Digestibility of dry matter and organic matter and the in vitro rumen parameters of complete feed from fermented corn cobs and moringa (*Moringa oleifera*) leaves meal

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Abstract. This research aimed to explore the effect addition of fermented corn cobs (FCC) and *Moringa oleifera* leaves (MOL) meal at different levels of complete feed on dry matter, organic matter digestibility, *in vitro* of NH₃ and VFA concentration. The experimental design used was completely randomized design consisted of three treatments and three replicates. The treatments were: T₀ = complete feed without addition of both FCC and MOL meal; T₁ = complete feed+10% FCC+10% MOL meal; T₂ = complete feed+20% FCC + 10% MOL meal. The results showed that increasing content of dry matter (DM), organic matter (OM), crude protein (CP), crude fat (CF), carbohydrate (CHO), Nitrogen Free Ether Extract (NFEE), and energy on FCC with addition of 10% FCC and 10% MOL meal into complete feed. In contrast, there was a decreasing of nutrients component at the addition of 20% FCC complete feed and 10% MOL meal. The treatment was significantly (P<0.05) affected by dry matter, organic matter digestibility, *in vitro* of NH₃, and VFA concentration. In conclusion, addition FCC and MOL meal at different levels into complete had increased the digestibility of dry matter and organic matter, as well as the *in vitro* of NH₃ and VFA concentration.

1. Introduction
Nowadays, the primary constraint of the availability of forages was limited to land due to increased usage of land for food, settlement, and industry. Consequently, other alternative feed sources should be sought in order to reduce the dependency on grass for the development of livestock production. Feed sources should be more available in enough quantity and at relatively low cost. Among agriculture by-products, corn cobs (Figure 1) can be used as fiber and energy sources, but its usage as feedstuff was limited by its physical structure and its high fiber component [2].

Corn cobs have a low protein content i.e., 5.62% but high in fiber content such as 44.9% cellulose, 31.8% hemicellulose, and 23.3% lignin. Therefore, an effort to overcome these problems by increasing the nutrients value, and decreasing fiber content and reducing fiber components such as cellulose and hemicelluloses to be soluble carbohydrate as a source of carbon skeleton and energy for rumen microbial which in turn more degradable and be absorbed in post rumen digestive tract [1]. A diet containing fermented corn cob (FCC) was higher in the digestibility of fiber and TDN compared with an unfermented diet, thus potential to be used as energy source feed. In order to optimize potential of FCC, the addition of other feedstuff is needed in attempting to fulfill the lack of nutrients and improve
nutrients required by ruminant which formulated in the form of complete feed [3]. The addition of other feedstuffs as protein and the amino acid source is important because various feedstuff has protein content with different solubility in producing NH₃ for ruminal microbes. One of such plants is moringa (*moringa oleifera* – MO – Figure 1). MO possesses many valuable properties which made it of great scientific interest. MO leaves (MOL) possess many valuable properties, which made it of great scientific interest. MOL containing 27.1% protein and 2050kcal/kg metabolize energy and also containing balance amino acids such as amino acida-L-amino and amino acid L-amino [4,5].

**Figure 1.** Corn cobs [2] and Moringa tree and its leaf stalk, leaf powdered [5]

In general, the high or low digestibility value of feedstuff was affected by the ability of ruminal microbes in degrading or digesting the feedstuff through a fermentation process in the rumen. The increasing digestibility value of feedstuff was following the fermentation process and growth of ruminal microbes, which indicated by the increasing of rumen fermentation products such as rumen VFA and NH₃. Therefore, VFA and NH₃ concentration in the ruminal fluid can be used as an indicator of feed fermentability that closely related to activity and population of microbes in the rumen [6]. Through the addition of FCC and MOL meal in complete feed, it is expected the increase of dry matter and organic matter digestibility as the result of energy and nitrogen source of the diet increased, which in turn increase rumen fermentation products such as VFA and NH₃. This research was aimed to explore the effect of the addition of FCC and MOL meal at different levels in the complete feed on a dry matter (DM) and organic matter (OM) digestibility and *in vitro* of NH₃ and VFA concentration.

2. Materials and methods

This research was carried out in the Feed Chemical Laboratory of Faculty of Animal Science, Nusa Cendana University, for six weeks, which divided into two weeks of preparation period, one-week fermentation period, and three weeks of laboratory analysis and data analysis.

**Table 1.** Percentage of complete feed ingredients

| Ingredients (%) | Treatments |
|-----------------|------------|
|                 | T₀  | T₁  | T₂  |
| Rice bran       | 60  | 55  | 50  |
| Grinding corn   | 20  | 15  | 10  |
| Fish meal       | 5   | 5   | 5   |
| *Gliricidia sepium* leaves meal | 10 | -   | -   |
| FCC meal        | -   | 10  | 20  |
| MOL meal        | -   | 10  | 10  |
| Urea            | 2.5 | 2.5 | 2.5 |
| Salt            | 2.0 | 2.0 | 2.0 |
| Starbio         | 0.5 | 0.5 | 0.5 |
| Total           | 100 | 100 | 100 |
Feedstuff used in this research were corn cob, EM as an inoculant, liquid palm sugar as an energy source, urea as N source for fermentation microbes, and complete feed of local feed basis (Table 1). The research method used was an experimental method using a completely randomized design consisted of three treatments and four replicates. Those treatments were: (1) \( T_0 \) = complete feed without the addition of both FCC and MOL meal; (2) \( T_1 \) = complete feed + 10% FCC + 10% MOL meal; and (3) \( T_2 \) = complete feed + 20% FCC + 10% MOL meal.

2.1. Parameters measured
Dry matter digestibility (DMD) and organic matter, digestibility (OMD), (2) \( \text{NH}_3 \), and (3) VFA.

2.2. Data analysis
Data collected were subjected to analysis of variance (ANOVA) to study the effect of treatments [7].

3. Results and discussion

3.1. Nutrients composition of experimental diets
Nutrient composition of experimental diets, as shown in Table 2. There was an increasing content of dry matter (DM), organic matter (OM), crude protein (CP), crude fat (CF), carbohydrate (CHO), Nitrogen Free Ether Extract (NFEE), energy on FCC treatment with the addition of 10% FCC and 10% MOL meal into complete feed. In contrast, there was a decreasing of nutrients component at the addition of 20% FCC and 10% MOL meal into a complete feed. This was due to the higher energy source feed added, which in turn decrease the availability of N required for optimizing microbial protein synthesis, which impacted to fermentation in the rumen was not optimum. The decreasing of protein after fermentation was the resulted of bioconversion of sugar into protein [8].

| Nutrients       | MOL meal (%) | FCC meal (%) | \( T_0 \) | \( T_1 \) | \( T_2 \) |
|-----------------|--------------|--------------|---------|---------|---------|
| Dry Matter      | 76.60        | 86.35        | 78.62   | 81.11   | 81.58   |
| Organic Matter  | 78.64        | 97.47        | 83.35   | 86.76   | 85.99   |
| Crude Protein   | 2.61         | 10.95        | 20.16   | 21.35   | 20.74   |
| Crude Fiber     | 29.54        | 19.61        | 15.48   | 11.59   | 17.11   |
| Crude Fat       | 1.57         | 6.22         | 4.28    | 5.12    | 7.07    |
| Carbohydrate    | 74.46        | 80.3         | 58.91   | 60.29   | 58.18   |
| NFEE            | 44.92        | 60.69        | 43.43   | 48.70   | 41.07   |
| Energy (kcal)   | 3,345.1      | 4,444.7      | 3,937.5 | 4,131.3 | 4,167.5 |

Note: Analysis from Laboratory of Dairy Animal Nutrition, Faculty of Animal Husbandry, IPB 2018

3.2. Effect of treatment on in vitro dry matter and organic matter digestibility of complete feed
Feed digestibility in post rumen is indicated by the value of DMD and OMD (Table 3). The value of DMD and OMD can be used as an indicator degree of how easy the feed be degraded by rumen microbial and digested by digestion enzyme in the post rumen.

Data in Table 3 showed that the highest mean of DMD and OMD were reached by then followed by \( T_2 \), and the lowest was \( T_0 \). The addition of FCC caused this and MOL meal at level 10%, which able to increase carbohydrate and NFEE content of ration as a source of C-skeleton and energy for rumen microbes. The addition of MOL meal also was able to increase the availability of N source, so able to meet the requirement of protein and energy for rumen microbial to increase their activity in digesting feed.
Table 3. Mean of DMD and OMD

| Parameters | Treatment | T₀±SD | T₁± SD | T₂± SD | MSE | P-value | Note |
|------------|-----------|-------|--------|--------|-----|---------|------|
| DMD (%)    | 57.86±0.39 | 67.94±0.41 | 60.11±0.58 | 0.220 | 0.00 | *      |
| OMD (%)    | 57.16±0.70 | 66.77±1.15 | 58.69±0.26 | 0.624 | 0.00 | *      |

Note: * = significantly effect (P<0.01)

According to [9], the fermentation process increases nutrients, especially protein and followed by the increase of total carbohydrate as an energy source, and decreasing of crude fiber, increased feed. It has been reported that efficiency growth and activity of cellulolytic microbes were the same as other ruminal microbes, required energy, nitrogen, minerals, and other factors such as vitamin. Energy is also the main essential factor used for the growth of ruminal microbes [10]. Ruminal microbes used energy for maintenance, especially for active transportation.

Statistical analysis (ANOVA) showed that treatment was highly significant (P<0.01) affected the digestibility of both DMD and OMD of complete feed. Different digestibility among three treatments was due to different crude fiber content of complete feed as a result of the addition of FCC and MOL meal. According to [11], the crude fiber-containing in a feedstuff, the more thick cell wall and more resistant to fiber digester microorganism and led to lower digestibility of the feedstuff. In contrast, feedstuff with low fiber content, in general, is more digestible, because its cell wall thinner and comfortable to be perforated by digester microorganism. The crude fiber of a feedstuff was very affected by the degradation of dry matter and organic matter; the higher crude fiber content of a feedstuff, the lower its degradation [12].

Further, Duncan’s test showed that there was a significant difference between treatments T₀-T₁ and between treatments T₁-T₂ on both DMD and OMD of complete feed. This was because of a difference in crude fiber content of each treatment, which led to a difference of either dry matter or organic matter digestibility of complete feed, besides adding MOL meal increase the protein content of complete feed and provide N source for microbes. Digestibility was affected by some factors such as composition comparison between one feedstuff with others, feed treatment, enzyme supplementation in the ration [13].

Feed digestibility in post rumen is indicated by the value of DMD and OMD (Table 3). The value of DMD and OMD can be used as an indicator degree of how easy the feed can be degraded by rumen microbial and digested by digestion enzyme in the post rumen. Overall, digestibility of DMD and OMD in this research was high enough as supported by [14], who reported that digestibility is high if its value is 70% or more, and low if its value is less than 50%. DMD in this research was parallel with OMD because increasing dry matter content was parallel with the increase of organic matter content, which was the component of dry matter. According to [15], organic matter is part of dry matter, therefore decreasing of dry matter will be followed by decreasing of organic matter.

3.3. Effect of treatments on in vitro of NH₃ and VFA concentration

Fermentation in the rumen resulted in volatile fatty acids (VFA) as the main product to provide energy and carbon for growth and maintain the live existence of microbes. NH₃ was the synthesis product of the deamination process of amino acids in the rumen (Table 4). Data in Table 4 showed that the highest concentration of NH₃ was found on treatment T₁ then followed by T₂, and the lowest was T₀. The concentration of NH₃ required for support microbial protein synthesis was ranging between 4-12 mM [16]. The results of this study concentration of NH₃ was ranging between 9.36–13.98mM, which means in normal ranging to support ruminal microbes’ growth. Statistical analysis (ANOVA) showed that treatment was highly significant (P<0.01) affected the NH₃ concentration.
The level of ruminal NH3, which is called ruminal NH3, when microbes will degrade entering rumen. Therefore, the rate of protein degradation, and NH3omes NH3, and use digested NH3-3.

Deficient in one of which affected the total of population of rumen microbes. especially the degradation of carbohydrate and carbon by rumen microbe. Therefore, VFA production in the rumen can come from the degradation of feedstuff protein that enters the rumen and increase content of carbohydrate and NFEE as energy and carbon skeleton which influence concentration of VFA rumen.

Table 4. Mean in vitro concentration of VFA and NH3

| Parameters         | Treatments | T0±SD | T1±SD | T2±SD | MSE  | P-value | Effect |
|--------------------|------------|-------|-------|-------|------|---------|--------|
| Concentration of NH3 (mM) |            | 9.36±0.44 | 13.98±0.70 | 11.22±0.28 | 0.255 | 0.00    | *      |
| Concentration of VFA (mM)   |            | 78.69±7.84 | 113.42±7.25 | 101.36±10.86 | 77.371 | 0.00    | *      |

Note: * = significantly effect (P<0.01)

This was due to the level of MOL meal added as a protein source, which affected the total of protein degraded into amino acids in producing NH3 on each treatment, and by adding 10%, FCC was able to fulfill the energy required by microbes to increase their activity in produce NH3. According to [16], feed protein which rumen microbes will degrade entering rumen. Rumen microbes NH3 indicated that degradable feed protein produced more than 12 mM, while undegradable protein feed (protein bypass) was indicated by NH3 produced less than 3 mM. The proportion of feedstuff protein degraded in the rumen was about 70 – 80%, or 20 – 30% escaped from degradation [14].

This finding was strongly supported by [16], who reported that NH3 concentration was affected by some factors such as kind of feedstuff, source of N solubility, level of protein degradation, and N concentration in the rumen. Further, Duncan's test showed that there was a significant difference (P<0.05) between T0-T1, between T0-T2, and between T1-T2, because the protein content of T0 was lower than both of T1 and T2 led to the difference in produce NH3 in the rumen. According to [17], the balance energy VFA and N in N-NH3 form were needed to synthesize optimum microbial protein. Deficient in one or the other can impede the growth of rumen microbes. Protein in the rumen will degraded become ammonia by a proteolytic enzyme produced by ruminal microbes. High feed protein content degradable protein will result in increasing of NH3 concentration in the rumen [14].

The lowest NH3 concentration of T0 is without the MOL meal added. This was because of low amino acids content resulted in lower NH3 concentration than other treatments. According to Mustofa [18], the concentration of NH3 was determined by the level of feed protein, degree of its degradability, and duration of feeding the rumin can determine NH3 concentration. If the protein content of the feed is low, the NH3 concentration of rumen will low and slow the growth of rumen microbes [19].

The low NH3 concentration will affect the synthesis production of rumen microbes. After degrading feedstuff protein that enters the rumen become NH3, rumen microbes will use the NH3 for their body protein requirement, which is called ruminal microbe’s protein. Due to rumen microbes degrade little feedstuff protein that entering rumen becomes NH3, and use digested NH3 to form its body protein, which in turn catabolized as ruminal microbes’ protein. If protein degradation is faster than microbial protein synthesis, then NH3 will accumulate and exceed its optimum concentration. Therefore, the NH3 concentration of rumen fluid depended on the amount and characteristic of feedstuff protein [20].

Statistical analysis (ANOVA) showed that treatment was highly significant (P<0.01) affected the VFA concentration. This was because of the addition of FCC and MOL meal into complete feed resulted in microbes able to penetrate into feed particles to decompose hemicellulose and cellulose which were non-structural carbohydrate and convert it become simple glucose such as organic acid (acetic, lactic, propionic, and butyric) and increase content of carbohydrate and NFEE as energy and carbon skeleton which influence concentration of VFA rumen.

According to [21], the increasing of VFA could indicate the degradable of a nutrient in the feed, especially the degradation of carbohydrate and carbon by rumen microbe. Therefore, VFA production in the rumen could be used as a standard of feed fermentability, which closely related to activity and population of rumen microbes. Further, Duncan's test showed that there was a highly significant
difference (P<0.01) between T₀-T₁, between T₀-T₂, and between T₁-T₂. This was due to C-skeleton source produced was low, and N source was high, so N source used was decreased according to C required, and vice versa. The high crude fiber content in the T₀ compared to T₁ and T₂, with the addition of FCC and MOL meal, resulted in microbes was unable to digest fiber correctly, and consequently microbes’ synthesis and activity in the rumen was not optimum in digesting crude fiber and produce low VFA to be used as source of C-skeleton and energy.

According to [21], the amount of VFA formed was very affected by digestibility and quality of feed added. In vitro total concentration of VFA in the rumen liquid as the consequence of feed, treatment was ranging between 128.37 – 153.53 mM [20]. Types of feed [14] influenced the value obtained from this study still in the range of average VFA concentration, where the normal total concentration of VFA for optimum growth of microbes was ranging between 70 - 150mM, and this value. Overall, the improved of VFA and NH₃ concentration was along with the high digestibility of DMD and OMD that increased the availability of C-skeleton resulted from FCC meal, also from protein and nitrogen-containing in MOL meal able to stimulate the microbial protein synthesis.

This was the following [16], who reported that the high total VFA produced was reflected that organic feed matter was able to be degraded by microbes in the rumen. Any differences VFA produced among treatments indicated that organic matter used in each treatment was different. According to [21], the ammonia concentration in the rumen was also determined the efficiency of microbial protein synthesis, which in turn influence fermentation results of organic feed matter as VFA, the primary energy source of animal.

4. Conclusion

The addition of FCC and MOL meal at the different levels into complete feed was affected by the increasing of dry matter and organic matter digestibility, and the in vitro of NH₃ and VFA concentration of the complete feed.

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