Research Article

Effects of Different Unconventional Energy Feed Combinations on Feed Intake, Nutrient Digestibility and Nitrogen Retention of Saanen Crossbred Goats

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Abstract | This study was conducted at an experimental animal farm in An Giang University of Vietnam. Four male Saanen crossbred goats were used in the Latin Square design (4 x 4) to evaluate the effects of feed supplement combinations on feed intake, nutrient digestibility and nitrogen retention. The feed sources were finely ground and used in the experiment were Maize (Ma), Brocken rice (Br), Cassava chip (Ca) and Wheat (Wh). The proportion of combination (% dry matter intake) in two energy feed sources was 15% and 15% such as MaCa, MaWh, BrCa and BrWh. The results show that dry matter intake per body weight of BrWh (3.42%) and BrCa (3.40%) treatments tended to high compared to the MaCa (3.29%) and MaWh (3.08%) treatments. The organic matter digestibility (%) of BrCa was not different (P>0.05) with MaWh and BrWh but it was higher (P<0.05) than MaCa (76.0, 74.9, 74.0 and 71.2, respectively). However, nitrogen retention (g/animal/day) was different (P<0.05) among treatments. It was 8.84, 7.56, 6.87 and 6.62 g corresponding to BrWh, BrCa, MaCa and MaWh treatments. Moreover, average weight gain was the same as nitrogen retention in this study. Therefore, the energy feed combination that feed intake, nutrient value, nitrogen retention and daily weight gain well from high to low were BrWh, BrCa, MaCa and MaWh.

Keywords | Soluble carbohydrates, Rumen, Ruminant, Combinations, Energy feed, Goat

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INTRODUCTION

In Vietnam, demand for goat meat has increased significantly in the past decades (Gray and Walkden-Brown, 2019). From 2008 to 2018 in Vietnam, goat and sheep production had increased significantly from 1.2 to 2.8 million heads, equivalent to an average 8.2% per year. However, there is a huge shortage of goat meat supply for the Vietnamese market. This was a great opportunity for Vietnamese and Lao farmers to promote the development of goat production to increase their income (Ba *et al*., 2021). Fattening is the final stage in the process of raising goats for meat, in order to provide the market with high-quality products that meet the needs of consumers. In recent years, the fattening of goats has only been carried out in some localities and some households in Vietnam. Therefore, until now, the understanding of goat fattening systems and the efficiency of goat farming by households in Vietnam has been limited. This affected the development of appropriate technical and economic solutions to improve the current goat raising system (Nam *et al*., 2023). The low ruminant productivity can be attributed to insufficient nutrient supply in high forage diets (Ba *et al*., 2008). Therefore, ruminant raising systems need to look for new sources and technologies for animal feed. Recently, smallholder farmers have supplemented in diets with a variety of energy feeds such as rice bran, maize and cassava as well as homemade concentrated mixtures from these energy feeds in ruminant production. However, results were limited due to a lack of information on the digestibility and characteristics of rumen fermentation and using only these feeds as the sole feed for cattle may be inadequate nitrogen for optimal nutrient digestibility and feed intake (Dung, 2014).

MATERIALS AND METHODS

Location and time

The experiment was carried out at the experimental farm of An Giang University, Vietnam June to September in 2023. The feeds and refusals were analyzed at laboratory E205 of the Faculty of Animal Sciences, Agriculture University of Can Tho University.

Experimental design and feeds and feeding

Four male Saanen x (Saanen x Boer) with an initial body weight (BW) of 20.8±1.48 kg, were used in a Latin square design (4x4). The goats were kept indoors in individual metabolism cages (0.75 x 1.50 m) and protected against mosquitoes by mesh screens covering the barn.

The treatments were energy-fed together such as maize and cassava chip (MaCa), maize and wheat (MaWh), broken rice and cassava chip (BrCa), broken rice and wheat (BrWh). The feed ingredient composition of the diet in this study is presented in Table 1.

Table 1: Feed ingredient composition of diet in the experiment.

Ingredients (%DM)	MaCa	MaWh	BrCa	BrWh
Maize	15.5	15.0	-	-
Broken rice	-	-	15.0	15.0
Wheat	-	15.0	-	15.0
Cassava chip	15.0	-	15.0	-
Operculina turpethum vines	35.0	35.0	35.0	35.0
Elephant grass	33.4	33.4	33.4	33.4
Urea	1.00	1.00	1.00	1.00
Premix	0.60	0.60	0.60	0.60
Total	100	100	100	100

MaCa: Maize + Cassava chip, MaWh: Maize + Wheat, BrCa: Broken rice + Cassava chip, BrWh: Broken rice + Wheat

Measurements taken

Feed, nutrient and energy intakes

The maize, broken rice, cassava chip and wheat were finely ground. The mix included: maize, broken rice, cassava chip, wheat, urea and premix depending on each treatment were fed twice at 7:00 am and 1:00 pm. The *Operculina turpethum* vines was fed twice at 8:00 am and 2:00 pm. Both elephant grass and freshwater were supplied *ad libitum*. Refused feeds and freshwater were weighed each morning.

Daily intakes of feed and nutrients were calculated from feed and refusals were collected and weighed daily in the morning.

Feeds offered were analyzed for chemical compositions: dry matter, organic matter and crude protein (DM, OM and CP, respectively) by standard AOAC methods (AOAC, 1990). Besides that, neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed following the procedure of Van Soest *et al.* (1991).

Metabolizable energy (ME) was calculated 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 digestible organic matter and DCP is digestible crude protein) of the diets or ME (MJ/animal/day) = 15.1 x DOM (with DOM/DCP>7.0).

Apparent nutrient digestibility and nitrogen retention

Apparent digestibility coefficients for DM, OM, CP, NDF and ADF, and nitrogen retention, were employed according to McDonald *et al.* (2010). Each experimental period was three weeks including two weeks for adaptation and one week for collection of feces and urine.

Daily weight gains (DWG)

The Saanen crossbred goats were weighed in the morning prior to feeding, at the beginning and end of each experimental period (two consecutive days).

Statistical analysis

The data were subjected to an analysis of variance (ANOVA) using the General Linear Model option in the Minitab Reference Manual Release 20.3 (Minitab, 2021). Sources of variation were energy sources, crossbred goats, periods and error. Then for the paired comparison of two treatments, the Tukey test was used in this study ($p<0.05$).

RESULTS AND DISCUSSION

Chemical composition of feeds

The composition chemical of the feed in the present study was similar to those reported by Dung (2014) for Maize and cassava etc (Table 2). The energy feed sources in this study are shown in Figures 1, 2, 3 and 4.

Table 2: Chemical composition of feeds (% DM basis) used in this study.

Feeds	DM, %	In DM, %			
		OM	CP	NDF	ADF
Maize	85.9	98.1	8.88	19.4	5.90
Broken rice	85.8	98.6	8.32	6.45	1.69
Wheat	88.3	97.8	9.43	9.4	3.50
Cassava chip	87.2	97.7	3.91	16.3	4.69
Operculina turpethum vines	12.6	88.2	12.4	43.3	34.6
Elephant grass	15.9	88.9	8.21	71.6	39.7
Urea	99.6		286		

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

Figure 1: Broken rice.

Figure 2: Maize.

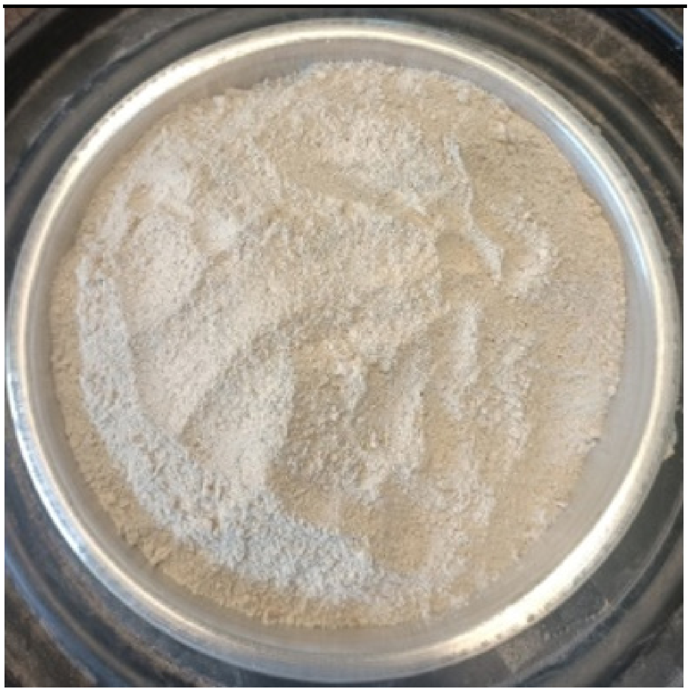

Figure 3: Cassava chip.

Figure 4: Wheat.

Feed and nutrient intakes

The feed and nutrient intake of goats' experimental diets are presented in Table 3.

Digestibility

The nutrient digestibility (%) and digestive nutrient (g/ animal/ day) are presented in Table 4.

Table 3: Feed, nutrient intake and output of experimental goats.

Item	MaCa	MaWh	BrCa	BrWh	SEM	P
Feed intake, gDM/animal/day						
Maize	116	105	-	-		
Broken rice	-	-	113	120		
Wheat	-	105	-	121		
Cassava chip	116	-	113	-		
Operculina turpethum vines	277	249	268	284	13.30	0.345
Elephant grass	271	242	282	277	24.60	0.674
Urea	7.85	7.09	7.71	8.16	0.370	0.313
Premix	4.71	4.25	4.63	4.90	0.222	0.311
Nutrient intake, gDM/animal/day						
DM	793	712	789	816	42.90	0.418
DM/BW, %	3.29	3.08	3.40	3.42	0.213	0.678
OM	716	644	712	737	38.10	0.418
CP	96.4	92.8	94.4	105	4.890	0.363
NDF	335	292	325	320	22.70	0.605
ADF	200	177	198	199	13.50	0.612
ME*, MJ/con/ngày	7.69	7.27	8.23	8.29	0.405	0.327
Water intake, g/head/day	398	390	205	182	91.8	0.825
Output						
Feces, gDM/animal/day	234	186	192	214	14.90	0.192
Urine, g/animal/day	2,045	1,609	1,835	1,635	185.0	0.378

MaCa: Maize + Cassava chip, MaWh: Maize + Wheat, BrCa: Broken rice + Cassava chip, BrWh: Broken rice + Wheat. DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, NFE: nitrogen free extract, ME: metabolizable energy (MJ/kg DM), *: Bruinenberg *et al.* (2002), BW: body weight. [a,b,c] Means within rows with different letters were differ (P<0.05).

Table 4: Nutrient digestibility and digestible nutrients in the present study.

Item	MaCa	MaWh	BrCa	BrWh	SEM	P
Nutrient digestibility, %						
DM	70.5	74.0	75.1	73.4	0.919	0.053
OM	71.2^{b}	74.9^{ab}	76.0^{a}	74.0^{ab}	0.912	0.042
CP	75.3	76.6	76.8	77.1	0.752	0.422
NDF	58.1	61.6	65.3	60.7	1.590	0.088
ADF	56.2	61.6	62.6	59.2	2.190	0.265
Digestible nutrient, g/animal/day						
DM	559	526	597	602	30.80	0.347
OM	509	482	545	549	26.80	0.327
CP	72.6	70.7	72.7	81.4	3.380	0.216
NDF	193	179	216	197	17.00	0.555
ADF	112	109	127	120	10.70	0.662

MaCa: Maize + Cassava chip, MaWh: Maize + Wheat, BrCa: Broken rice + Cassava chip, BrWh: Broken rice + Wheat. DM: dry matter, OM: organic matter, CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber. [a, b, c] Means within rows with different letters were differ (P<0.05).

Nitrogen retention and daily weight gain

Both nitrogen balance and weight gain are shown in Table 5, Figures 7 and 8.

Table 5: Nitrogen retention and average weight gain of goats in this study.

Item	MaCa	MaWh	BrCa	BrWh	SEM	P
Nitrogen balance, g/animal/day						
N intake	15.4	14.8	15.1	16.8	0.782	0.363
N in feces	3.80	3.52	3.47	3.80	0.255	0.703
N in urine	4.75	4.70	4.08	4.18	0.613	0.811
N retention, g/animal/day	6.87^{bc}	6.62^{c}	7.56^{b}	8.84^{a}	0.180	0.001
N retention g/W$^{0.75}$/day	0.619^{c}	0.616^{c}	0.709^{b}	0.820^{a}	0.014	0.001
Body weight, kg						
Initial BW, kg	23.6	23.1	22.7	23.2	0.489	0.624
Final BW, *kg*	25.0^{ab}	24.0^{c}	24.3^{bc}	25.1^{a}	0.159	0.007
Average weight gain *(g/animal/day)*	66.1	43.0	75.7	90.2	21.80	0.525

MaCa: Maize + Cassava chip, MaWh: Maize + Wheat, BrCa: Broken rice + Cassava chip, BrWh: Broken rice + Wheat. [a, b, c] Means within rows with different letters were differ (P<0.05).

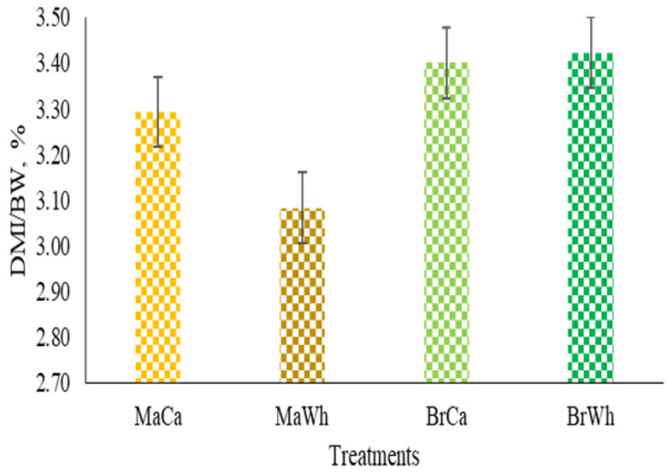

Figure 5: DM intake per body weight in this study.

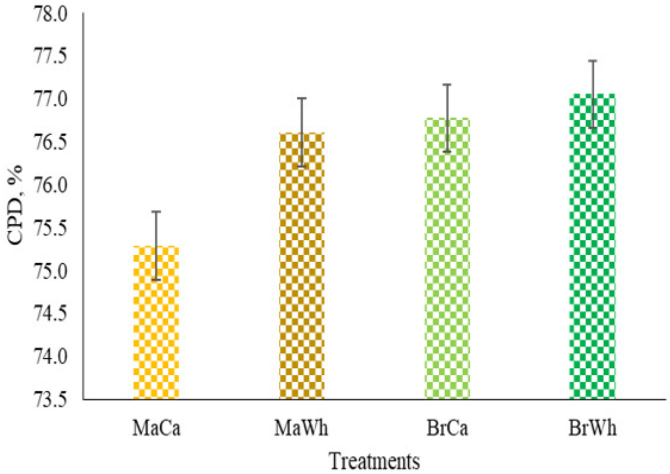

Figure 6: CP digestibility in the present study.

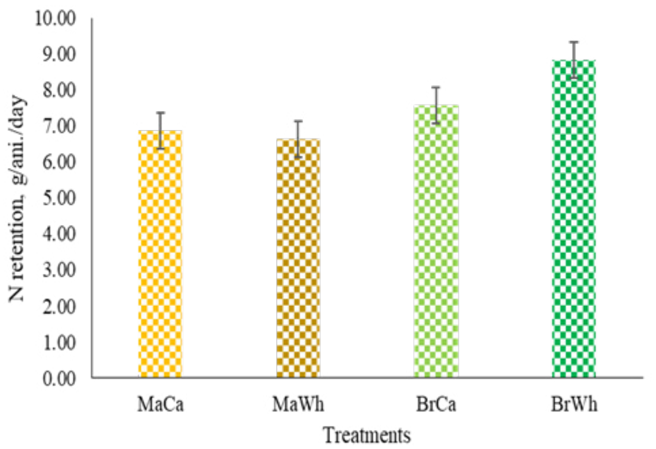

Figure 7: Effect of energy feed combination on nitrogen retention

Total DM, OM, CP, NDF, ADF and ME intakes were not different (P>0.05) between dietary groups. This can probably be explained that the chemical composition in diets was similar to each other (Table 2) and animals were accessed to feed freely. These results agreed with Rahman *et al*. (2020) who fed freely growing goats by Napier grass. The amount of DM intake as per body weight in the present study was not different among diets, showing that the amount of DM consumption by goats was adequate. According to Devendra and McLeroy (1982), goats in tropical consumed 3.0% or more daily DM intake of their body weight. The DM, CP and ME intake in this study were equivalent to the NRC Recommendation (2007), recommending daily DM, CP and ME intake should be 3.3-3.7% of body weight; 94.6 g; and 1.6 Mcal, respectively. However, Figure 5 for DMI/BW (%) of BrCa and BrWh diets tended to be higher than MaCa and MaWh diets (3.42; 3.40; 3.29 and 3.08%, respectively).

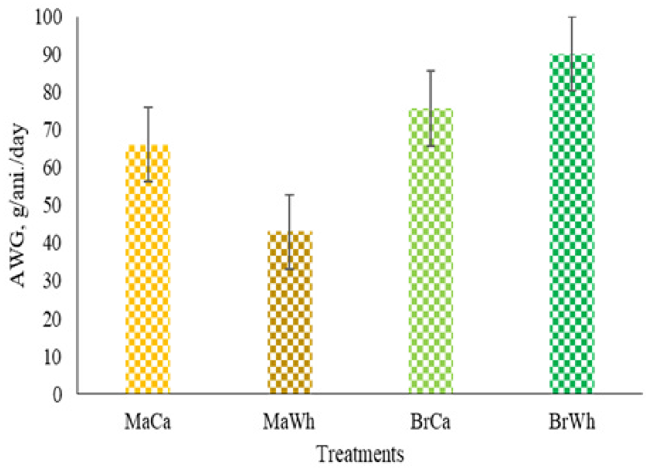

Figure 8: Average weight gain of experimental goats.

The digestibility of DM, OM, CP, NDF and ADF (in g/animal/day or percentage) was not affected by the combination of energy feed sources. The nutrient digestibility of goats was similar between diets. This can be explained by the fact that goats were fed the same fiber sources (Operculina turpethum vines and elephant grass) with equivalent to intakes of NDF and ADF (Table 3). Starch from different sources such as corn, broken rice, wheat and cassava is not affected in digestibility because its composition has almost the same structure and is formed by amylose and amylopectin. According to McDonald *et al*. (2002), the main influent factor of feed digestibility is fiber portion including the chemical composition and amount of fiber content in the feed. The previous *in vitro* study reported that starch from cassava powder was higher DM and OM digestible at 24 to 72 hours after incubation than maize because NDF content in cassava powder was lower than in Maize and rice bran (Dung, 2014). However, the digestibility of OM in the BrCa diet was not different (p>0.05) BrWh and MaWh diets but it was higher than the MaCa diet (76.0, 74.0, 74.9 and 71.2%, respectively). Similar to OM digestibility, CP digestibility was well from high to low with BrWh, BrCa, MaWh and MaCa diets as shown in Figure 6.

Nitrogen consumption (Figure 7) was not different (P>0.05) among diets. However, nitrogen retention (g/animal/day) of BrWh diet (8.84 g) was higher than BrCa

(7.56 g), MaCa (6.87 g) and MaWh (6.62 g). Nitrogen retention was considered the most common index of the protein nutrition status of ruminants. Because, the low NDF of feed supplements that means high non-structural carbohydrates. In addition, Wanapat *et al*. (2012) found that protozoal populations increased by proportion of the diet as non-structural carbohydrates were increased. This observation can be attributed to the type of protein and its degradability and also possibly due to a lack of synchrony between nitrogen release through protein degradation and energy availability (Wanapat and Khampa, 2006). Therefore, the daily weight gain of the BrWh diet was better than BrCa, MaCa and MaWh diets (Figure 8).

CONCLUSIONS AND RECOMMENDATIONS

Saanen crossbred goats fed with BrWh tended to be higher feed intake, nutrient digestibility, nitrogen retention and daily weight gain when compared with Saanen crossbred goats fed MaWh. Therefore, the combination of energy-feed sources with protein or fat for goats should be tested.

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AUTHOR'S CONTRIBUTION

NBT conceived, designed and performed the experiments. NBT analyzed the data. NBT, HXN and TTT wrote the paper. All authors reviewed and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest

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