EFFECTIVENESS OF USING FERMENTED TOTAL MIXED RATION (FTMR) FROM DRAGON FRUIT BRANCHES ON BACH THAO MEAT GOATS

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ABSTRACT

This study, conducted from March 8th to October 2nd, 2024, at the Ruminant Research and Development Center-Institute of Animal Sciences for Southern Vietnam, aimed to evaluate the effectiveness of incorporating fresh dragon fruit branches (DFB) into fermented total mixed ration (FTMR) for meat goats. A total of 240 Bach Thao meat goats at 5 months old were randomly assigned to three treatments in a randomized complete design with 4 replicates (20 heads per replicate per treatment). Treatment 1: Control (0.3 kg commercial feed + 0.6 kg cassava residue and grass fed ad libitum); treatment 2: using 60% DFB in FTMR (FTMR1); treatment 3: using 70% DFB in FTMR (FTMR2). The results indicated that the FTMR diet containing 60% DFB was the most effective, maintaining the growth performance of the goats comparable to the control group. Additionally, the use of DFB reduced feed costs by 7.03-7.57% per kg of weight gain in Bach Thao goats. This suggests that incorporating DFB into the diet can be a cost-effective strategy without compromising growth performance.

Keywords*: Bach Thao meat goat, DFB, FTMR, growth performance*

INTRODUCTION

Goat meat are a vital source of high-quality protein in Vietnam. By the end of 2023, the country boasted a population of 2,835,846 goats, yielding 40,046 tons of live goat meat (General Statistics Office, 2024). According to Bui Thi Nga et al. (2022), goat farming in Vietnam was practiced through three main methods: extensive, semi-intensive, and intensive farming. Among these, intensive farming stood out as the most economically efficient. This method offers several advantages: it eliminated the need for grazing and reduced the risk of disease transmission from external sources. However, the increasing severity of climate change poses a significant challenge. During the dry season, green forage for goats becomes scarce, particularly in the South Central region, which is also renowned as the dragon fruit capital.

Dragon fruit (*Hylocereus undatus*) is a key crop in the southern provinces of Vietnam. By the end of 2023, the country had 55,000 hectares of dragon fruit, yielding over 1.2 million tons, primarily located in Binh Thuan, Long An and Tien Giang provinces (Vietnam Agriculture Newspaper, 2024). During cultivation and harvest, farmers often remove a significant amount of branches and leaves that are no longer useful. It is estimated that each hectare of dragon fruit generates about 12-15 tons of waste branches annually (Le Quang Khoi and Nguyen Thi Ngoc Truc, 2017). Currently, most of these waste branches are either used as fertilizer or discarded, without being effectively utilized. Improper handling of these waste products not only leads to waste but can also cause environmental pollution.

Interestingly, dragon fruit branches have nutritional value comparable to many types of green fodder, with crude protein and fiber content on a dry matter basis of approximately 9.72% and 30.62 %, respectively (Espedido et al., 2009). Some studies have explored using dragon fruit branches for livestock and poultry feed, such as supplementing dried dragon fruit branch powder for broiler chickens (Espedido et al., 2009) or using fresh fermented dragon fruit branches as feed for beef cattle (Doan Vinh et al., 2022), both

yielding very positive results. Therefore, finding solutions to effectively utilize these waste products from dragon fruit is crucial to bring economic benefits to farmers.

Given these circumstances, utilizing dragon fruit branches (DFB) as feed for meat goats presents a promising research avenue. However, DFB are high in water content and low in dry matter, making preservation challenging (Doan Vinh et al., 2022). To address this, incorporating DFB into a fermented total mixed ration (FTMR) for meat goats could be a viable solution. FTMR is an effective method for preserving high-moisture by-products, capable of meeting the daily nutritional needs of livestock and enhancing their productivity (Wang et al., 2024). This research aims to develop an FTMR diet from fresh DFB that fulfills the nutritional requirements for the growth and development of meat goats.

MATERIALS AND METHOD

Materials

The feed ingredients included fresh dragon fruit branches, mombasa, rice bran, cassava residue, soybean meal, and probiotics, etc. The experimental animals are Bach Thao meat goats, approximately 5 months old, all with consistent weight.

Location and time

Time: From March 8th, 2024 to October 2nd, 2024.

Location: The experiment was conducted at the Ruminant Research and Development Center-Institute of Animal Sciences for Southern Vietnam.

Experimental Design

A total of 240 Bach Thao goats, each around 5 months old, were used in a completely randomized experiment. The study included 3 treatments (T) with 4 replicates each, and 20 goats per replicate. The treatments were as follows: Treatment 1 (Control) with the farm diet, Treatment 2 (FTMR1) with 60% DFB, and Treatment 3 (FTMR2) with 70% DFB. The goats were selected to ensure a uniform initial weight of approximately 19 kg each and provided with consistent care and feeding according to the protocols of the Ruminant Research and Development Center. The goats were housed in 12 experimental pens, with 20 goats per pen, and each pen representing one replicate. The detailed experimental design is presented in Table 1.

Table 1. Experimental Design

Parameter	Unit	T1 (Control)	T2 (FTMR1)	T3 (FTMR2)
Number of goats/T/ replicate Number of goats	head	20	20	20
Number of replicates	times	4	4	4
Total number of goats	head	80	80	80

Experimental Feed: The nutritional composition of the feed ingredients was analyzed at the Nutrition and Animal Husbandry Analysis Laboratory - Institute of Animal Sciences for Southern Vietnam. The analyses were conducted as follows: Dry Matter (DM) according to TCVN 4326:2001; Crude Protein (CP) according to TCVN 4328-1:2007; Ether Extract (EE) according to TCVN 4331:2001; Crude Fiber (CF) according to TCVN 4329:2007; Neutral Detergent Fiber (NDF) according to TCVN 9590:2013; Acid Detergent Fiber (ADF) according to TCVN 9589:2013. Metabolizable Energy (ME) values were calculated using the PT/VCN24:2017 method of the Natinal Institute of Animal science and referenced from the

INRAE CIRAD AFZ © 2017-2024 databases (feedtables.com). The nutritional composition of the feed ingredients is detailed in Table 2. Treatment 1 consisted of 0.3 kg of complete mixed feed purchased from a company, combined with 0.6 kg of cassava residue and ad libitum mombasa. Treatments 2 and 3 used the respective FTMR1 and FTMR2 diets, fed ad libitum. The FTMR diets were formulated according to NRC (2007) recommendations for local meat goats weighing 20-30 kg with a weight gain of 100-150 g/day, requiring a diet with 1,910-2,390 kcal/kg ME and ensuring a daily intake of at least 690 g of dry matter, 1,660 kcal ME, and 86 g CP. The detailed FTMR compositions are shown in Table 3. The probiotics used in the study contained *Saccharomyces cerevisiae* (10^7 CFU/g) and *Lactobacillus sp.* (10^7 CFU/g). All goats had access to mineral licks and free access to water.

Table 2. Nutritional composition of experimental feed ingredients (Based on DM)

Ingredients	**Price** (d/kg)	**DM** (%)	**ME** (kcal/kg)	**CP** (%)	**EE** (%)	**CF** (%)	**ADF** (%)	**NDF** (%)
Complete mixed feed fefeedComplete mixe feed	10,000	87.00	2,876	21.88	3.51	15.32	17.57	28.14
Mombasa	500	15.50	1,716	10.52	2.12	27.29	31.61	55.54
Cassava residue	1,100	23,98	1,810	3.03	0.66	16.35	18.42	35.92
Dragon fruit branches	350	14.69	2,034	8.02	2.57	33.26	32.08	41.33
Rice bran	6,600	89.20	2,320	13.34	11.39	12.97	14.04	33.86
Corn	7,500	87.00	3,350	8.71	3.89	2.73	2.92	12.58
Soybean meal	12,000	87.98	3,330	52.61	1.79	6.79	8.31	14.48
Dry straw	1,500	90.04	1,400	2.99	1.89	31.86	40.82	61.84
Molasses	8,000	72.30	2,160	2.80	-	-	-	-
Probiotics	50,000	90.75	-	-	-	-	-	-

The study employed anaerobic lactic fermentation, enhanced with microorganisms (*Saccharomyces* and *Lactobacillus*). Fresh dragon fruit branches and dry straw were chopped and thoroughly mixed with other ingredients and a microbial preparation blended with rice bran, following the experimental formulas. This mixture was then packed into specialized nylon bags, compressed layer by layer, and sealed. Each bag was labeled with the treatment type and ensiling date for easy identification. After 20 days of fermentation, the feed was ready for the goats. Each batch was designed to provide sufficient feed for the goats for 60 days, with subsequent batches were prepared in a staggered manner to maintain the quality of the ensiled feed.

Table 3. FTMR diets for meat goats

Ingredients	**Unit**	**FTMR1**	**FTMR2**
Dragon fruit branches	%	60.0	70.0
Rice bran	%	7.3	6.0
Corn	%	4.8	3.1
Soybean meal	%	7.0	5.6
Dry straw	%	17.7	12.3
Molasses	%	3.0	2.8
Probiotics	%	0.2	0.2

Ingredients	Unit	FTMR1	FTMR2
Nutritional Composition (Based on DM)			
DM	%	43.95	36.54
ME	(kcal/kg)	2,151	2,152
CP	%	13.01	13.01
EE	%	3.51	3.49
CF	%	21.36	22.03
ADF	%	24.76	24.79
NDF	%	38.96	38.21

Measurements taken

Body weight (BW) at different time points: BW was recorded at the start; after 30, 60, and 90 days of the experiment to calculate average daily gain (ADG). Goats were weighed using a 100 kg electronic scale in the early morning before feeding.

Feed consumption at each experimental stage: This was tracked to calculate the intake of dry matter (DM), metabolizable energy (ME), and crude protein (CP).

Feed conversion ratio (FCR) and feed efficiency: The FCR and the cost of feed per kilogram of weight gain were be determined.

Data analysis

All data were statistically analyzed using one-way ANOVA with Minitab 17 software (Minitab Inc., State College, Pennsylvania, PA, USA). Tukey's test was employed to compare the mean values, with statistical differences considered significant at $P<0.05$.

Analysis of variance model:

$$Y_{ij} = \mu + T_i + E_{ij}$$

Which: Y_{ij}: Observed data.

μ: Overall mean of the observed data.

Ti: The contribution of the diet i (where (i = 3))

Eij: Random error or the effect of unidentified factors on the observed data for the goat j and the diet i.

RESULTS AND DISCUSSION

Nutrient intake

Throughout all experimental stages, significant differences were observed in the intake of DM, ME, and CP among the goats across different treatments ($P<0.001$) (Table 4). During the first 30 days, the control group had the highest intake, followed by goats fed with FTMR1, and the lowest intake was seen in the FTMR2 group. This initial lower intake in T2 and T3 could be attributed to the goats adjusting to the new feed. As the experiment progressed and the goats became accustomed to the FTMR diets, however, the nutrient intake in T2 and T3 increased significantly compared to T1. Over the 90-day experiment, the DM, ME and CP intake in both FTMR treatments surpassed that of the farm diet, with the most notable increase observed in ME intake (3.76-4.86%).

Table 4. Dry matter (DM), metabolizable energy (ME), and crude protein (CP) intake

Items	Stages	T1	T 2	T 3	SEM	P
DM *(kg/head/day)*	5-6 months old	0.806[a]	0.784[b]	0.757[c]	0.005	<0.001
	6-7 months old	0.899[c]	0.932[b]	0.954[a]	0.003	<0.001
	7-8 months old	0.908[b]	0.903[b]	0.934[a]	0.003	<0.001
	5-8 months old	0.871[b]	0.873[b]	0.882[a]	0.002	<0.001
ME *(kcal/head/day)*	5-6 months old	1,699[a]	1,687[a]	1,630[b]	10.02	<0.001
	6-7 months old	1,859[c]	2,006[b]	2,054[a]	5.452	<0.001
	7-8 months old	1,873[c]	1,943[b]	2,010[a]	5.219	<0.001
	5-8 months old	1,810[c]	1,878[b]	1,898[a]	3.738	<0.001
CP *(g/ head/day)*	5-6 months old	104.2[a]	102.0[b]	98.5[c]	0.607	<0.001
	6-7 months old	114.0[c]	121.3[b]	124.1[a]	0.331	<0.001
	7-8 months old	114.9[c]	117.5[b]	121.5[a]	0.317	<0.001
	5-8 months old	111,0[c]	113.6[b]	114.7[a]	0.226	<0.001

Note: Means with different letters in the same row are significantly different (P<0.05)

The diet and nutrient intake of goats in this study ensured optimal growth and development, adhering to NRC (2007) recommendations. The dry matter intake was consistent with the findings of Nguyen Thi Mong Nhi and Nguyen Van Si Lam (2021) for Boer x Bach Thao goats (5-7 months old, with DM intake ranging from 892-903 g/head/day) and the report by Phan Van Sy et al. (2021) for Bach Thao goats, which showed DM intake ranging from 780-930 g/head/day for 5-6 months old and 930-1,010 g/head/day for 6-7 months old. In terms of CP intake, the results in Table 3 indicated an improvement over the 97-110 g/head/day reported for Bach Thao crossbred goats aged 5-7 months by Nguyen Thi Mong Nhi and Nguyễn Van Si Lam (2021). This intake also surpassed the earlier recommendation by Ho Quang Do and Nguyen Minh Thuy (2013), which suggested that meat goats require a minimum of 90 grams of protein per day for growth. Furthermore, Nguyen Thi Ha Phuong et al. (2021) noted that a fully fermented diet enhances ME intake, a finding that aligns with the current study, where ME intake in T2 and T3 was higher than in T1. Therefore, incorporating DFB in the FTMR diet improved DM, ME and CP intake.

Body weight and average daily gain

At the start of the experiment, the goats had similar weights, averaging around 19 kg per head (Table 5). Throughout the growth stages, the weights of the goats across different treatments remained relatively stable (P>0.05), averaging about 22 kg per head at 6 months old and 26 kg per head at 7 months old. These results are higher than those reported for Bach Thao goats by Phan Van Sy et al. (2021) at the same ages. By the end of the experiment (8 months old), the highest weight was recorded in T1 (29.30 kg per head) and the lowest in T3 (29.12 kg per head), though these differences were not statistically significant (P>0.05). This final weight is also higher than the 26.49 kg per head reported for 9-month-old Bach Thao goats in the study by Nguyen Thanh Hai and Do Hoa Binh (2019).

Table 5. Body weight and average daily gain across different stages

Items	Stages	T1	T 2	T 3	SEM	P
BW (kg/head)	5 months old	19.02	18.99	18.98	0.189	0.970
	6 months old	22.17	22.02	21.99	0.157	0.267
	7 months old	26.15	26.08	26.02	0.171	0.588
	8 months old	29.30	29.20	29.12	0.188	0.424
ADG (g/head/day)	5-6 months old	105.29	100.92	100.33	2.536	0.053
	6-7 months old	132.50	135.08	134.29	2.020	0.233
	7-8 months old	105.17	104.13	103.33	1.273	0.180
	5-8 months old	115.60^{a}	114.65^{ab}	113.92^{b}	0.743	0.032

Note: Means with different letters in the same row are significantly different (P<0.05).

Regarding absolute growth, the ADG of experimental goats during the stages of 5-6, 6-7, and 7-8 months did not show statistically significant difference between treatments (P>0.05). The ADG results were comparable to the best-growing Bach Thao goats (101.54 g/head/day) at 5-6 months old in the study by Phan Van Sy et al. (2021). During the 6-7 month stage, however, the ADG of Bach Thao goats in this study exceeded the 128.11 g/head/day of the fastest-growing group in the authors' study. In general, for the 3-month experiment, there was a significant difference in ADG, most notably between the goats in T1 and T3 (P<0.05). The weight gain in T1 was 115.6 g/head/day; 1.45% higher than in T3. The reduction in ADG might be attributed to the FTMR2 diet, which contains 70% DFB with high moisture content. To fulfill their dry matter needs for growth, goats tend to consume more. However, for ruminants, an increase in feed quantity can hinder microbial efficiency in processing the feed, leading to lower digestion and absorption rates (Le Duc Ngoan and Du Thanh Hang, 2014). Nevertheless, the absolute growth of goats in this study was much higher than the 83.4 g/head/day reported for Bach Thao goats aged 6-9 months in the study by Nguyen Thanh Hai and Do Hoa Binh (2019).

In short, using an FTMR diet with DFB as the main component did not negatively impact the growth and body weight of meat goats. However, to ensure optimal growth, the DFB ratio in the diet should be maintained at 60%.

Feed conversion ratio and feed efficiency

Table 6. Feed conversion ratio and feed efficiency of experimental goats

Items	Stages	T1	T2	T3	SEM	P
FCR *(kgDM intake/ kg weight gain)*	5-6 months old	7.66	7.77	7.55	0.184	0.283
	6-7 months old	6.79^{b}	6.90^{ab}	7.11^{a}	0.107	0.007
	7-8 months old	8.63^{b}	8.68^{b}	9.04^{a}	0.111	0.001
	5-8 months old	7.62^{b}	7.70^{b}	7.83^{a}	0.051	0.002
Feed price (d/kgDM)	-	6,432	5,882	5,821	-	-
Feed efficiency *(d/ kg weight gain)*	5-8 months old	49,017^{a}	45,302^{b}	45,567^{b}	313	<0.001

Note: Means with different letters in the same row are significantly different (P<0.05)

During the first 30 days of the experiment, the difference in FCR was not significant (P>0.05), ranging from 7.55 to 7.77 kg of dry matter intake per kg of weight gain. However, in the subsequent stages and overall throughout the experiment, FCR varied significantly between the groups, most notably between T3 and the other groups during the 7-8 month stage and throughout the experiment (P<0.01). The average FCR from the start to the end of the experiment was highest in T3, higher than T1 and T2 by 0.21 and 0.13 kg of dry matter intake per kg of weight gain, respectively, equivalent to 2.76% and 1.69%. The results in table 6 indicate that the FCR of goats in T3 tended to be lowest in the initial stage but increased in the later stages. This was because the goats were not accustomed to the new feed initially and did not eat much. In the later stages, although the goats ate more, their weight gain did not improve, leading to a higher FCR. Table 6 also shows that the FCR of goats fed the FTMR diet with 60% DFB was not significantly different from the control group fed the farm diet, but this ratio improved by 1.66% compared to the FCR of goats fed the FTMR diet with 70% DFB. The FCR results in this study are consistent with the report by Nguyen The Mong Nhi and Nguyen Van Si Lam (2021), where the FCR for Boer x Bach Thao goats aged 5-7 months ranged from 6.85 to 9.06 kg of dry matter per kg of weight gain. Additionally, compared to Bach Thao goats in the study by Phan Van Sy et al. (2021), where the best FCR during the 3-7 month stage for goats fed fermented cashew apple was 8.59 kg of dry matter per kg of weight gain, the average FCR throughout the experiment in this study showed significant improvement.

Calculating the feed efficiency per kilogram of weight gain, the results demonstrated the effectiveness of using DFB to formulate the FTMR diet for meat goats. The lowest cost was observed in the group of goats fed the FTMR diet with 60% DFB (45,302 VND/kg), while the highest cost was in the control group fed the farm diet (49,017 VND/kg). Compared to the control group, goats fed the FTMR diet with 60% and 70% DFB saved 3,751 Vnd (7.57%) and 3,450 Vnd (7.03%) per kilogram of weight gain, respectively.

CONCLUSIONS

Conclusion

Incorporating 60% DFB into the FTMR diet not only sustained well growth in goats but also did not lead to increased feed consumption. Additionally, this diet reduced feed costs by 7.57% for Bach Thao meat goats.

Recommendation

Dragon fruit branches can be effectively used to create a fermented total mixed ration for meat goats in regions where dragon fruit is grown.

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