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EFFECTIVENESS OF COCONUT MEAT WASTE IN FEED INTAKE, DIGESTION AND PROTEIN RETENTION IN GOATS

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ABSTRACT: The objective of the experiment was to determine the proportion of coconut meat waste on feed consumption, nutrient digestibility and nitrogen retention of goats. The experiment was conducted using a Latin square design on 4 male Bach Thao goat (16.2±2.93 kg). Treatments were 4 levels of coconut meat waste (CMW) at 0, 5, 10 and 15% in basal diet of rice distillers' by-product, cabbage waste, *Operculina turpethum* vines, urea and premix. Results indicated that dry matter intake per body weight tended to increase from CMW0 to CMW5 treatment but it was gradually reduced from CMW5 to CMW10 and CMW5 treatments (3.34; 3.50; 3.46 and 3.28, respectively). The ME consumption was higher at supplemented treatments coconut meat waste compared to CMW0 treatment. The nutrient digestibility (%) was gradually increased from CMW0 to CMW15 treatment. Similarly, digestive nutrients tended to increase with increasing coconut meat waste in the diet. The nitrogen retention was numerically lower for the CMW5, CMW10 and CMW15 treatments compared to CMW0, while daily weight gain was not different among treatments. In conclusion, 10% coconut meat waste could be used as an additional source of dietary regimen in goats, without negative effects on animal fattening performance.

Keywords: Agricultural waste, Alternative feedstuff, Digestibility, Local feeds, Small ruminants.

INTRODUCTION

Agricultural by-products and local feeds are very popular in the Mekong Delta from the countryside to market such as cabbage waste, *Operculina turpethum* vines and rice distillers' by-products (Trung and Dong, 2013; Trung et al., 2013; Olson and Morton, 2018). In a previous study, Phong and Thu (2018) found that para grass (*Brachiaria mutica*) can be replaced by cabbage waste up to 50% in the goat's diet. Further, *Operculina turpethum* vines is a local plant and it can be added to goat diets by up to 35% without affecting gained weight daily (Dat et al., 2018). With supplementary food, rice distiller's by-product improved feed intake, feed conversion ratio and daily weight gain was reported when it was supplemented at 15% in dietary female Bach Thao goats (Truong and Trung, 2023). After mechanically extracting the coconut process from coconut meat, it is a coconut milk and coconut meat waste (CMW). The CMW contains low crude protein (approximately 5.81%), however high in ether extraction and carbohydrate content such as galactomannan and mannan in dry matter (Harnentis et al., 2022).

In this context of livestock farming economics, feed utilization for high income for farmers is very necessary. Goats can thrive in harsh environments and can utilize a wide range of forages (Nair et al., 2021). Furthermore, the goat population is estimated to have increased more than two-fold over the last decade in Vietnam (Don et al., 2023).

Based on literature review in databases, limited information is available for using coconut meat waste supplemented in Bach Thao goat. Therefore, the hypothesis of this study is that the coconut meat waste supplementation can affect the goat's feed intake, nutrient digestibility and nitrogen storage, and in overall efficacy of goat farming.

MATERIALS AND METHODS

The experiment was carried out, based on ethical regulations of animal studies in the farm of the Department of Animal Husbandry and Veterinary medicine of An Giang University, from January to April 2023.

The chemical composition of the experimental diets was analyzed in the laboratory of E205 (Ruminal animal production techniques – 4) of the Faculty of Animal Husbandry, Agriculture University of Can Tho University.

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Design of experimental

Four male Bach Thao goats (16.2±2.93 kg) used in this study. The processing methods (experimantal desing) are applied according to the Latin Square design (4x4) with the period of 2 weeks for adaptation and 1 week for data collection. The four treatments were supplement coconut meat waste at 0%, 5%, 10% and 15% dry matter. The coconut meat waste, Bach Thao goats and compositions of diets are shown in Figure 1 and 2 and also in Tables 1. The premix accounted for 2.0% of the feed supplement from rice distillers' by-products and coconut meat waste. The cabbage waste ratio for roughage was 35% of forages. The rice distillers' by-products, coconut meat waste, cabbage waste, and *Operculia turpethum* vines were purchased, harvested and cut down around Long Xuyen town, An Giang prefecture, Vietnam.

Figure 1 - Coconut meat waste preparation.

Figure 2 - Individual pen of goats in present experiment.

Table 1 - Ingredients used in the experiment.

Ingredients (% DM)	CMW0	CMW5	CMW10	CMW15
Coconut meat waste	0.00	5.00	10.0	15.0
Rice distillers' by-product	15.0	15.0	15.0	15.0
Cabbage waste	29.3	27.5	25.7	23.9
Operculina turpethum vines	54.4	51.1	47.8	44.5
Urea	1.00	1.00	1.00	1.00
Premix	0.30	0.40	0.50	0.60
Total	100	100	100	100

*CMW: coconut meat waste. CMW0, CMW5, CMW and CMW15: coconut meat waste at 0, 5, 10 and 15% per dry matter consumption.

The mixture content

Coconut residue, rice distillate, urea and premix were fed twice at 7:00 am and 1:00 pm. Cabbage was fed twice at 8:00 am and 2:00 pm. *Operculia turpethum* vines were provided freely.

Measurements taken

Feed, nutrients and energy intake

The provided feeds, feed wastes and feces were examined for dry matter (DM), organic matter (OM), crude protein (CP) and ash content following to AOAC (1990) procedures. However, neutral detergent fiber (NDF) and acid detergent fiber (ADF) were investigated using the method of Van Soest et al. (1991). The metabolizable energy (ME) was determined following the method suggested by Bruinenberg et al. (2002), in which ME (MJ/animal/day) = 14.2 x DOM + 5.9 x DCP (with DOM/DCP<7.0 DOM is a digestible organic substance and DCP is able to be digested crude protein) of the diets or ME (MJ/head/day) = 15.1 x DOM (with DOM/DCP>7.0). Water intake was weighed before onset of feeding in the morning, daily. The amount of methane released was estimated according to the formula of Mills et al. (2003):

CH_4 (MJ/day) = 1.06 + 10.27 * roughage %) + 0.87 x DMI (kg/day).

- ***Apparent nutrient digestibility:*** Apparent digestibility of DM, OM, CP, NDF and ADF were determined according to McDonald et al. (2010). The experiment was conducted for four periods, and each period was 3 weeks including 2 weeks for adaptation and 1 week for samplings.

- ***Nitrogen retention:*** The nitrogen (N) content in feeds, waste, feces and urine was calculated following to the Kjeldahl method (AOAC, 1990). By eliminating the amount of N in feed residues, feces and urine from the N in the feed, the amount of N retained was determined, too.

- ***Daily weight gains (DWG):*** Experimental goats were weighed using an electronic scale and checked using live goat weights, which were weighed for 3 continual days in the early morning before feeding at the beginning and end of each experiment.

Statistical analysis

The data were analyzed using the ANOVA Linear Model (GLM) of Minitab Reference Manual Release 20.3 (Minitab, 2021). Differences among means were also compared by Tukey's test ($P<0.05$) when there was a significant overall effect. The statistical equation for this design was: $y_{ijk} = \mu + T_i + A_j + P_k + e_{ijk}$; where y_{ijk}: = the dependent variable, μ: the overall mean, T_i = the outcome of treatment (i = 1 to 4), A_j: the effect of Bach Thao goats (j = 1 to 4), P_k= the effect of period (j = 1 to 4), and e_{ijk} = the random error.

RESULTS AND DISCUSSION

Chemical composition of feeds

The results presented in Table 2 indicated that the NDF content was lower in rice distillers' by-product (28.3%) than coconut meat waste (57.5%), cabbage waste (33.1%) and *Operculina turpethum* vines (43.7%). Manh et al. (2009) reported that rice distillers' by-product CP and NDF were about 16.6-32.5% CP and 8.40-28.2% NDF. The nutrient of cabbage waste was 14.5%, 25.5% and 14.9% corresponding to CP, NDF, and ADF (Phong and Thu, 2018). The CP, NDF, and ADF of *Operculina turpethum* vines in the experimental goats same as that shown by Trung and Thu (2018) being 15.6% CP, 40.9% NDF and 11.2% ADF. Thus, the nutrient of feed in the present study agrees with previous studies.

Feed, nutrient and ME intakes of experimental goat

Results in Table 3 indicated that the DM consumption (g/head/day) was not different among treatments. It was 803, 861, 826 and 789 g corresponding to CMW0, CMW5, CMW and CMW15. However, the CMW5 and CMW10 treatments were higher DM intake than the CMW0 and CMW15 treatments. In detail, the DM/BW (%) increased from CMW0 to CMW5 and down to CMW10 and CMW15 treatments (3.34, 3.50, 3.46 and 3.28 %, respectively; Figure 3).

The DM/BW (%) in the present study was similar to the result reported by Hong et al. (2021) in Bach Thao goats was 2.72-3.01 %. The CP intake per day was not different among treatments. It was ranged from 147 to 167 g/head, which was similar to those reported by Phong and Thu (2018) being 149-159 kg/head/day. The NDF intake increased ($P>0.05$) by increasing coconut meat waste supplement levels in diets. It was 289, 322, 311 and 305 g/head/day corresponding to CMW0, CMW5, CMW and CMW15 treatments. It was explained by the high NDF of coconut meat waste supplement levels in diets. Metabolizable energy consumption was not different among treatments. While the highest value for CMW5 (9.19 MJ) compared to CMW10 (8.81 MJ), CMW15 (8.56 MJ) and the lowest value for CMW0 (8.39 MJ). The CH_4 (MJ/animal/day) was not different among treatments being 10.4-10.6 MJ.

In the present study, it's found that both DMI/BW, ME consumption and CH_4 product were not affected by supplementation with coconut meat waste. However, nutrient intake in CMW15 was lower than in CMW0, CMW10 and CMW5 treatments.

Apparent nutrient digestibility and digestive nutrient in the experimental goat

The result of Table 4 showed that the DM digestibility of CMW15 treatment (77.1%) was higher than CMW0 treatment (75.1%) but it was not different ($P>0.05$) compared to CMW5 and CMW10 treatments (76.4 and 75.9%, respectively). The DM digestibility in the experiment was higher than reported by Phong and Thu (2018), who found that DM digestibility from replacing increasing levels Para grass (*Brachiaria mutica*) with cabbage waste (*Brassica oleracea*) in the diets of Bach Thao goats about 64.9-66.6%. In our study, the CP digestibility was not different among treatments and it was 78.0, 78.3, 77.3 and 78.3% (CMW0, CMW5, CMW and CMW15, respectively).

Dong and Thu (2018) reported that CP digestibility of Bach Thao goats was about 75.6-77.8%. The NDF and ADF digestibility inceased by increasing the dietary coconut meat waste supplement levels and it were about 61.3-70.1% and 61.2-67.6%, respectively. Trung and Thu (2018) reported that NDF digestibility was about 56.2-59.6%. To our knowledge, coconut meat waste is qualitatively poor due to low crude protein and high dietary fiber (Harnentis et al., 2022). However, the feed in this study such as Rice distillers' by-product, Cabbage waste and *Operculina turpethum* vines were lower in fiber and higher in crude protein than coconut meat waste. Therefore, the matching and utilization of local feed were shown well for nutrient digestibility and digestive nutrients. Thus, increasing coconut meat waste intake from 5 to 15 %DMI was improved nutrient intake, digestibility and digestive nutrient.

Table 2 - Ingredient of feed (% basic DM) in the research

Feed \ Chemical composition	DM, %	OM, %	CP, %	NDF, %	ADF, %	Ash, %
Coconut meat waste	42.2	99.2	3.70	57.5	41.8	0.80
Rice distillers' by-product	11.2	97.0	27.2	28.3	18.5	3.00
Cabbage waste	8.36	88.6	16.3	33.1	23.3	11.4
Operculina turpethum vines	13.0	88.9	14.5	43.7	35.1	11.1
Urea	99.6	-	286	-	-	

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber

Table 3 - Effect of coconut meat waste on feed and nutrient intakes

Item \ Treatments	CMW0	CMW5	CMW10	CMW15	SEM	P-value
Feed intake, gDM/animal/day						
Coconut meat waste	0.00^{d}	40.4^{c}	82.5^{b}	118^{a}	5.340	0.001
Rice distillers' by-product	111	114	118	112	3.840	0.565
Cabbage waste	239^{a}	237^{a}	215^{ab}	189^{b}	7.480	0.010
Operculina turpethum vines	443^{a}	458^{a}	398^{ab}	357^{b}	14.50	0.010
Urea	7.71	8.02	8.22	7.85	0.227	0.475
Premix	2.31^{c}	3.20^{b}	4.10^{a}	4.69^{a}	0.152	0.001
Total nutrient intake, kg/animal/day						
DM	803	861	826	789	23.40	0.248
DM/BW, %	3.34	3.50	3.46	3.28	0.071	0.206
OM	711	767	739	710	20.80	0.272
CP	164	167	159	147	4.230	0.059
NDF	289	322	311	305	9.830	0.217
ADF	216	242	231	226	7.610	0.213
ME, MJ/day	8.39	9.19	8.81	8.56	0.338	0.433
Water intake, g/animal/day	63.9	69.8	64.0	67.1	5.290	0.838
Output, animal/day						
CH_4 (MJ/day)	10.5	10.6	10.5	10.4	0.047	0.175
Feces, gDM	201	201	197	178	7.990	0.224
Urine, g	4036^{a}	3899^{a}	3548^{ab}	3116^{b}	145.0	0.016

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ME: Metabolizable energy. CMW: coconut meat waste. CMW0, CMW5, CMW and CMW15: coconut meat waste at 0, 5, 10 and 15% per dry matter consumption

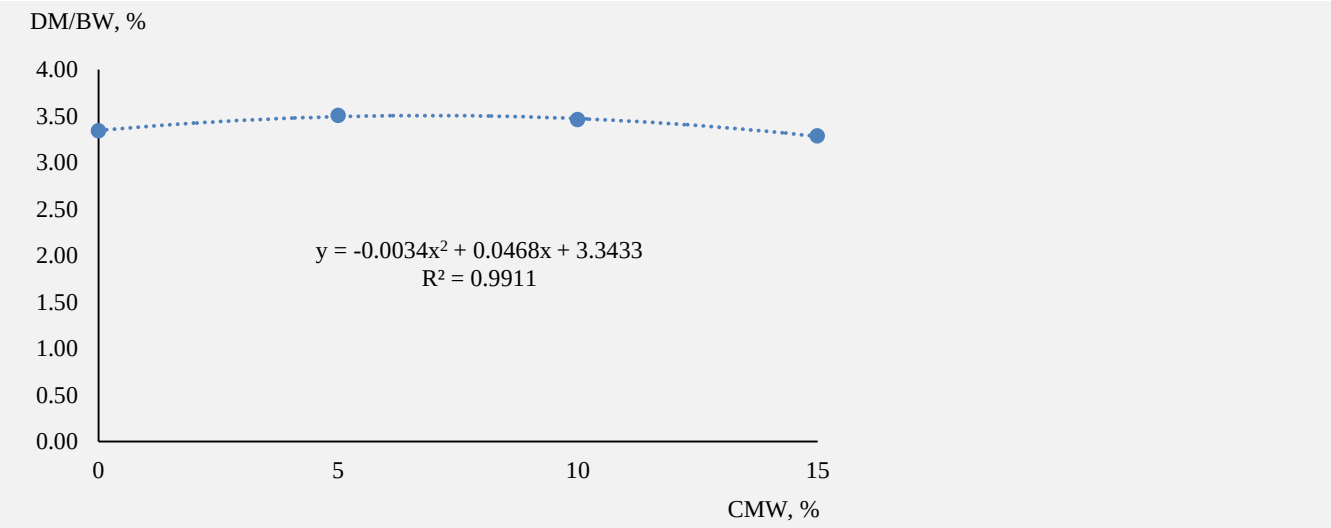

Figure 3 - DM intake per body weight is increased with a curvilinear trend as the feeding level of coconut meat waste was increased

Table 4 - The nutrient digestibility of goats in the study

Item \ Treatments	CMW0	CMW5	CMW10	CMW15	SEM	P-value
Nutrient digestibility, %						
DM	75.1	76.4	75.9	77.3	1.030	0.558
OM	75.8	77.1	76.7	78.1	1.030	0.525
CP	78.0	78.3	77.3	78.3	0.916	0.859
NDF	61.3	66.5	66.3	70.1	2.020	0.105
ADF	61.2	66.0	64.8	67.6	1.360	0.135
Digestive nutrient, g/animal/day						
DM	602	660	629	611	24.30	0.423
OM	538	593	569	555	22.00	0.416
CP	128	131	124	115	4.560	0.180
NDF	176	215	207	214	10.20	0.102
ADF	137	160	150	153	7.070	0.359

DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber. CMW: coconut meat waste. CMW0, CMW5, CMW10 and CMW15: coconut meat waste at 0, 5, 10 and 15% per dry matter consumption

Storage nitrogen and gain weight daily

The N consumption of Bach Thao goats was similar (P>0.05) among treatments and ranged from 23.5 to 26.8 g/head/day. However, the nitrogen retention (g/head/day) had a trend of decrease by increasing dietary coconut meat waste. The daily weight gain in this study was similar (P>0.05) and had a trend of increase for CMW0, CMW5, CMW10 and CMW15 treatments being 180, 202, 194, and 187 g/head/day. The average weight gain (g/head/day) of the experiment was higher than other studies such as Phong and Thu (2018) being 71.4-116 g; Trung and Thu (2018) being 52.0-123g. In summary, results from this study suggest that DMI/BW (%) increased with increasing dietary CMW intake levels (5-10% DMI), while, the 15% CMW in the diet was lower than the CMW0 treatment. However, the ME intake was positive in Bach Thao goats the different coconut meat waste consumption levels. Although the N retentions did not affect this study. However, nutrient digestibility increased with increasing dietary coconut meat waste intake levels (5-15%DMI). Therefore, daily weight gain had a trend of increase in this study.

Table 5 - Storage nitrogen and gain weight daily of goat

Item \ Treatments	CMW0	CMW5	CMW10	CMW15	SEM	P-value
Nitrogen (N), g/head/day						
N intake	26.2	26.8	25.5	23.5	0.677	0.059
N fecal	5.78	5.75	5.69	5.07	0.182	0.092
N urin	11.1	11.7	10.2	9.43	0.854	0.336
N retention	9.67	9.15	7.29	9.01	1.400	0.670
N retention/$BW^{0.75}$	0.83	0.85	0.88	0.81	0.116	0.780
Body weight, kg						
BW Initial	22.5	22.3	22.6	22.2	0.314	0.780
BW Final	26.3	26.5	26.7	26.2	0.162	0.196
Daily weigh gain, g	180	202	194	187	12.80	0.667

CMW: coconut meat waste. CMW0, CMW5, CMW and CMW15: coconut meat waste at 0, 5, 10 and 15% per dry matter consumption.

CONCLUSION

Increasing coconut meat waste supplement levels in the diets of male Bach Thao goats improved feed and nutrient intake, nutrient digestibility, nitrogen storage, and daily weight gain. A level of 10% coconut meat waste in the diet could be recommended for further research in terms of available agricultural waste local utilization.

DECLARATIONS

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Data availability

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Authors' contribution

Corresponding author contributed on data analysis and the write up of the manuscript: Truong N.B. and Trung N.B. conceived and designed the experiments; Truong N.B. performed the experiments; Truong N.B. analyzed the data; Truong N.B. and Trung N.B. wrote the paper; all authors reviewed and approved the final manuscript.

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Competing interests

The authors declare no competing interests in this research and publication.

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