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Research Article
Effects of Cocoa Pod Fermented by *Phanerochaete chrysosporium* with the Addition of Mn^{2+} on the Performance of the Javanese Thin-Tailed Sheep

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Abstract
Objective: This study aimed to determine the effect of cocoa pod fermented by *Phanerochaete chrysosporium* with the addition of 600 µg Mn^{2+} g^{-1} substrate on the performance of the Javanese thin-tailed sheep. **Materials and Methods:** Twelve Javanese thin-tailed sheep with body weights of 15-17 kg were put into individual cages that were equipped with feed and drink containers. The study used a completely randomized design in a unidirectional pattern, with three treatments and four replications. The treatments involved the use of cocoa pod fermented by *Phanerochaete chrysosporium* with the addition 600 µg Mn^{2+} g^{-1} substrate as thin-tailed sheep feed. The treatments were T1 = 40% concentrate+60% forage, T2 = 40% concentrate +42% forage +18% fermented cocoa pod and T3 = 40% concentrate +18% forage +42% fermented cocoa pod. Rations were prepared for a crude protein determination of 12%. Observed variables included dry matter intake, average daily gain (ADG) and feed conversion ratio. **Results:** The results showed that feeding Javanese thin-tailed sheep cocoa pod fermented by *Phanerochaete chrysosporium* with the addition of 600 Mn^{2+} g^{-1} substrate produced the highest DM, OM and CP consumption with a composition of 40% concentrate +18% grass +42% fermented cocoa pod, at 1030.85±1.30, 672.26±0.89 and 123.80±0.99 g $head^{-1}$ day^{-1}, respectively ($p<0.05$). The highest DM, OM and CP *in vivo* digestibility was obtained with 40% concentrate +18% grass +42% fermented cocoa pod (67.69±0.50%, 66.33±0.54% and 60.05±0.66%, respectively). The highest average daily gain (145.46±1.05 g $head^{-1}$ day^{-1}) was obtained with 40% concentrate +18% grass +42% fermented cocoa pod. The lowest feed conversion ratio (7.39±0.08) was obtained with 40% concentrate +18% grass +42% fermented cocoa pod ($p<0.05$). **Conclusion:** It can be concluded that cocoa pod fermented by *Phanerochaete chrysosporium* with the addition of 600 µg Mn^{2+} g^{-1} substrate can be used to substitute for up to 42% of dietary composition for Javanese thin-tailed sheep.

Key words: Cocoa pod fermentation, Javanese thin-tailed sheep, *Phanerochaete chrysosporium*, nutrient consumption, plantation waste

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Competing Interest: The authors have declared that no competing interest exists.

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

INTRODUCTION

Cocoa pod is sometimes not used optimally but rather discarded near plantations, where it can have a negative effect on the environment. According to the Center for Agricultural Information System and Data[1] the largest component of cocoa (74%) is the cocoa pod[2], so if Indonesian cocoa production reaches 735.000 t year^{-1}, the quantity of cocoa pod that is wasted and left in the environment is 543.900 t year^{-1}.

Cocoa pod is one of the types of plantation waste that can be used as an alternative feed material for ruminants. High levels of lignin and low protein are the main obstacles for the use of this material as feed. The high level of lignin causes low cocoa pod digestibility, because the presence of lignin prevents the process of breaking down cell wall polysaccharides by rumen microbes. The use of cocoa pod as a feed ingredient requires a touch of bioconversion technology, which can change the composition with the help of microbes.

Cocoa pods contain crude protein and crude fiber contents of 6.17 and 35.83%, respectively[3]. The low crude protein content (nitrogen) is accompanied by high contents of lignin and silica[4], because in the cocoa pod of old plants, the fiber fraction content is elevated to protect the seeds and results in a reduced crude protein content. The contents of fiber fractions such as neutral detergent fiber (NDF) and acid detergent fiber (ADF) are 80.65 and 74.64%, respectively, while hemicellulose is 6.01%, cellulose is 35.33% and lignin is 38.78%[5]. The magnitude of the difference in the proportion of fiber (lignocellulose) fraction from cocoa pod is influenced by the variety or species of cocoa plants and several other agronomic factors, including the characteristics of the soil where it grows and the time of harvest[6].

In the process of lignin degradation, manganese plays an important role in the activity of manganese peroxidase and regulates the production of manganese peroxidase, laccase and lignin peroxidase[7]. Manganese increases manganese peroxidase activity and regulates laccase and lignin peroxidase activity[7].

Fermentation using white rot fungi and the addition of Mn^{2+} minerals causes a decrease in the contents of the fiber fraction consisting of hemicellulose, cellulose and lignin, which are components that are difficult to digest by rumen microbes. An effort to delignify needs to be made to increase the accessibility of cellulose as an energy source for livestock, namely, by carrying out the process of cocoa pod fermentation with fungi.

High digestibility in the rumen reduces the digestion time of feed from the rumen to the small intestine, which is followed by high absorption of nutrients. An increase in the digestibility of feed or a shorter length of stay in the digestive system of a ruminant animal, especially in the rumen, can increase feed consumption resulting in an increase in body weight gain.

This research was conducted to determine the effect of the use of *Phanerochaete chrysosporium* and the addition of Mn^{2+} minerals in the cocoa pod fermentation process on aspects of Javanese thin-tailed sheep production, including feed consumption, feed digestion, daily weight gain and feed conversion ratio.

MATERIALS AND METHODS

Materials: Board-floored individual cages (60×100 cm) were used as housing in this study, each occupied by one sheep. Each cage was equipped with a wooden tub where the feed was kept full, while a plastic bucket was used as a drinking water container. Digital analytical scales were used with a sensitivity of 0.0001 g, a scale capacity of 10 kg with a sensitivity of 0.1 kg, a scale capacity of 1000 kg with a sensitivity of 0.5 kg and a container of feed. The subjects used in this study were 12 thin-tailed sheep. The feed ingredients used were silage of tofu dregs, soybean hull, soybean meal, forage and fermented cocoa pod.

Methods: *P. chrysosporium* used in this study were grown and maintained using Potatoes Dextrose Agar (PDA) media. *P. chrysosporium* were grown on solid PDA media by inoculating the PDA with small pieces of *P. chrysosporium* and incubating for approximately 1 week. Short-term culture storage on PDA media was at 4°C, while long-term storage took place on cocoa pod media. The weathered *P. chrysosporium* was then propagated by transferring it into a liquid medium to be used in the fermentation process. The liquid medium contained PDA broth with the usage rules of 26.5 g L^{-1}. A total of 0.3975 g/15 mL of distilled water was put into a 250 mL Erlenmeyer flask and then heated for 1 min until boiling. The liquid medium was then autoclaved at 121°C for 15 min. *P. chrysosporium* from the solid medium was inoculated into the liquid medium.

Manganese in the form of $MnSO_4$ was used in addition to the fermentation process. The quantity of manganese to be included in the fermentation process was determined by calculating the molecular weight of Mn and the molecular weight of $MnSO_4$.

P. chrysosporium inoculants to be used in field applications were prepared with finely chopped cocoa pod.

The chopped cocoa pod was sterilized in a 121°C autoclave for 15 min. The cocoa pod was then inoculated with *P. chrysosporium* and 600 μg Mn^{2+} g^{-1} substrate based on dry matter[8]. This cocoa pod preparation was used as an inoculant on a field scale.

Fresh cocoa pods were collected from the people's plantations in Selorejo Village, Girimarto District, Wonogiri Regency. The cocoa pod was then chopped and cut into sizes of 1-3 cm and dried in the sun to 35% water content. Fermented cocoa pod for field-scale application was prepared once a week. Cocoa pods that had been prepared for the fermentation process were placed in a 30 L barrel and then inoculated with mold in a quantity as high as 5% of the dry matter weight of the chopped cocoa pod. Cocoa pod fermentation was carried out for 7 days before the preparation was used as thin-tailed sheep feed.

Dietary feeds prepared by determining 12% crude protein for fattening programs based on DM are described in Table 1. Dietary feeds prepared by determining 12% crude protein for fattening programs, based on total weight, are described in Table 2.

The third stage of the study used a completely randomized design in a unidirectional pattern with three treatments and four replications. Twelve thin-tailed sheep with body weights of 15-17 kg were put in individual cages equipped with feed and drink containers. The treatments involving cocoa pod, fermented using *P. chrysosporium* with addition of 600 μg Mn^{2+} g^{-1} substrate[8], as Javanese thin-tailed sheep feed were as follows:

- P1 = 40% concentrate +60% forage
- P2 = 40% concentrate +42% forage +18% fermented cocoa pod
- P3 = 40% concentrate +18% forage +42% fermented cocoa pod

Observational variables in this study included consumption of feed nutrients, feed digestibility, average daily gain and feed conversion ratio.

Data were analyzed using one way Analysis of Variance (ANOVA). Duncan's multiple range test was used to test the significant difference among treatments[9]. Statistical significance was set at p<0.05.

Table 1: Feed composition (% DM)

	Feed composition (%DM)		
Variables	40% concentrate +60% forage	40% concentrate +42% forage +18% fermented cocoa pod	40% concentrate +18% forage +42% fermented cocoa pod
Kinds of feed (%)			
Forage	60.000	25.200	10.800
Fermented cocoa pod	0.000	10.800	25.200
Concentrate			
soybean hull	10.220	19.560	28.620
Soybean meal	6.220	8.890	9.160
Silage of tofu dregs	23.560	35.560	26.220
	100.000	100.000	100.000
Nutrient composition			
Dry matter (g)	1.125	1.125	1.125
Crude protein (%)	12.910	12.930	12.930
Crude fiber(%)	24.890	23.000	26.220
Total digestible nutrients (%)	68.070	71.560	72.120

Table 2: Feed Composition (g as fed)

	Feed composition (% DM)		
Variables	40% concentrate +60% forage	40% concentrate +42% forage +18% fermented cocoa pod	40% concentrate +18% forage +42% fermented cocoa pod
Kinds of feed			
Forage	60.00	612.18	262.36
Fermented cocoa pod	0.00	159.87	373.03
Concentrate			
soybean hull	10.22	252.15	369.05
Soybean meal	6.22	110.64	113.96
Silage of tofu dregs	23.56	621.12	458.07
	2078.32	1755.96	1576.48

RESULTS AND DISCUSSION

Nutrient consumption: Daily dietary consumption in the study was calculated as the average amount of feed consumed by livestock during maintenance. Nutrient consumption per day is the consumption of dry matter feed multiplied by its nutrient content. The results for nutrient consumption are shown in Table 3.

Consumption of dry matter (DM): The test of means showed that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in a higher consumption of DM (g head^{-1} day^{-1}) (p<0.05) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod).

This outcome shows that sheep that have been adapted to fermented cocoa pod feed have no problems with the provision of fermented cocoa pod in their feed up to 42%. Astuti[9] stated that adequate dietary protein content and finer particle size can increase food consumption. Fermented cocoa pod was supplied by mixing it with concentrate so that the feed becomes homogeneous so that cattle were not able to choose feed ingredients, resulting in increased consumption of fermented cocoa pod.

Feeding P2 (40% concentrate +42% forage +18% fermented cocoa pod) can increase feed palatability. This increase is indicated by the increase in consumption of DM (g/kg metabolic weight) with feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) (p<0.05) over feeding P1 (40% concentrate +60% forage) and P2 (feeding 40% concentrate +42% forage +18% fermented cocoa pod). Parakkasi[10] stated that one of the factors that can affect the level of feed consumption in ruminants is the physical nature of the feed itself. Foods that are easily digested generally have a short retention time, so the feed can be absorbed or digested. This outcome causes the rumen to empty quickly so that the sheep will consume more feed.

Feed consumption is the amount of feed that can be consumed by livestock in a certain period of time. The level of feed consumption is the most important factor determining the quantity of nutrients obtained by livestock and subsequently affects the level of production of these animals.

Consumption of organic matter (OM): The test of means showed that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher OM consumption (g head^{-1} day^{-1}) (p<0.05) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod).

This outcome demonstrates that sheep that have been adapted to fermented cocoa pod feed have no problems with the provision of fermented cocoa pod in their feed up to 42%. Astuti[9] stated that adequate dietary protein content and fine particle size can increase the level of food consumption. Fermented cocoa pod was supplied by mixing it with concentrate so that it became homogeneous, resulting in cattle not being able to choose feed ingredients and thus increased consumption of fermented cocoa pod.

Based on Table 3, it appears that good cocoa pod fermentation treatment can increase the consumption of OM (g kg^{-1} of metabolic weight). Feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher consumption of OM (g kg^{-1} metabolic weight) (p<0.05) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% cocoa pod fermentation). Ngadiyono[11] stated that the dry matter consumption of feed needs to be considered, because nutrient consumption depends on the level of consumption of dry matter.

Consumption of crude protein (CP): The test of means showed that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher CP consumption

Table 3: Average nutrient consumption of Javanese thin-tailed sheep fed with cocoa pod feed fermented with *P. chrysosporium* and the addition of 600 μg Mn^{2+} g^{-1} substrate

	Feed composition (% DM)		
Variables	40% concentrate +60% forage	40% concentrate +42% forage +18% fermented cocoa pod	40% concentrate +18% forage +42% fermented cocoa pod
Dry matter (g head^{-1} day^{-1})	1001.02±2.18^{a}	1010.81±2.34^{b}	1030.85±1.30^{c}
Organic matter (g head^{-1} day^{-1})	630.83±2.08^{a}	658.82±1.55^{b}	672.26±0.89^{c}
Crude protein (g head^{-1} day^{-1})	110.91±1.20^{a}	116.47±0.79^{b}	123.80±0.99c
Dry matter (g kg^{-1} metabolic weight)	98.08±0.48^{a}	107.26±0.89^{b}	111.62±1.30^{c}
Organic matter (g kg^{-1} metabolic weight)	87.95±1.30^{a}	92.56±1.16^{b}	98.11±0.57^{c}
Crude protein (g kg^{-1} metabolic weight)	11.02±0.65^{a}	12.52±0.16^{b}	13.56±0.58^{c}

^{a,b,c}Different superscripts on the same row indicate significance (p<0.05)

Table 4: Average nutrient digestibility for Javanese thin-tailed sheep fed with cocoa pod feed fermented using *P. chrysosporium* and the addition of 600 µg Mn^{2+} g^{-1} substrate

	Feed composition (% DM)		
Variables	40% concentrate +60% forage	40% concentrate +42% forage +18% fermented cocoa pod	40% concentrate +18% forage +42% fermented cocoa pod
Dry matter digestibility	60.89 ± 0.48^a	65.42 ± 0.43^b	67.69 ± 0.50^c
Organic matter digestibility	59.64 ± 0.76^a	64.64 ± 0.49^b	66.33 ± 0.54^c
Crude fiber digestibility	55.39 ± 0.34^a	58.00 ± 0.48^b	60.05 ± 0.66^c

a,b,cDifferent superscripts on the same row indicate significance (p<0.05)

(g $head^{-1}$ day^{-1}) (p<0.05) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod).

The results of the study showed that the energy and protein consumption of sheep under all three treatments were sufficient. According to NRC[12], adequate nutrition for basic needs and growth of sheep with body weights between 15-25 kg requires TDN of 310-410 g $head^{-1}$ day^{-1} and CP levels of 95-122 g $head^{-1}$ day^{-1} for daily gain of 100 g $head^{-1}$ day^{-1}.

Based on Table 3, it appears that the cocoa pod fermentation treatment can increase CP consumption (g kg^{-1} metabolic weight). Feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher CP consumption (g kg^{-1} metabolic weight) (p<0.05) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod).

The increase in nutrient consumption with the fermented cocoa pod feed may also have resulted from the palatability level of fermented feed, which is higher than that for non-fermented cocoa pod feed. Forbes[13] stated that the palatability of feed is one of the factors that influences the level of feed consumption. Fermented feed is generally more palatable than unfermented feed.

Nutrient digestibility: Nutrient digestibility measures the quantity of feed nutrients that can be digested by livestock. Parakkasi[10] defined digestibility as the amount of food that can be digested in the digestive tract. Digestion or digestibility entails the part of feed nutrients that are not excreted in feces and are assumed to be absorbed by livestock[9]. The digestibility levels of nutrients in this study are shown in Table 4.

Dry matter (DM) digestibility: The test of means shows that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher DM digestibility (p<0.05) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod). The digestion of dry matter in this study was 64.3-66.3%, which is greater than that previously reported[14].

The fermentation treatment can improve the nutritional value of the feed so that the feed becomes easier to digest, maximizing its digestibility value. This improvement shows that the fermentation process can increase feed digestibility. Fermentation is a process of breaking down hard structures physically, chemically and biologically so that the material from complex structures becomes simple and the compound therefore becomes easier to digest. With an increase in the amount of feed that can be digested, the digestibility value of the feed increases.

Differences in digestibility are due to differences in the composition of feed ingredients. McDonald *et al.*[15] explained that the chemical composition of feed ingredients is one of the factors determining the level of degradation and digestibility of feed ingredients in the rumen. A similar opinion was expressed by Petterson[16], who stated that the digestibility of feed is influenced by the type of livestock, the age of the animal, the type of feed ingredients and the chemical composition of the feed.

One aspect of feed composition that determines the digestibility of the feed is the crude fiber content, which includes cellulose, hemicellulose and lignin. The source of fiber in the control feed was forage, while the other treatments used forage and fermented cocoa pod. The value of cocoa pod is higher than that of the forage, because the cocoa pod had undergone a fermentation process with the addition of molds and Mn^{2+}. The DM digestibility value is also determined by the CP digestibility value. Foods that have a higher CP digestibility value tend to have higher DM digestibility values as well.

Cocoa pods have a high CP content and the fermentation treatment using *P. chrysosporium* causes DM digestibility to be higher. Forages have lower DM digestibility, because the feed is more difficult to digest.

Organic matter (OM) digestibility: The test of means shows that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher OM digestibility (P<0.05) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod). This outcome shows that the use of feed with fermented cocoa pod is better than the control treatment. The use of fermented cocoa pod can replace the control feed in the form of concentrate and forage.

Table 4 shows that OM digestibility of P3 is higher (66.33%) than that of P1 (50.64%) and P2 (64.64%). This difference is influenced by the digestibility of the fiber source feed ingredients used in each treatment.

The fermentation process serves to break down complex organic compounds into simpler compounds so that the organic compounds become easier to digest. The addition of *P. chrysosporium* and 600 μg Mn^{2+} g^{-1} substrate made OM digestibility of fermented cocoa pod higher.

Crude protein (CP) digestibility: The test of means shows that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in a higher CP digestibility ($p<0.05$) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod). This outcome shows that the use of feed with fermented cocoa pod is better than the control treatment. Fermented cocoa pod can be a replacement for forage feed.

The increase in CP levels is caused by the addition of *P. chrysosporium* and enzymes secreted by this fungus. The enzymes generally consist of protein, while the mold itself is a unicellular organism. This increase in the CP levels raises the quantity of protein that can be utilized by livestock so that the CP digestibility of the feed increases.

The increase in CP digestibility in fermented cocoa pod feed affects the daily weight gain of livestock. Wahyudi[17] stated that daily weight gain of sheep given control feed and complete fermented feed is higher than daily weight gain of sheep that are given complete non-fermented feed. Daily weight gain of sheep fed with control feed was 120.29 g $head^{-1}$ day^{-1} and daily weight gain of sheep fed complete fermentation feed was 128.67 g $head^{-1}$ day^{-1}, while daily weight gain for sheep that were given complete non-fermented feed was 114.48 g $head^{-1}$ day^{-1} [17].

Initial body weight, final body weight, average daily gain and feed conversion ratio: The mean initial body weight, final body weight, average daily gain and feed conversion ratio are listed in Table 5.

Initial body weight: The test of means showed that the sheep did not differ significantly among treatments in initial body weight. Similar initial body weight indicates that the sample was tested with a uniform fermented cocoa pod feed application.

Final body weight: The test of means shows that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher weight ($p<0.05$) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod).

Fermented cocoa pod feed up to 42% results in the greatest final body weight. This outcome shows that fermented cocoa pod can be used by livestock as grass substitute feed.

Average daily gain: The test of means shows that feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in a higher average daily gain ($p<0.05$) than did feeding P1 (40% concentrate +60% forage) or P2 (40% concentrate +42% forage +18% fermented cocoa pod).

Weight gain reflects the quality of feed provided. The treatment of feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) showed the highest average daily gain, because the quantity of nutrients consumed by this feeding treatment was higher; also, the digestibility of nutrients in the treatment of feeding P3 (40% concentrate +18% forage +42% fermented cocoa pod) was also higher than feeding with P1 (40% concentrate +60% forage) or with P2 (40% concentrate +42% forage +18% fermented cocoa pod).

Average daily gain of sheep, besides being influenced by feed, is also influenced by genetic factors. Growth is a physiological activity that can be expressed by weight gain on

Table 5: The mean initial body weight, final body weight, average daily gain and feed conversion of Javanese thin-tailed sheep fed with cocoa pod fermented using *P. chrysosporium* with the addition of 600 μg Mn^{2+} g^{-1} substrate

	Kind of feed		
Variables	40% concentrate +60% forage	40% concentrate +42% forage +18% fermented cocoa pod	40% concentrate +18% forage +42% fermented cocoa pod
Initial body weight (kg $head^{-1}$)^{ns}	15.12±0.66	15.09±0.59	15.30±0.82
Final body weight (kg $head^{-1}$)	27.67±0.47^{a}	30.07±0.93^{b}	31.60±0.45^{c}
Average daily gain (g $head^{-1}$ day^{-1})	121.50±0.50^{a}	140.22±0.99^{b}	145.46±1.05^{c}
Feed conversion	9.39±2.24^{a}	8.40±0.27^{b}	7.39±0.06^{c}

^{a,b,c}Different superscripts on the same row indicate significance ($p<0.05$), ^{ns}non-significant ($p>0.05$)

average per unit of time. Growth is influenced by factors such as feed, sex, hormones, age and environmental variables such as disease and climate[18]. McDonald *et al.*[15] stated that livestock growth is controlled by nutrient consumption, especially energy consumption. Muck[19] noted that the rise and fall of average daily gain is strongly influenced by high and low feed consumption.

Feed conversion ratio: The test of means showed that feeding with P3 (40% concentrate +18% forage +42% fermented cocoa pod) resulted in higher feed conversion values ($p<0.05$) than did feeding with P1 (40% concentrate +60% forage) or with P2 (40% concentrate +42% forage +18% fermented cocoa pod). This outcome occurred because the consumption of dry matter and average daily gain produced were also significantly different. According to Tillman[20], feed conversion ratio is a comparison between feed consumption and average daily gain. The average feed conversion ratio for each treatment was 9.39 ± 2.24 (T1), 8.40 ± 0.27 (T2) and 7.39 ± 0.06 (T3). The feed conversion value indicates that to increase body weight by 1 kg requires 9.39 kg of dry matter feed for the treatment with P1 (40% concentrate feed +60% forage), 8.40 kg dry matter feed for the treatment with P2 (40% concentrate +42% forage +18% fermented cocoa pod) and 7.39 kg dry matter of feed for the treatment with P3 (40% concentrate +18% forage +42% fermented cocoa pod).

Conversion of feed produced in all treatments is quite good. A lower value of feed conversion, according to Tillman[20], indicates that the livestock are more efficient in utilizing feed. Feed conversion ratio is used to determine production efficiency. Feed conversion ratio is obtained from consumption divided by weight gain. The lower the feed conversion ratio is, the higher the feed efficiency.

Feed conversion ratio is influenced by the level of feed consumption and average daily gain. Feed conversion ratio depend on the quality of feed provided; the better the digestibility value is, the better the conversion of feed. This outcome is consistent with the opinion expressed by Parakkasi[10] who stated that a lower conversion rate of feed is more profitable because less food is consumed to achieve optimal meat products within a certain period of time.

CONCLUSION

The results of this research show that 42% supplementation of Javanese thin-tailed sheep diet with cocoa pod fermented using *P. chrysosporium* and the addition of 600 µg Mn^{2+} g^{-1} substrate resulted in the highest nutrient consumption, the highest nutrient digestibility, the highest average daily gain and the most favorable feed conversion ratio.

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