Performance of local goat fed on complete feed containing cocoa pulp with different fiber sources

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Abstract: Due to the limitation of the forage, especially during the dry season, utilization of complete feed formulated from such agricultural by-product and agro-industry as rice straw, corn cobs, soybean straw, and cocoa pulp is an alternative to solve the problem. The aim of this study was to determine the performance of local goats fed on complete feed containing 10% of cocoa pulp with different fiber sources. Sixteen local male goats, with an average initial body weight of 17.7±4.6 kg, were randomly assigned to one of four treatment diets according to completely randomized block design consisted of four treatments and four blocks as replication. The treatment was T1: Complete feed with rice straw as the fiber source, T2: complete feed with corn cobs as the fiber source, T3: complete feed with soybean straw as the fiber source, and T4: mini elephant grass + concentrate. Analysis of variance indicated that treatment affected DMI (P<0.001) and %DMI/BW (P=0.049) but the treatment did not affect ADG (P= 0.366) and FC (P= 0.468). In conclusion, the use of 10% of pulp cocoa pulp in the formulation of complete feed containing different sources of fiber, i.e., either rice straw corn cobs, or soybean straw is satisfactory in supporting the performance of the local goats.

1. Introduction
Forage availability is the main factor determining the success of the ruminant production system. Ruminant, including goat, is very dependent on the forage availability to support their production [1]. Due to the limitation of the forage, especially during the dry season, utilization of complete feed formulated from such agricultural by-product and agro-industry as rice straw, corn cobs, soybean straw, and cocoa pulp is an alternative to solve the problem [2]. Indonesia is one of the top six of cocoa producing countries in the world with an average yield of cocoa production each year reaches 661.243 tons [3]. Among the provinces in Indonesia itself, South Sulawesi Province is well known as one of the cocoa production centers, producing approximately 143,237 tons of cocoa beans out of 246,223 ha of cocoa plantation land [4]. The main products derived from cocoa processing is cocoa powder or cocoa butter. In addition to cocoa butter, processing of cocoa produce cocoa pods, cocoa pods husk, and cocoa pulp. According to Pratama et al. [5] 68.5% of fresh cocoa weight will become waste, and this waste is very potential in polluting the environment if not handled properly. In the cocoa processing industry, the amount of cocoa pulp, one of the byproducts from the cocoa processing, could reach up to 40% the fresh weight of cocoa beans [6].
Based on its physical and chemical characteristics, cocoa pulp could be used as animal feeding. Physically, the cocoa pulp is very potential to be used as feedstuff if combined or mixed with other ingredients, especially with the one that is containing less water, such as corn cobs meal and rice brand [2]. Chemically, the cocoa pulp is containing a high percentage of sugar [7, 8] which can be utilized as an energy source in formulating animal feed. Based on those characteristics, the cocoa pulp might be used to substitute molasses in complete feed formulation. Many studies have shown that formulation of feedstuff into a form of complete provides some benefits, for example, it increased feed consumption, daily body weight gain of bali cattle [9], improved the quality and yield of goat milk [10]. Moreover, the use of complete feed formulated from such materials as corn cobs resulted in a good performance of local goats in South Sulawesi [11].

Despite its potency, there is very limited information or studies that have been done in terms of using the cocoa pulp as feedstuff for animals. So far the cocoa pulp is only used for such purposes as to produce acetic acid [12], herbicides for the plants [13], for production of jam, juice and fermented beverages [14]. So far, we only noted one study that has been done in using the cocoa pulp as one of the ingredients in formulating complete feed [15]. They reported that the use of cocoa pulp up to 10% in the complete containing corn cobs as the main fiber source did not cause any significant negative effects on in vitro dry matter and organic matter digestibility of the feed. Unfortunately, there is no in vivo studies have been done to evaluate the use of cocoa pulps as a feedstuff for the animal, especially for a ruminant animal. Therefore, this experiment was designed to evaluate the effects of provision of complete feed containing 10% of cocoa pulp with different fiber sources, i.e., either rice straw, corn cobs, or soybean straw on the performance of local goats and comparing the impacts with those given control ration (grass + concentrate).

2. Materials and Methods

2.1. Complete feed formulation
All feedstuff such as rice straw, corn cobs, soybean straw, coconut cake meals, cocoa pulp were obtained from the area surrounding the experimental site or from the village of neighboring regencies. Formulation of the complete feed for this study was carried out according to the following protocols: All feed ingredients having a large or rough particle size, such as rice straw, corn cobs, soybean straw, coconut cake meal was grounded to smaller particles using a hammer mill. After the grinding, each feed ingredient was weighted according to the treatment composition. Following the weighing procedure, all feedstuff were mixed thoroughly using a hand mixer. The mixture (complete feed) was allowed overnight before offering to the experimental animal.

2.2. Animal handling and experimental design
Sixteen local male goats were placed in an individual metabolism cage (1 goat/cage) throughout the study period. The cage was designed purposely so that the feces and the urine can be separated. The experiment was carried out according to a completely randomized block design, consisting of four treatments and four blocks as replication. The blocking system was based on the initial body weight of the animal, averaging 17.7±4.6 kg. Each of the experimental goat was randomly assigned to one of four treatment diets, namely T1: Complete feed with rice straw as the fiber source, T2: complete feed with corn cobs as the fiber source, T3: complete feed with soybean straw as the fiber source, and T4: mini elephant grass + concentrate as control diet. All complete feed (T1 – T3) were formulated to contain 10% of cocoa pulp. The composition of the feed component of the experimental diets is presented in table 1. The feed was given ad libitum and provided twice a day, at 08.00 in the morning and at 16:00 in the afternoon. Drinking water was freely available throughout the day.

2.3. Sampling and data collection
The animal was fed for 14 weeks, in which 2 weeks were treated as a preliminary period and 12 weeks for data collection. During the period of data collection, the amount of feed offered and feed refusal was recorded on a daily basis. The fed was offered twice at 08.00 and 16.00, while the feed refusal
was collected the next morning before giving the fresh feed. Every week the samples of feed and feed refusal were collected and determined for dry matter content. The bulked feed and feed refusal samples for the entire period of the experiment were subsampled (10%) for laboratory analysis. With regard to body weight data collection, each animal was weight every two weeks to monitored body weight gain during the study using commercial weight.

Table 1. The feedstuff composition of the experimental diets

| Feedstuff (%) (DM basis) | Treatments |
|--------------------------|------------|
|                          | T1  | T2  | T3  | T4  |
| Rice straw               | 50  | 0   | 0   | -   |
| Corn cobs                | 0   | 50  | 0   | -   |
| Soybean straw            | 0   | 0   | 50  | -   |
| Rice bran                | 20  | 20  | 20  | -   |
| Coconut cake meal        | 9   | 9   | 9   | -   |
| Cocoa pulp               | 10  | 10  | 10  | -   |
| Shrimp waste meal        | 6   | 6   | 6   | -   |
| Salt                     | 2   | 2   | 2   | -   |
| Mineral Mix              | 2   | 2   | 2   | -   |
| Urea                     | 1   | 1   | 1   | -   |
| Elephant grass           | -   | -   | -   | 60  |
| Concentrate              | -   | -   | -   | 40  |
| Total                    | 100 | 100 | 100 | 100 |

T1= Complete feed with rice straw as the fiber source, T2= Complete feed with corn cobs as the fiber source, T3= Complete feed with soybean straw, T4= Elephant grass + concentrate (60:40%)

2.4. Laboratory analysis and calculation

Prior to chemical analysis, feed and refusal samples were dried in the oven at 65°C for 72 hours then the samples were ground to pass a 1-mm screen. Dry matter (DM) content of the samples was determined by drying the samples in the oven overnight at 105°C (Memmert, Germany). The percentage of ash of the samples was determined by combustion of samples in the furnace (Nabertherm, Germany) for 6 h at 550°C. Organic matter (OM) was calculated as 100 - %ash (DM basis). The procedure of Kjeldahl [16] was used to determine the N content of the feed, and crude protein (CP) of the samples was calculated as total N x 6.25. The procedure of Goering and Van Soest [17] was applied in order to determine the fiber composition of the ration.

2.5. Parameters and calculation

Parameters observed in this study were performance parameters consisted of average dry matter intake (DMI), average daily gain (ADG), feed conversion (FC), and the percentage of feed consumption based on the body weight (DMI/BW). Calculation of each parameter was as follows:

\[
\text{DMI (g/h/d)} = \text{the amount DM of feed offered} - \text{the amount DM of feed refusal}
\]

\[
\text{ADG (g/h/d)} = \text{final body weight (g)} - \text{initial body weight (g)/duration of measurement (d)}
\]

\[
\text{FC} = \frac{\text{DMI}}{\text{ADG}}
\]

\[
\%\text{DMI of BW} = \frac{\text{DMI}}{\text{BW}} \times 100\%
\]

2.6. Data Analysis

All the experimental data were analyzed using analysis of variances according to the completely randomized block design consisted of 4 treatments and 4 blocks as replication. The model was

\[
Y_{ij} = \mu + \beta_i + T_j + \epsilon_{ij}
\]
\[Y_{ij} = \text{observation}, \mu = \text{grand mean}, \beta_i = \text{effects of block (i= 1, 2, 3, 4)}, + \tau_j = \text{effects of treatment (j= 1,2,3,4)}, \text{and } \epsilon_{ij} = \text{experimental error}. \] 

Contrast orthogonal was applied to compare the treatment effects, i.e. C1: P1, P2, P3 vs P4, C2= P1 vs P2, C3= P1 vs P3, and C4= P2 vs P3 [18]. Data were analyzed using SPSS Ver. 16.

3. Results and Discussion
3.1. The chemical composition of the ration

There was no statistical analysis that was carried out to compare the chemical components of the experimental diets (table 2). Proximate analysis indicated that the crude protein content of the diets varied from 127 g/kg DM (T1) to 168 g/kg DM (T4). Similarly, other chemical components such as crude fiber, lipid, nitrogen-free extract were also variable. As in the proximate components, fiber fraction of the feed was also variable (table 2). Neutral detergent fiber (NDF) varied from 434 g/kg DM to 536 g/kg DM (T2). The ADF fraction ranged from 274 g/kg DM (T4) to 380 g/kg DM (T2). Cellulose contents varied between 189 g/kg DM (T1) to 238 g/kg DM (T3), hemicellulose component was ranged between 131 g/kg DM (T1) to 237 g/kg DM (T4), while the lignin components varied between 64 g/kg DM (T1) and 166 g/kg DM (T2).

| Components (g/kg DM) | Treatments |
|---------------------|------------|
|                     | T1 | T2 | T3 | T4 |
| **Proximate components** |     |     |     |     |
| Crude protein       | 127 | 131 | 166 | 168 |
| Ether extract       | 32  | 45  | 59  | 57  |
| Crude fibre         | 178 | 177 | 174 | 161 |
| Nitrogen free extract | 582 | 548 | 487 | 484 |
| Minerals            | 82  | 99  | 114 | 129 |
| **Fiber components** |     |     |     |     |
| NDF                 | 434 | 536 | 429 | 512 |
| ADF                 | 303 | 380 | 280 | 274 |
| Cellulosa           | 238 | 234 | 189 | 194 |
| Hemicellulosa       | 131 | 157 | 142 | 237 |
| Lignin              | 64  | 166 | 90  | 75  |

*Animal Feed Chemical Laboratory, Hasanudin University, 2018. T1= Complete feed with rice straw as the fiber source, T2= Complete feed with corn cobs as the fiber source, T3= Complete feed with soybean straw, T4= Elephant grass + concentrate.

The variability of the chemical components of the diets is understandable as the chemical composition of the fiber sources used to formulate the diets is also variable. For example, The crude protein content of the fiber sources was varied from 4.1-5.4% for rice straw to 16.6% for soybean straw [2, 19]. As the consequences, the average crude protein content of the diets was also variable, from 12.7% (T1) to 16.8% (T4). Despite the slight differences in crude protein contents, all ration contained crude protein over the minimum percentage required for ruminant, which is 7.5% [20, 21]. With regard to the fiber components, the variation of NDF and ADF among the diets were observable. It varied from 429 g/kg DM (T3) to 536 g/kgDM (T2) for NDF and from 274 g/kg DM (T4) to 380 g/kg DM (T2) for ADF. With regards to the lignin content, it varied from 64 g/kg DM (T1) to 166 g/kg DM (T2).
3.2. Performance of the goats

Some of the parameters of animal performance usually measured to evaluate the impact of diets on the animal performance, including dry matter intake (DMI), average daily gain (ADG), feed conversion (FC), and the ratio of DMI to body weight (BW). Table 3 shows the performance of the animal during the study period. In general, the animal is in good condition throughout the study. This was indicated by a good level of feed consumption and the body weight gain by the animal during the study period. The analysis of variance indicated that treatment significantly affected DMI (P=0.001) and % of DMI/BW(P=0.049). However, the treatment did not have any significant effects (P>0.05) on ADG and FC.

Table 3. Performance of experimental animal according to the treatments

| Parameters       | T1     | T2     | T3     | T4     | Significant (P<) |
|------------------|--------|--------|--------|--------|-----------------|
| DMI (g/h/d)      | 487±   | 617±   | 549±   | 904±   | 0.001           |
| ADG (g/h/d)      | 85.4±  | 83.3±  | 93.8±  | 133.3± | 0.366           |
| DMI/ADG (FC)     | 5.8±   | 9.7±   | 6.9±   | 10.3±  | 0.468           |
| DMI/BW (%)       | 2.42%± | 2.97±  | 2.71±  | 4.16±  | 0.049           |

Contrast orthogonal (C) for ADG and for DMI/BW: C1= T4 vs T1, T2, T3 was differed (P<0.05). C2 = T1 vs, T2 (P>0.05), C3 = P1 vs P3 (P>0.05), and C4 = P2 vs P3 (P>0.05). T1= Complete feed with rice straw as the fiber source, T2= Complete feed with corn cobs as the fiber source, T3= Complete feed with soybean straw, T4= Elephant grass + concentrate (60:40%)

Further test using the contrast orthogonal analysis indicated that average DMI intake of goat given T4 (grass + concentrate) was much higher (P<0.05) than those given either T1, T2, or T3 (904 vs 551 g/h/d), while there was no difference (P>0.05) in DMI observed for the animal consuming either T1, T2, or T3 respectively. The data indicated that all complete feed containing cocoa pulp is less appetite compared to the control diet (table 3). The average DMI of feed containing cocoa pulp (T1-T3) was about 39% lower than that of the control diet. This most likely is related to the palatability of the diet. One of the factors determining the feed consumption of animal is palatability [21]. Cocoa pulp so far is never used as feedstuff for the animal [15], and this factor may be the reason why the level of intake of animal consuming ration containing cocoa pulp (T1-T3) was lower compared to that of animal consuming control diet (T4). The significant difference was also observed for DMI/BW (%) between the animal consuming one of the three kinds of complete feed (T1-T3) and the control (T4). The average ratio of DMI/BW (%) for animal fed on T4 was higher 35% higher (P<0.05) than that of animal given T1, T2, or T3 (4.16% vs 2.70%). However, there was no difference observed for animal given the treatment T1, T2, and T3. The ratio between DMI and BW reported in this study was quite similar to those reported by Mirsha [22] who claimed that the ratio between DMI kg/100 kg BW ranged from 2.8 to 3.3.

Unlike the parameters of DMI and ratio DMI/BW(%), the treatment had no significant effects (P>0.05) on ADG and FC. Even though there were no statistical differences observed among the treatments for ADG and FC parameters, there was a tendency that ADG of animal consuming control diet (T4) was much higher than those given either T1, T2, or T3 (133.33 vs 87.5 g/h/d). Average daily gain of goat in this experiment was similar to those reported by other studies (22, 23, 24). With regard to the FC, which showed the amount of feed (kg) required by the animal for gaining 1 kg of body weight, the effects of treatments were similar across the treatments, averaging 8.17 meaning that on the average, the animal required 8.17 kg of feed to gain 1 kg of body weight. Numerically, ration T1 had the least number of feed required to gain 1 kg of body weight followed by T3, T2, and T4. F/C obtained this study is in agreement with previous studies (11, 24). High variation of data in this study may be one of the factors contributing to the fail of detecting the different effects of the treatment on the ADG and FC.
4. Conclusion
Formulation of complete feed using 10% of cocoa pulp combined with different sources of fiber, i.e., either rice straw corn cobs or soybean straw is very satisfactory in supporting the performance of local goats comparing to those fed on control diet (grass + concentrate). This is proved by the fact that the goat given complete feed containing cocoa pulp can convert the feed into body weight gain as efficient as those given control diet (grass + concentrate). However, further study is still required using a higher number of an animal with a longer duration of time to confirm this initial finding.

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