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The Utilization of Coconut Coir as Supplementary Feed for Beef Cattle Production

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Abstract

High feed price is a major problem in the production of beef cattle. Therefore, this study aims to determine coconut coir's technical and economic potential for beef cattle feed. This is an *in vivo* and *in vitro* study that involved 95 days trial period and 16 male Brahman crossbreed cattle weighing 134±12.1 kg. The coconut coir was fermented using buffalo rumen liquid and was termed fermented coconut coir (FCC). A randomized block design was used in this research, including four feed treatments, namely complete feed D1 using 15% FCC, D2 using 20% FCC, D3 using 25% FCC and D4 using 30% FCC. The parameters observed were technical performance (protein, dry and organic matter intake), ruminal fermentability, purine derivatives and economic performance. The data were analyzed using analysis of variance and Duncan's multiple range test for posthoc multiple comparisons. The results showed that the intake of beef cattle feed D1, D2 and D3 was higher than D4. Furthermore, the digestibility of D1, D2 and D4 was higher than D3. The purine derivatives of D2 were the highest but not significantly different ($P > 0.05$) from D1 and D4. In addition, the ruminal fermentability was not significantly different ($P > 0.05$) among treatments. Moreover, the beef cattle feed on D2 had the best economic performance. The performance results showed that ruminal fermentability, purine derivatives and economic performance of D2 (20% FCC) gave the best results but were not statistically different ($P > 0.05$) from other variables. Conclusively, coconut coir can be used as beef cattle feed without causing health problems.

Keywords: coconut coir; economic performance; purine derivatives; ruminal fermentability; technical performance

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INTRODUCTION

Coconut is a common multifunctional found in Indonesia found on the North Coast of Java, growing from Banten Province to Banyuwangi Regency. Furthermore, it is spread across many Asian countries and is widely used as food, drinks, biodiesel and even cosmetics (Ramesh et al., 2021). Coconuts' production worldwide covers more than 10 million hectares, distributed in 92 countries. Indonesia, India and the Philippines account for nearly 75% of its production worldwide. Indonesia has become the largest coconut producer in the globe. One of its available biomasses is coconut coir, which has a high calorific value in the form of lignin and cellulose and consists of charcoal, pyroligneous acid, tar, gas, potassium and tannin (Zafar, 2021). Generally, coconut coir has a great potential to be used as ruminant feed.

Coconut coir is primarily used for direct combustion to generate heat; otherwise, it is just

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discharged into the environment. This condition has exacerbated current pollution caused by agricultural production since the Green Revolution era (Mariyono, 2015). According to Mariyono (2015) and Mariyono et al. (2018), considerably high external costs are associated with agricultural pollution in Indonesia. Therefore, creativity to utilize coconut coir for valuable purposes is expected to reduce environmental pollution.

Coconut coir can be transformed into a value-added feeding material, supplementing the existing feeding sources in livestock production. In terms of availability and costs, it has good potential for feeding materials. This idea of using supplementary materials for animal feed is consistent with the studies of Santoso et al. (2016); (2017). In the case of coconut coir, the significant advantage is that coconut is permanently cultivated and the product is available year-round (Bello et al., 2020; Asadu et al., 2021; Verma et al., 2021), resulting in a constant supply of biomass. In terms of contents, Nuswantara et al. (2020) state that coconut coir has a sufficiently high fiber and low protein content, indicating that it is useful as animal feed. Its chemical compositions include 14.25% pectin, 26% water, 21.07% cellulose, 8.50% hemicellulose and 29.23% lignin.

In Indonesia, beef cattle production has grown stagnant, with a population ranging from 16 to 17 million heads in 2019. Most beef consumption, which is expected to supply nutritious diets and vegetables, is still met from imports from other countries (Wijaya et al., 2021a, 2021b). The consumption of beef and vegetables increases together with demographic growth. In Indonesia, coconut coir has not been used to feed beef cattle, hence, increased production is required by providing healthy feeding material at affordable prices.

Sustainable agriculture and feed are indispensable for future livestock development (Uwineza et al., 2021). Coconut coir is a fiber source that can replace rice straw; however, it has not been used optimally and a large number can cause environmental pollution. Furthermore, the use of coconut coir for cattle feed will support sustainable agriculture. Nuswantara et al. (2020) stated that coconut coir can replace rice straw waste, which is significantly reduced during the dry season.

The development of animal feed is indispensable because it influences the production and productivity of livestock. Utilizing agricultural, plantation and industrial waste is one of the efforts that increase productivity and reduce the price of animal feed. Coconut coir contains 3.13% protein (Kairupan et al., 2021) and can be used as a mixture of ruminant animal feed as a source of fiber (Muzaki et al., 2020). It is a natural fiber often used to manufacture household products; hence, it can be converted into animal feed with the suitable fermentation method that will reduce the cost in the livestock business (Shamim et al., 2016). However, an abundance of coconut coir has not been adequately utilized as feeding materials. This study aimed to determine the potential utilization of coconut coir in beef cattle production, such as technical performance, ruminal fermentability, purine derivatives and economic performance.

MATERIALS AND METHOD

Experiment location

This research was conducted at the Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia.

Animal and treatments

Sixteen male Brahman crossbred cows aged 8 to 10 months with a bodyweight of 134±12.1 kg were arranged in a randomized block design for 95 days. The study used four feed treatments and four replications, namely complete feed D1 using 15% Fermented Coconut Coir (FCC), D2 using 20% FCC, D3 using 25% FCC and D4 using 30% FCC.

Feeding trial study

The study involves 95 day treatments and the feeding trial was used to determine the FCC's potential for beef cattle production. The feed composition used is shown in Table 1. The coconut coir is fermented using buffalo rumen by cutting into 1 to 2 cm sizes to be homogeneous. The cultured microbes of buffalo rumen fluid had the highest enzyme activity inoculated in liquid media for 16 hours before being used as an inoculum in the coconut coir fermentation method. Then, fermentation was carried out by adding 0.1% urea, 3% molasses, distilled water (60% moisture content calculation based on dry coconut coir) and 5% inoculum. The coconut coir was stirred

evenly, placed in an airtight room and incubated for four weeks. Before being used as a complete feed, FCC was analyzed for proximate analysis (AOAC, 2012).

Table 1. Ingredients and chemical composition of complete feed containing FCC

Materials	Dietary			
	D1	D2	D3	D4
Composition		(%)		
Corn	20.00	20.00	22.00	25.00
Rice bran	14.00	7.00	5.00	4.00
Palm oil	15.00	15.00	14.00	7.00
Coconut oil	1.00	1.00	1.00	1.00
Kapok seed meal	8.00	8.00	6.00	7.00
Coconut meal	10.00	12.00	13.00	17.00
Coffee husk	6.00	6.00	3.00	2.00
$CaCO_3$	0.20	0.20	0.10	0.20
Salt	0.20	0.20	0.10	0.10
Molasses	10	10	10	6
Urea	0.6	0.6	0.8	0.7
FCC	15.00	20.00	25.00	30.00
Content of nutrient		(%)		
Gross energy (cal g^{-1})	3633.51	3634.92	3739.36	3683.83
Dry matter	88.53	88.39	87.15	87.20
Nitrogen-free extract matter	43.19	46.39	42.09	44.75
Crude protein	11.14	11.62	12.29	12.41
Organic matter	91.37	90.85	90.10	92.72
Crude fiber	32.53	28.85	31.21	30.41
Ether extract	4.52	4.00	4.51	5.15
Total digestible nutrient	66.75	69.59	69.20	70.70

Source: (Hartadi et al., 1993).

***In vitro* experiment**

Experiment 2 was aimed at evaluating the *in vitro* ration fermentability. The observed fermentability parameters of partial VFA (acetate, propionate, butyrate), acetate/propionate, hexose conversion efficiency and N-NH_3 were measured *in vitro* based on the method of (Tilley and Terry, 1963) with a modified incubation of 4 hours (Tillman et al., 1998). Furthermore, acetic, propionic and butyric acid concentrations were measured using a gas chromatography technique (AOAC, 2012). The formula used to calculate the VFA concentration of the sample is equation I.

The hexose utilization efficiency was calculated based on the stoichiometry of the carbohydrate fermentation reaction from hexose to VFA (acetate, propionate, butyrate) according to (Owens and basalan, 2016). The formula used was equation II.

$$\text{VFA partial (mM)} = \frac{\text{Sample Area x Standard Concentration}}{\text{Standard Area x MW}} \qquad \text{(I)}$$

Where; MW is the molecular weight of acetate, propionate and butyrate, respectively.

$$\text{E (\%)} = \left(\frac{0.622\ pA + 1.091pP + 1.558\ pB}{pA + pP + pB}\right) \text{x } 100 \qquad \text{(II)}$$

Where; pA = proportion of acetate; pP = proportion of propionate; pB = proportion of butyrate.

The measurement of N-NH_3 concentration was based on an endophenol reaction catalyzed to produce a consistent blue compound. Subsequently, the mixture stages of 1 ml of 10% sodium tungstate solution, 2 ml of rumen fluid and 1 ml of H_2SO_4 were centrifuged at 15,000 rpm for 10 minutes. Afterward, a 20 ml supernatant sample was taken and mixed with 2.5 ml phenol and hypochlorite solution. Incubation was carried out for 30 minutes in a water bath at a temperature of 40°C until a blue color was formed. Finally, the cold mixture was read using a spectrophotometer with a wavelength of 630 nm (Cui et al., 2018).

Parameters measured

The observed parameters include technical performance (dry matter intake, organic matter intake, crude protein intake), ruminal fermentability, purine derivatives and economic performance. In addition, the data collected included: NH_3 concentration and total rumen VFA concentration *in vitro*. The determination of NH_3 and VFA concentrations was based on (Satter and Slyter, 1974).

Sample analysis

Feed intake, digestibility and economic performances were calculated using the formula of Dolewikou et al. (2016), Santoso et al. (2016), and Tayengwa et al. (2020). The entire analysis was used to prove that FCC is safe to be used for beef cattle production.

Data analysis

Data were subjected to a one-way analysis of variance using SPSS Version 24. Means were separated with Duncan's multiple range test (DMRT) (Santoso et al., 2017).

RESULTS AND DISCUSSION

The results of feed intake, nutrient digestibility and rumen fermentability in beef cattle feed on FCC are shown in Tables 2, 3 and 4, respectively. As shown in Table 2, dry matter intake containing FCC showed significantly different ($P < 0.05$) results between treatments. Dry and organic matter and crude protein intake in beef cattle feed D1, D2 and D4 diets were higher than D3. These results indicate that the beef cattle consume the same amount of dry and organic matter and protein intake when fed a complete feed containing 15%, 20% and 30% FCC. This result is consistent with the report of Xue et al. (2020) that the utilization of natural waste is only around 20% in feed.

Tables 2 and 3 show that the differences in FCC levels on the D1, D2 and D4 rations has no significant effect on the consumption and digestibility of treated cattle rations. However, they were significantly different from the D3 rations. This is due to the higher digestibility possessed by D1, D2 and D4 than the D3 rations, resulting in the digestive tract emptying rate, thereby increasing consumption. The ruminal characteristics value of NH_3 and VFA concentrations were not statistically different and they provide precursors for microbial protein synthesis in the rumen, as shown in Table 4. Furthermore, rumen microbes require nitrogen in the form of NH_3 or oligopeptides for bacteria, peptides for protozoa, carbon framework branch chain, isobutyrate and isovalerate and ATP as an energy source in protein synthesis (Kondo et al. 2014). The products of rumen fermentation in branched-chain fatty acids (isobutyrate and isovalerate) are produced from the degradation of feed protein (Gilliam, 2016; Alnouss et al., 2020). According to Cui et al. (2018), the NH_3 concentration of rumen fluid varies from 1 to 34 mg 100 ml^{-1} of rumen fluid. The maximum rate of microbial protein synthesis is achieved when NH_3 concentration ranges from 3.0 to 8.0 mg 100 ml^{-1} of rumen fluid (Alnouss et al., 2020).

According to Alnouss et al. (2020), the concentration of VFA in the rumen varies from 0.2 to 1.5 g 100 ml^{-1} or 10 to 70 mmol l^{-1}. This condition is determined from the excretion of purine derivatives, which also significantly affected the ratio treatment. This demonstrates the large number of microbes that have undergone a proliferation process and can degrade nutrient rations. Consequently, the greater the number of purine derivates excreted in the urine, the greater the microbial protein synthesis.

According to Orskov (1982), allantoin is the result of nucleic acid metabolism in rumen microbes used to measure microbial protein production. Singh et al. (2007) reported that the total concentration of purine derivatives is related to organic matter's digestibility. This is because the digestible organic matter in the rumen is a source of energy for rumen microbes. Furthermore, a higher digestibility of organic matter resulted in a higher rumen

microbial biomass. Liang et al. (1994) stated that allantoin is the main purine catabolism in microbial nucleic acids, which is used as an indicator of microbial digestion in ruminants and contributes to the excretion of endogenous purine derivatives and enzymes involved in purine metabolism. The difference in the excretion of purine derivative in urine is influenced by the contribution of allantoin and uric acid, in which allantoin is the highest concentration in purine catabolism (Liang et al., 1994), the contribution of excretion of endogenous purine derivatives and the types of enzymes involved in the process.

Table 2. Nutrient intake of beef cattle fed on complete feed containing consumption of metabolizable body weight (Intake of metabolizable body weight (MBW))

No.	Items	Dietary			
		D1	D2	D3	D4
1	Dry matter intake (%)	136.09^{a}	132.17^{a}	102.01^{b}	111.69^{a}
2	Organic matter intake (%)	124.34^{a}	120.08^{a}	91.90^{b}	103.55^{a}
3	Crude protein intake (%)	15.16^{a}	15.36^{a}	12.54^{b}	13.86^{a}

Note: Different superscripts on the same line indicate significant differences ($P < 0.05$)

Table 3. Nutrients digestibility in beef cattle fed on complete feed containing FCC

No.	Items	Dietary			
		D1	D2	D3	D4
1	Dry matter digestibility (%)	66.75±1.75^{a}	68.20±0.74^{a}	50.72±4.07^{b}	64.80±2.5^{a}
2	Organic matter digestibility (%)	71.45±1.62^{a}	72.42±0.70^{a}	52.25±3.83^{b}	68.60±2.3^{a}
3	Crude protein digestibility (%)	71.77±3.23^{a}	73.80±1.44^{a}	67.75±4.56^{b}	75.26±3.3^{a}

Note: Different superscripts on the same line indicate significant differences ($P < 0.05$)

Table 4. Fermentability of coconut coir in beef cattle fed FCC

No.	Items	Dietary			
		D1	D2	D3	D4
1	NH_3 (mg 100 ml^{-1})	24.50±1.141	26.18±1.47	26.34±1.40	25.30±0.45
2	VFA (mM)	46.39±9.68	42.52±8.02	42.72±5.86	36.76±4.84
3	C2 (mM)	27.05±6.40	21.76±5.01	23.06±3.76	19.93±2.97
4	C3 (mM)	8.78±1.91	7.5±1.68	9.1±2.42	7.3±1.05
5	C4 (mM)	10.55±1.82	8.34±1.93	10.1±1.38	9.45±0.96
6	CH4 (mM)	16.61±3.68	13.15±2.96	14.48±2.17	17.85±1.64
7	Purine derivatives	31,208^{a}	35,075^{a}	21,253^{b}	24,943^{ab}
8	EMNS (g N day^{-1})	21,392^{a}	23,449^{a}	13,436^{b}	15,910^{a}
9	EMNR (g N $BOTR^{-1}$)	8,372^{a}	8,574^{a}	5,343^{b}	5,874^{b}

Note: Different superscripts on the same line indicate significant differences ($P < 0.05$); EMNS = Efficiency of Microbial N Supply; EMNR = Estimation of Microbial N fermented in the Rumen

As shown in Table 3, there are statistical differences between treatments in dry and organic matter and crude protein digestibility. The results showed that the digestibility of beef cattle fed D1, D2 and D4 was greater than D3. This is consistent with the reports of De Souza et al. (2017) that the optimal use of fiber sources at 20% level results in optimal digestibility levels (dry matter and crude protein). As shown in Table 4, NH_3 concentration, VFA production, C2 production, C3 production, C4 production and CH4 production has no significant difference ($P > 0.05$). This is consistent with the reports of Kumar et al. (2016) that the fermentation of beef cattle fed with fiber sources was not significantly different between treatments in NH_3, VFA, C_2, C_3, C_4 and CH_4.

The total VFA concentration is below the optimum range for microbial growth and the rumen system, which accounted for 60 to 120 mM (Alnouss et al., 2020). This low VFA concentration can be influenced by the amount of non-structural and structural carbohydrates arranged in a complete feed. Furthermore, the ingredients of non-fiber carbohydrate (NFC) and neutral detergent fiber (NDF) were used in the complete feed formulation. The total VFA concentration is positively correlated with NFC and NDF. Kondo et al. (2014) reported that the NFC fraction is an important element in supporting adenosine triphosphate (ATP) formation in the rumen to form microbial proteins. Rahayu et al. (2019) reported a complete feed based on ammonia rice straw with 12% crude protein, 60% total digestible nutrient, 18% NFC and 68.71% NDF, resulting in a total VFA of 58.33 mM. Mbiriri et al. (2012) reported that complete feed treatment of concentrate and rice straw 60:40% with 13% CP resulted in a total VFA of 51.65 mM. Nuswantara et al. (2020) reported that the high fiber component in the feed could inhibit the digestibility of other fractions in the feed. This is because the energy needed to digest cellulose, hemicellulose and lignin is large enough to lower the VFA.

According to Kondo et al. (2014) and Cui et al. (2018), NDF content negatively correlates with the formation of VFA in the rumen and the digestibility of organic feed matter. The fermentability of feed ingredients influences the production of level VFA, the number of soluble carbohydrates, rumen pH, digestibility of nutrients, the number and types of bacteria present in the rumen. Miguel et al. (2021) reported complete fermented feed treatment with 41.35% NDF content during 6 and 24 hours incubation, resulting in 67.33 mM and 96.04 mM concentrations. As shown in Figure 1, the efficiency of hexose utilization showed is not much different. These results are in line with Amaryanti et al. (2015) that found the efficiency of hexose utilization insignificantly different in using the combination of soybean meal and hibiscus leaves in goat feed.

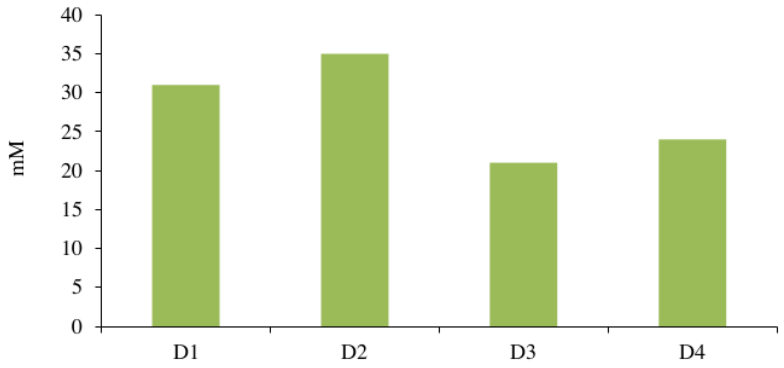

Figure 1. Hexose utilization efficiency

As shown in Table 4, microbial protein production showed significant differences between the four treatments. Treatments D1, D2 and D4 were not significantly different but higher than the D3 feed. These results are consistent with the reports of Amaryanti et al. (2015) that microbial protein production was not significantly different ($P > 0.05$) in the use of a combination of soybean meal and *Hibiscus tiliaceus* leaves in goat feed. Subsequently, FCC and *Hibiscus tiliaceus* leaves have the same nutrient contents.

As shown in Table 4, the purine derivatives were not significantly different among the four treatments. Ariyani et al. (2016) found that purine derivatives were not significantly different ($P > 0.05$) when using bagasse as basal feed. Purine derivatives reflect that the use of FCC does not interfere with the digestive system in cattle.

As shown in Table 5, the feed price decreased when coconut coir in the feed increased, but 20% FCC (D2) in the feed resulted in the highest income over feed cost (IOFC). Furthermore, the utilization of coconut coir waste reduces feed costs and increase income (IOFC). This result is consistent with the reports of Xue et al. (2020) and Santoso et al. (2017) that the use of agricultural waste could increase income.

Table 5. Economic analysis of beef cattle fed FCC

No.	Items	Dietary			
		D1	D2	D3	D4
1	Feed price (IDR kg^{-1})	2,500	2,415	2,375	2,280
2	Income over feed cost (IDR kg^{-1})	2,300	2,750	1,050	1,520

CONCLUSIONS

Based on the research results, coconut coir can be used as a beef cattle feed supplement without harming the health and growth of beef cattle. The abundance of coconut coir production will potentially reduce production costs.

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