Research Article

Utilizing Fermented Soya Waste in the Diet of Boer Crossbred Goats

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Abstract | The production of goats in Vietnam has been steadily increasing each year because of the low cost of investment and the use of local forage. However, the rising cost of concentrated feed in recent years has resulted in a decrease in profits from goat production. Fermented soya waste is a byproduct that can be utilized for goats as it provides high nutrition at a low feed cost. The experiment was designed as a 5×5 Latin square composed of five crossbred buck goats (Boer x Bach Thao) aged 3 months and weighing an average of 13.46± 1.04 kg. This trial aimed to assess how substituting mixed concentrate feed with fermented probiotic soya waste (FPSW) affected the growth performance of crossbred bucks. There were four periods, each lasting 21 days. This included 14 days for diet adaptation and 7 days for collecting all samples, resulting in a total of 105 days of data collection. Goats were fed a control diet (Ctrl) with 100% mixed concentrate feed (MCF) while the other four treatments included varying levels of MCF replacement with FPSW in diet: 75% MCF, 50% MCF, 25% MCF, 0% MCF. The results showed that this replacement did not significantly affect the digestibility of nutrients (P>0.05), nitrogen balance (P>0.05), and digestible nutrients, except for a gradual decrease in digestible neutral detergent fiber (P<0.05). The treatment replacing 75% FPSW gave higher results compared to others on performances: ADG (196 g/day), FCR (3.55), and amount of VFAs after 3 hours of feeding (109 µmol/ml) and the best economic returns (more than 47% increased in income compared to using a diet of 100% mixed concentrate feed). To conclude, replacing 75% of the diet with FPSW improved growth performance without adversely affecting the digestibility of nutrients and nitrogen balance of the animals.

Keywords | Fermented probiotics soya waste, Growing goat, Mixed concentrate feed, Rumen fermentation, Economic efficiency, Daily weight gain

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INTRODUCTION

The Mekong Delta is known for the diversity of vegetation development and agro-industrial by-products multiplicity which subsequently offer more advantageous opportunities for local farmers to enhance livestock performances and boost economic returns. Goats are considered superior to other ruminants in using high-fiber forage for body maintenance and production (Nazan and Nissim, 2018). Goat production in Vietnam tends to increase year by year. In 2020, the total goat population was 2.65 million heads compared to 1.29 million head in 2010. In Vietnam, goats are raised using three production methods: extensive, semi-intensive, and intensive. Approximately 70% of goat keepers utilize semi-intensive systems, primarily smallholder farmers. Approximately 73.4% of households (306,000) were raising less than 10 goats each, while 23.3% (97,000 households) were raising between 10 and 29 goats. Additionally, 2.6% of households raised between 30 and 49 goats, and only 0.8% of households raised more than 50 goats. Co and Bach Thao were the main native goat breeds in Vietnam, whereas imported breeds like Boer, Saanen, Alpine, Kiko, Barbari, and Jamunapari were utilized to enhance meat and milk production by crossbreeding. Crossbred goats (Boer x Bach Thao) are mainly raised for meat production due to better growth rates compared to indigenous breeds. Goat meat is mainly for domestic consumption (Don *et al*., 2023).

As most farms run the smallholder system, the main source of available feed is vegetables and natural grass, which hardly meet the nutritional requirements of goats. Supplement concentrate to goat's diet in captivity would increase the amount of feed intake and productivity of goats (Binh, 2004). Meanwhile, commercial feeds are expensive and many farmers cannot afford it. To address these problems, farmers have gradually shifted to local agro-industrial by-products that are not only available and a lower price compared to commercial feeds, including soya waste, brewery waste, and coconut meal. Compared to other by-products, soya waste is preferred due to its low price, i.e., a low cost (1,000 Vietnam Dong compared to brewery waste i.e., 2,000 Vietnam Dong and coconut meal 7,000 Vietnam Dong), and high appetite. Soya waste has a high nutritional value, counting 20.7% crude protein (CP) (Dong, 2009). However, its high moisture content (ranging from 70% to 85%) poses challenges in handling and preserving fresh soya waste (Li *et al*., 2013). While soya waste contains valuable nutrients, its rough texture is a result of its high cellulose content, water, and larger fiber particles. Moreover, it contains antinutritional factors, such as soybean trypsin inhibitors, which are partially deactivated during the solvent extraction and toasting process (Marty and Chavez, 1995). Furthermore, soya waste may also include saponin, and other antinutritional elements like hemagglutinin, which can be difficult to digest (Li *et al*., 2013).

To treat anti-nutrients, farmers often use heat by cooking soya waste (Anderson and Wolf, 1995). However, this method takes more cost of labor and fuel while soya waste can only be used for a short time. Moreover, cooking treatment can reduce the nutritional value of soya waste and sometimes does not completely remove the anti-nutrients (Li *et al*., 2014). Some authors as (Hotz and Gibson, 2007; Egounlety and Aworh, 2003) stated that fermentation is commonly used to enhance the absorption of nutrients and reduce the negative effects of anti-nutrient factors in soybeans. The fermentation process aims to reduce anti-nutrients and toxins in the feed, break down crude fiber, and decrease lignin content to improve feed digestibility (Michalak *et al*., 2021). Fermentation can increase significantly the total amino acids in soy waste, making it more beneficial for utilization in products (Song *et al*., 2008). Yeast products with live microorganisms can also benefit animals by enhancing gut health (Bajagai *et al*., 2016). Additionally, organic acids, probiotics, prebiotics, phytogenics, and zeolite are effective alternatives to antibiotics in livestock (Papatsiros *et al*., 2014). Using fermented probiotic in the diet of growing goats including soya waste promises to enhance profit for goat keepers due to reduced feed costs.

While there are benefits to fermenting soya waste to increase nutritional values of the feed in a low cost, fermenting the soya waste is hardly done by the smallholder farmers due to the lacking knowledge of fermentation technology among farms. In addition, to be adopted by the farmers, the research is required to analyze the roles of soya waste fermentation to reduce the feed costs and improve productivity for the goat. Such research has never been conducted, especially at the farms level. Hence, the study aims to evaluate the effects of using fermented probiotic soya waste (FPSW) for replacing mixed concentrate feed (MCF) in the diet on the growth performances and economic returns of crossbred male goats (Boer x Bach Thao).

MATERIALS AND METHODS

The research was carried out with permission from the Animal Ethics Committee of Can Tho University for animal care, housing, and sample collection (CTU-AEC24005).

Location and Time

The research was conducted at Cam Nhung goat farm in Can Tho City, Vietnam from June 2022 to November 2022. The feed, urine, and feces were chemically analyzed at E205 Laboratory, Faculty of Animal Sciences, College of Agriculture, Can Tho University.

Experimental Design and Feeds and Feeding

Five crossbred buck goats (Boer x Bach Thao) weighing 13.46 ± 0.4 kg at three months old were chosen for the study after weaning. They were individually housed in wooden cages measuring 1m in height, 1m in width, and 1.5m in length. The goats were fed three times daily at 7:00, 14:00, and 18:00, with unlimited access to water and ample space for exercise.

The goats were allocated to a 5×5 Latin square design, with five treatments and five periods. Each period lasted 21 days, including 14 days for diet adaptation and 7 days for sample collection, totaling 105 days for data collection.

The treatments included five levels replacing mixed concentrate feed (MCF) by fermented probiotic soya waste (FPSW) in varying proportions of diet: 0% FPSW (100MCF), 25% FPSW (75MCF), 50% FPSW (50MCF), 75% FPSW (25MCF), and 100% FPSW (0MCF). The treatment of 100MCF was considered as a control. The feed of the animals consisted of roughage (*Operculina Turpethum* and *Pennisetum purpureum*) and feed supplementation (mixed concentrate feed and fermented probiotic soya waste). The feedstuffs composition in the trial was shown in the Table 1.

Table 1: Experimental design.

Period	Goat				
	270	301	400	378	253
1	0% FPSW	25% FPSW	50% FPSW	75% FPSW	100% FPSW
2	50% FPSW	0% FPSW	100% FPSW	25% FPSW	75% FPSW
3	100% FPSW	50% FPSW	75% FPSW	0% FPSW	25% FPSW
4	25% FPSW	75% FPSW	0% FPSW	100% FPSW	50% FPSW
5	75% FPSW	100% FPSW	25% FPSW	50% FPSW	0% FPSW

The MCF, FPSW, and *Operculina Turpethum* were fed twice daily, at 7:00 am and 2:00 pm. At 6:00 pm, the animal was fed with *Pennisetum purpureum ad libitum*. The dietary formula for the goat is shown in Table 2.

Table 2: Feed ingredients and diet chemical composition.

Item	Chemical composition %DM				
	DM	OM	CP	NDF	Ash
Supplementation feed					
Fermented probiotics soya waste	17.4	95.8	18.8	31.9	4.25
Mixed concentrate feed	87.9	94.4	17.6	40.2	5.62
Roughage					
Operculina turpethum	14.2	90.0	16.8	51.3	9.99
Pennisetum purpureum	16.7	87.1	10.2	59.5	12.9

DM: dry matter; **OM:** organic matter; **CP:** crude protein; **NDF:** neutral detergent fiber; **Ash:** total mineral.

The diets of the experimental goats were monitored daily throughout the experiment to ensure they consumed the predetermined ratios as experimental design.

The Faculty of Animal Science at Can Tho University in Vietnam created the MCF for this study. The mixed concentrate feed used in the experiment contained 17.6% CP and had an ME of 12.3MJ/kgDM. It was composed of rice bran (38%), broken rice (36%), extraction soybean meal (25%), salt (1%), and a vitamin and mineral premix (1kg/200kg of feed). The feed was mixed weekly.

The fermentation process was started by collecting the soya waste from the soya waste processors. Soya waste was utilized in its fresh state and combined with extraction soybean meal, broken rice, vitamins, and minerals. The mixture consisted of 96% tofu waste, 1.7% soybean extraction meal, 1.7% of broken rice, 0.1% vitamins and minerals, and 0.5% probiotics. After that, we combined all the ingredients and placed them in a sealed container to ferment without oxygen for three days before feeding it to the goats. The composition of probiotic products (commercial products) used for fermenting the soya waste is shown in Table 3. Every day, MCF and FPSW were measured and combined for the animals' feed. The experimental goats were given a diet containing 5.5g of CP per kilogram of body weight per day with a DM intake equivalent to 3.5% of their body weight. The vitamins and minerals product contains at least 2,000,000 IU of Vitamin A, 400,000 IU of Vitamin D3, and 2,000 mg of Vitamin E; Zinc: 6,300-7,700 mg; Iron: 5,400-6,600 mg; Magnesium: 4,500-5,500 mg; Manganese: 5,400-6,600 mg; Copper: 360-440 mg; Bacillus subtilis: 10^9 CFU; Pediococcus: 10^6 CFU; Phytase: 99,750 IU per kilogram.

Table 3: Experimental goat's diet during the initial period.

Feedstuff, %DM	100 MCF	75 MCF	50 MCF	25 MCF	0 MCF
Fermented probiotic soya waste	0	12	24	36	48
Mixed concentrate feed	48	36	24	12	0
Operculina turpethum	31	31	31	31	31
Pennisetum purpureum	22	22	22	22	22

100MCF, 75MCF, 50MCF, 25MCF, 0MCF are levels replacing mixed concentrate feed by fermented probiotic soya waste corresponding to 0, 25, 50, 75 and 100%.

In 100g probiotic product (BIO – Pharmachemie company) including *Lactobacillus acidophilus* (2 x 10^9CFU), *Bacillus subtilis* (2 x 10^9CFU), *Saccharomyces cerevisiae* (2 x 10^9CFU), *Aspergillus oryzae* (2 x 10^9CFU), Vitamin A (100.000 UI), Vitamin D3 (15.000 UI), Folic acid (10 mg), Nicotinamide (200 mg), Vitamin B1 (25 mg), Lactose, Dextrose just enough (100g)

Sampling, Measurements and Chemical Analysis

Feeds offered were recorded daily in the morning during the experiment, and in the following day, the refusal was collected in order to calculate the actual feed consume. Samples of feeds, refusals, feces, urine, and rumen fluid were collected during the final three days of each observation period to assess nutrient digestibility (DMD, OMD, CPD, and NDFD) and nitrogen retention balance.

The feed samples were dried at 60°C for 72 hours in a forced-air oven from Binder, Germany. They were then ground through a 1-mm mesh using a Cutting Mill SM100 from Retsch, Germany, and kept at -20°C for later analysis of DM, OM, Ash, and CP following the AOAC (2005) standard methods. The neutral detergent fiber (NDF) content was analyzed as per the method outlined by Van Soest *et al.* (1991).

Feces and urine of experimental goats were collected using a plastic net under each cage. Feces were collected to calculate nutrient digestibility. Digestibility of dry matter, organic matter, crude protein, and neutral detergent fiber was determined following the method described by McDonald *et al.* (2010) (Equation 1).

$$Nutrient\ digestibility\ (\%) = \frac{(Nutrient\ intake\ (g) - Nutrient\ in\ feces\ (g)}{Nutrient\ intake\ (g)} \times 100$$

After weighing, 20% of the 24-hour feces were dried, ground, and saved for future chemical analysis like the feed samples. Using 10% H2SO4 to treat daily urine samples to maintain a final pH below 3 (Pathoummalangsy and Preston, 2008), and then 20 mL of urine solution was collected. The urine samples were combined and examined for nitrogen concentration. Nitrogen retention was determined by calculating nitrogen (N) intake data, feces, and urine to establish N retention using the formula (Equation 2):

$$Nitrogen_{retention} = Nitrogen_{intake} - (Nitrogen_{feces} + Nitrogen_{urine})$$

Samples of rumen fluid were collected before and after morning feedings at 0 and 3 hours using a stomach tube for the analysis of pH, total volatile fatty acids (VFAs), and ammonia (N-NH3). The pH of the rumen fluid was measured promptly using a portable pH meter (EcoTestr pH2, Eutech – Singapore). VFAs were analyzed following the Barnet and Reid (1957) procedure, while ammonia concentration was determined through distillation and titration using the Kjeldahl method (AOAC, 2005).

Metabolizable energy intake (MEI) was determined using the formula from Bruinenberg *et al.* (2002). Equation 3 was used to calculate the Non-fiber carbohydrates (NFC).

$$NFC = 100 - (Crude\ Protein + Ether\ Extract + Neutral\ Detergent\ Fiber + Ash)$$

Live weights were measured at the beginning and end of each period to determine changes in live weight. The diet's nutrient digestibility was assessed using McDonald (2010) method. The feed conversion ratio formula (FCR) was calculated by using Equation 4.

$$FCR = \frac{DM\ intake\ (g)}{weight\ gain\ (g)}$$

Economic Calculation

Economic returns were calculated by the income of selling goats minus for total cost (feed and breed cost). The feed cost was obtained by multiplying the daily feed intake with the price of feed at local market. The price for *Operculina Turpethum* was 1000 VND/kg, *Pennisetum purpureum* was 1000 VND/kg, fermented probiotic soya waste was 1.800 VND/kg, mixed concentrate feed was 9.960 VND/kg, the price of breed goats: 120.000 VND/kg. The price of selling goats was based on the local market with the price of goats: 110.000 VND/kg live weight. (1USD = 24,000VNĐ).

Statistical Analysis

The ANOVA Linear Model (GLM) in Minitab Reference Manual Release 20 (Minitab, 2021) was utilized for analyzing the experimental data. Subsequently, the Tukey test was used for pairwise comparison of two treatments in the study (p<0.05).

Table 4: Feed intake, nutrient intake and metabolism energy.

Item	Treatment					SEM	P
	100 MCF	75 MCF	50 MCF	25 MCF	0 MCF		
Feed Intake, gDM/per/day							
Operculina Turpethum	164	165	163	164	165	0.910	0.445
FPSW	0[e]	97.9[d]	196[c]	292[b]	387[a]	15.68	0.001
MCF	355[a]	266[b]	178[c]	88.8[d]	0[e]	15.12	0.001
Pennisetum purpureum	164[a]	129[ab]	110[bc]	91.0[bc]	77.8[c]	8.499	0.001
Nutrient intake, g/per/day							
DM	684[a]	658[ab]	646[b]	636[b]	629[b]	7.512	0.002
OM	626[a]	606[ab]	597[b]	590[b]	586[b]	6.372	0.006
CP	107	106	107	107	108	0.623	0.155
NDF	325[a]	299[b]	282[bc]	267[cd]	254[d]	5.506	0.001
Ash	57.6[a]	52.2[b]	48.7[bc]	45.5[cd]	42.9[d]	1.167	0.001
Metabolism energy, ME							
MEI/LW, MJ/kg	0.381	0.375	0.378	0.367	0.365	0.014	0.907
MEI, MJ/day	8.11	8.01	7.98	7.88	7.70	0.135	0.324

FSW: Fermented probiotic soya waste; **MCF:** Mixed concentrate feed. 100MCF, 75MCF, 50MCF, 25MCF, 0MCF are levels replacing mixed concentrate feed by fermented probiotic soya waste corresponding to 0, 25, 50, 75 and 100%. **MEI:** metabolism energy intake. Items in the same row with different superscripts have significant differences (P<0.05).

RESULTS AND DISCUSSION

Feed and Nutrient Intakes

Table 4 presented data on the feed intake, nutrient intake, and metabolic energy of the goats in the study. The daily intake of fermented probiotic soya waste, mixed concentrate feed, and *Pennisetum purpureum* varied significantly between treatments (P<0.05), while the intake of *Operculina turpethum* was consistent across treatments (P>0.05). Differences were observed in the daily intake of DM, OM, NDF, and ash (P<0.05), while the CP intake remained similar across treatments (P>0.05). Additionally, the metabolic energy showed no significant differences between treatments (P>0.05).

In this study, there were no significant differences (P>0.05) in digestibility and digestible nutrients when replacing MCF with FPSW, except for digestible NDF (Table 5).

Table 5: Nutrient digestibility, digestible nutrient and nitrogen balance

Item	Treatment					SEM	P
	100 MCF	75 MCF	50 MCF	25 MCF	0 MCF		
Nutrient digestibility, %							
DM	77.5	79.0	79.6	80.1	78.4	1.179	0.575
OM	78.2	79.6	80.4	80.8	79.2	1.127	0.538
CP	78.8	79.8	80.4	81.2	79.4	0.935	0.467
NDF	77.4	76.2	75.5	75.2	72.8	1.782	0.496
Digestible nutrient, g/day							
DM	530	521	517	509	495	9.063	0.136
OM	490	484	483	477	466	7.858	0.310
CP	84.1	85.0	85.8	87.4	86.1	1.317	0.512
NDF	252[a]	229[ab]	214[bc]	200[bc]	186[c]	6.758	0.001
Nitrogen balance							
N intake, g	17.1	17.0	17.0	17.2	17.3	0.100	0.155
N feces, g	3.63	3.37	3.32	3.20	3.56	0.176	0.441
N urine, g	3.84	3.74	3.84	3.60	5.72	0.657	0.191
N retention, g	9.62	9.86	9.89	10.4	8.06	0.539	0.083
%NR/NI	56.9	58.7	58.4	60.5	44.8	4.100	0.110
$NI/W^{0.75}$	1.72	1.70	1.72	1.71	1.75	0.041	0.914
$NR/W^{0.75}$	0.98	1.00	1.00	1.00	0.78	0.741	0.189

NI: nitrogen intake; **NR:** nitrogen retention. 100MCF, 75MCF, 50MCF, 25MCF, 0MCF are levels replacing mixed concentrate feed by fermented probiotic soya waste corresponding to 0, 25, 50, 75 and 100%. Items in the same row with different superscripts have significant differences (P<0.05).

The N intake, N feces, N urine, and N retention of the experimental goats were not affected by replacing levels of FPSW (P>0.05). The proportion N retention to N intake ranges from 44.8 to 60.5%. In the treatment 25MCF, the N in urine and in feces showed the smallest value compared to others.

There were no significant differences in pH, VFAs, and N-NH3 levels between treatments at either 0 or 3 hours after feeding (P<0.05). The VFAs at 3 hours after feeding had a rising tendency from 100MCF (97.3 µmol/ml) to 50MCF (110 µmol/ml), after that slightly decreased to 25 MCF and 0MCF (109 and 106 µmol/ml, respectively) (P>0.05). The pH value was a decline from 0 hours to 3 hours after feeding, this change was without affecting rumen microbial activity (Table 6).

Table 6: The pH, NH_3, VFAs at 0 hour, 3 hours in the rumen fluid of goats in the experiment.

Item	Treatment					SEM	P
	100 MCF	75 MCF	50 MCF	25 MCF	0 MCF		
0 hour							
pH	7.09	6.99	7.00	7.02	7.11	0.082	0.763
VFAs, µmol/ml	68.8	68.2	81.0	83.3	75.2	5.913	0.305
$N-NH_3$, mg/100ml	26.2	26.4	27.3	26.7	24.9	1.438	0.823
3 hours after feeding							
pH	6.75	6.82	6.73	6.59	6.63	0.075	0.273
VFAs, µmol/ml	97.3	102	110	109	106	7.167	0.701
$N-NH_3$, mg/100ml	29.3	32.0	35.4	32.0	28.9	1.600	0.084
Difference between 0 hours and 3 hours							
VFAs, µmol/ml	28.5	33.5	28.9	25.8	31.0	6.414	0.932
$N-NH_3$, mg/100ml	3.09	5.62	8.11	5.36	4.02	1.571	0.272

100MCF, 75MCF, 50MCF, 25MCF, 0MCF are levels replacing mixed concentrate feed by fermented probiotic soya waste corresponding to 0, 25, 50, 75 and 100%.

Weight Gain and Feed Conversion Ratio

There were no significant differences in the initial live weight and daily weight gain among the treatments (P>0.05; Table 7). The final live weight showed the highest value at 75MCF (24 kg), 50MCF (23.7kg) and 25MCF (23.7 kg/per) (P<0.05). The DWG and FCR had higher results at 25MCF compared to the other treatments were 196 g/per/day and 3.55, respectively.

Economic Returns

Total feed costs (Table 8) were the highest cost at 75MCF (3.072.247 VND) and the lowest cost at 25MCF (2.948.284 VND). The income showed that the highest value in 25MCF being 1.471.516 VND and the lowest in 0MCF being 764.070 VND/head.

Table 7: Daily weight gain and feed conversion ratio of experimental goats.

Item	Treatment					SEM	P
	100 MCF	75 MCF	50 MCF	25 MCF	0 MCF		
Initial live weight, kg	20.0	20.4	20.1	19.6	19.9	0.324	0.481
Final live weight, kg	23.4[ab]	24.0[a]	23.6[ab]	23.7[a]	22.7[b]	0.215	0.011
DWG, g/day	160	171	171	196	134	14.76	0.124
FCR	4.38	4.21	3.71	3.55	5.11	0.468	0.203

100MCF, 75MCF, 50MCF, 25MCF, 0MCF are levels replacing mixed concentrate feed by fermented probiotic soya waste corresponding to 0, 25, 50, 75 and 100%. Items in the same row with different superscripts have significant differences (P<0.05).

Table 8: Economic returns of experimental goats.

Item (Vietnamese Dong)	Treatment				
	100MCF	75MCF	50MCF	25MCF	0MCF
Feed cost	646,747	624,247	610,993	596,284	584,630
Breed cost	2,400,000	2,448,000	2,412,000	2,352,000	2,388,000
Total cost	3,046,747	3,072,247	3,022,993	2,948,284	2,972,630
Selling goats	4,048,000	4,219,050	4,186,050	4,419,800	3,736,700
Income	1,001,253	1,146,803	1,163,057	1,471,516	764,070

100MCF, 75MCF, 50MCF, 25MCF, 0MCF are levels replacing mixed concentrate feed by fermented probiotic soya waste corresponding to 0, 25, 50, 75 and 100%. Operculina Turpethum: 1000 VND/kg, Pennisetum purpureum: 1000 VND/kg, fermented probiotic soya waste: 1.800 VND/kg, mixed concentrate feed: 9.960 VND/kg, the price of breed goats: 120.000 VND/kg, the price of broiler goats: 110.000 VND/kg. 1USD = 24,000VNĐ.

Replacing mixed concentrate feed (MCF) with fermented probiotic soya waste (FPSW) in the diet has changed the nutrient composition. The decreased intake of dry matter (DM), organic matter (OM), neutral detergent fiber (NDF), and ash with an increase levels of FPSW found in this study could be explained by the rumen's capacity to consume soya waste. Moreover, the FPSW having high moisture resulted in the diet having low intake levels of *Pennisetum purpureum*. Our study was consistent with Rahman *et al*. (2015), who noted a reduction in DM intake as the levels of soya waste in the diet increased. Their research also demonstrated that goats can consume up to 2.0% of their body weight in soya waste as a concentrated supplement when provided with *ad libitum Pennisetum purpureum*. However, the similarity of nutrient digestibility and digestible nutrients among dietary groups was found, except digestible NDF had a gradual decline tend to crossing the rise of replacing levels of FPSW. The result could be explained that NDF digestibility was consistent among diets, but NDF intake decreased as the levels of FPSW replacement increased. Our findings differred from Rahman *et al*., (2020), who demonstrated that replacing groups with higher levels of soya waste in the NDF would result in a decrease in DM intake.

The nitrogen balance indicators were similar among treatments. It could be explained that soya waste can be used in goat diets without affecting nutrient digestibility and digestible nutrients. In 25MCF, the N in urine and N faces were smallest and it caused to higher N retention, leading to higher daily weight gain compared to other treatments. Harjanti *et al*. (2012) mentioned that incorporating soya waste into sheep diets could maintain a favorable nitrogen balance.

The results in this study showed that the similarity of pH values between 0 hours and 3 hours after feeding could be explained by a stable rumen digestion. It means that using fermented soy waste in goat diets did not have a negative impact on rumen fermentation. The pH was lower than 5.5 and higher than 7.5, fiber digestibility was reduced (Hoover *et al*., 1984; Cotta and Hespell, 1986) suggested that proteolytic bacteria work well when the pH is between 5.5-7.0. Supplying soy waste into sheep diets had the potential to enhance the glucogenic propionate levels in the rumen, as suggested by Harjanti *et al*. (2012).

No diffrence were observed in the initial live weight, feed conversion ratio (FCR), and daily weight gain across the diets, except the final live weight got the lowest value at 0MCF due to the lowest values of nutrient intake and nitrogen retention in this treatment. Harjanti *et al*. (2012) showed that soya waste possesses nutritional and functional properties that support weight gain in the body. This might explain the similarity of total BW gain between control and treatment diets goats. The research conducted by Harthan and Cherney (2017) indicated that ewes fed hay tended to consume more soya waste compared to ewes fed hay crop silage (P=0.07). Additionally, the higher NDF content in both forage and soya waste resulted in an increased milk fat percentage in the diets of the ewes.

The 25MCF treatment resulted in the highest growth performance and economic returns compared to the other treatments (more than 47% increased in income compared to using a diet of 100% mixed concentrate feed). The study showed that using a soya waste diet is cheaper than a diet with soybean meal because soya waste is available for free as industrial leftovers, whereas soybean meal must be bought (Rahman *et al*., 2020).

CONCLUSIONS AND RECOMMENDATIONS

Using 75% fermented probiotic soya waste in the growing goat diets did not affect digestibility of nutrient, digestible nutrients, nitrogen balance, VFAs, and pH values of crossbred buck goats (Boer x Bach Thao). Feeding 75% FPSW (25MCF) in the diet gave higher results in the final live weight, daily weight gain, FCR, and economic returns with more than 47% increased in income compared to using a diet of 100% mixed concentrate feed. Therefore, replacing 75% FPSW (25MCF) is a feeding strategy to improve growth performance positively without negative effects on animal performance.

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NOVELTY STATEMENTS

Determining the optimum level of fermented probiotic soya waste in the diet of buck goats with high growth performance and income for goat keepers in the Mekong Delta is a new finding.

AUTHOR'S CONTRIBUTIONS

Truong Thanh Trung: Concept note, experimental designed and performed the experiments.
Nguyen Thuy Linh data analyze.
Truong Thanh Trung, Nguyen Thuy Linh, Nguyen Thi Kim Dong and Windi Al Zahra: Wrote the paper and revised the manuscript.

Conflict of Interest

We confirm that there are no conflicts of interest.

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