried cassava.

2.2.4. Collection of rumen fluid. On the 98th day, the rumen fluid from each cow collected through the esophagus in the morning before feeding. The pH value measured and the sample then centrifuged 1008 g for 15 minutes to remove feed particles. The samples were then stored for analysis of VFA, NH₃, and microbial proteins [10–11–12].

2.2.5. Statistic. Data were analyzed for variance by following an incomplete randomized blocked design. The Difference between means of treatments were analyzed using Duncan multiple range test at significance level 5% [13].

3. Results and discussion

As shown in Table 2, there was no significant changes in rumen pH (ranged from 7.10 – 7.50), indicating rumen microbes still perform a normal fermentation with 70% inclusion of dried cassava. This result was different from previous study that showed a reduce of ruminal pH below the optimal value (6.5 - 7.0), namely 6.3 and 5.7, due to the use of cassava-based concentrate 2% and 3% in brahman crossbreed diet. [14]. It was explained that the ruminants have three primary means of buffering either acid ingested, or acid produced by rumen microorganisms, those are buffers naturally occurring in saliva, buffering capacity of ingested feed, and added dietary buffers [15]. The use of rice straw as basal diet and rumen sampling time at 0 h before feeding might be also influence the result. Previous study found that rumen pH of dairy cattle fed with concentrate at level 20 to 80% in the diet did not show any differences at 0 h-post feeding, and started to decline at 4 hours after feeding, but increasing on 6 hours after feeding [14]. Regarding the use of roughage as basal diet, it was stated that rumen pH of goat feed with roughage is varied from 7.3 at 0 h, 7.2 at 3 h, and 7.4 at 6 h after feeding [16]. Previous studies also demonstrated that rumen pH varies significantly among sampling sites within the rumen and sampling technique [17]. The pH of ruminal fluid collected by oral tube was significantly higher than ruminal fluid samples with puncture method [18].

Table 2. The effect of varying proportion of rice straw, gaplek and palm kernel cake on rumen fermentation characteristics

| Item                  | T1                  | T2                  | T3                  |
|-----------------------|---------------------|---------------------|---------------------|
| pH (ms)               | 7.10±0.37           | 7.29±0.23           | 7.50±0.30           |
| Total VFA (mM)        | 88.40±9.92 b        | 71.60±2.08 a        | 70.30±6.45 a        |
| Acetate (%) (ms)      | 70.88±7.02          | 78.08±6.19          | 70.99±12.68         |
| Propionate (%) (ms)   | 16.92±3.90          | 13.77±4.24          | 17.19±6.87          |
| Butirate (%) (ms)     | 12.20±3.54          | 8.15±3.31           | 11.83±5.86          |
| Acetate:Propionate    | 3.51±1.15 a         | 4.82±0.59 ab        | 6.32±1.01 b         |
| NH₃-N (mg/100mL)      | 4.64±1.46 a         | 9.92±0.77 b         | 5.44±2.97 a         |
| Microbial protein (mg)| 3.83±0.60 a         | 4.95±1.52 ab        | 6.66±1.15 b         |

abc Means with different superscripts within a row are significantly different (P<0.05), ms Means in the same row are not significantly different (P>0.05)

CP = crude protein

Total VFA was significantly higher in cattle fed with T1 (88.40 mmol/L) due to the higher proportion of gaplek, and start declining with reduction of gaplek proportion (71.60 and 70.30 mmol/L for T2 and T3). Higher total VFA in cattle fed with T1 is in line with higher metabolizable carbohydrate content in the diet The range of total VFA in this study is normal, as compared with
previous study that cattle fed with high protein diet and rice straw as basal diet produced 78.0 mmol/L total VFA at 1 h after feeding, this value was increasing afterward and then start declining after 4 h [19–20].

There was no significant change in the percentages of acetate, propionate, and butyrate of rumen fluid for all treatment. Although there was no significant difference, A:P ratio was tended to increase along with the decrease of gaplek and the increase of PKC. It means that propionate production is declining by reduction of gaplek in the diet. The proportion of acetic acid decreased with higher levels of concentrate in the diet, whereas the proportion of propionic acid increased. But the fiber content in the concentrate will resulted in different VFA concentration regardless of the concentrate level in the diet [21].

Cattle fed with T2 had the highest rumen N-NH3 concentration (9.92±0.77 mg/100mL) which is significantly higher than T1 dan T3 (P<0.05). A higher concentration of N-NH3 in rumen is due to the higher proportion of PKC. This results was in accordance with previous study that the production of rumen N-NH3 is influenced by protein intake and protein content of the feed [22]. Cattle with 70:10 dried cassava and PKC proportion (T1) had the lowest concentration of rumen N-NH3 (4.64±1.46 mg/100mL) that was not significantly different with T3 (5.44±2.97 mg/100mL). Concentration in T1 is below 5 mg/dl, a minimum ammonia concentration for ruminal bacterial growth [23].

As shown in Table 2, addition of PKC in the diet increased the rate of microbial protein synthesis. The rate of microbial protein synthesis ranged from 3.83 to 6.66 mg CP/mL, with the highest rate at T3 and the lowest in the T1 (P<0.05). The increase in the rate of microbial protein production along with the increase of PKC proportion in the diet. In cattle fed with T2, a high N-NH3 production did not contribute on a higher microbial protein synthesis in the rumen. This may be due to the low efficiency of microbial protein synthesis. The rate of microbial protein synthesis reported to be between 10.6 and 17.25 g/100 g DM digested in the rumen [24].

4. Conclusion

High proportion of dried cassava had no adverse effect on rumen digestion. A safe proportion of rice straw, dried cassava, and PKC was 20:30:50. Dried cassava and PKC in this combination provided an optimum rumen microbial protein synthesis.

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