The Durian Peel Waste as High-Quality Feed on Goat Performance and Economic Worthiness

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Abstract

The experiments aimed to investigate the potential of durian peel (DP) as roughage feed on goat performance. There were two treatments such as fermented durian peel (FDP; T1) and fresh grass (*Brachiaria decumbens*) (FG; T2). Twelve crossbreed Thai Native–Anglo-Nubian goats (50%) at 5 to 7 months of age and 20 ± 1.0 of body weight (BW) were assigned to a Student t-test. All of the goats were fed 2% BW of concentrate diet. Evaluated treatments were fermented discarded durian peel and grass as roughage feed sources. The study shows that the concentrated feed in this experiment has a protein level of 16.97%, and the fermented durian peel has a protein level of 16.01%. Meanwhile, the grass had a low protein level of 6.12%. The dry matter intake (DMI) of goat that ingested fermented durian peel (1920.40 g/h/d) was significantly ($P<0.05$) higher than goat ingested fresh grass (1355.60 g/h/d). The body weight change of goat that ingested fermented durian peel (8.92 kg) was significantly ($P<0.05$) higher than ingested fresh grass (5.33 kg). The growth rate of goat that ingested fermented durian peel (108.14 g/h/d) was significantly ($P<0.05$) higher than ingested fresh grass (61.80 g/h/d).

This study showed the profit in goat that ingested fermented durian peel was significantly ($P<0.05$) higher than ingested fresh grass and the group was able to reduce feed cost 45 %. Therefore, fermented discarded durian peel could be constitute roughage feed source for feeding goats without a negative impact.

Keywords: Durian peel, goat performance, economic worthiness

Introduction

Durian (*Durio zibethinus*) is a famous seasonal fruit grown widely in tropical countries with a distinct flavor and unique aroma. It is mainly found in Thailand, followed by Malaysia and other countries such as Indonesia and the Philippines (Nordin et al., 2017). Approximately 20 to 30% of durian is appropriate for human consumption up 70 to 80% accounts for the durian peel, which is discarded as waste. Discarded durian peel contains 10.30% crude protein, 3.24% fat, 22.33% crude fiber, 50.51% nitrogen-free extract, 9.50% cellulose, and 10.32% acid detergent lignin. The waste of durian peels is a big problem for the environment (Waramit *et al.,* 2016). So, the management and utilization of animal feed is one of the most promising methods for diversifying and adding value to the usage of agricultural waste (Hasan et al., 2006). Due to the limitation of the forage, especially during the dry season. The utilization of agricultural by-products such as durian peel is an alternative to solve the problem (Natsir, 2012). Based on its physical and chemical characteristics, durian peel is used for animal feeding. Physically, the durian peel has the potential to be used as a roughage feed source. Ensiling is a well-known technique used to preserve high-fermentable-containing feed resources using lactic acid bacteria (LAB), converting sugar into lactic acid, resulting in low pH (Khota et al., 2017). Ensiling additives such as salt, urea, and molasse are added to improve the fermentation quality of durian peel.

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This study hypothesized that fermented durian peel could replace roughage feed source. The aim of this study was to evaluate the effect of fermented discarded durian peel and grass on goat performance and also the economic worthiness in feeding crossbreed Thai Native–Anglo-Nubian goats.

Meterial and Methods

Animals and Experimental Design

Twelve crossbreed Thai Native–Anglo-Nubian goats (50%) at 5 to 7 months of age and 20 ± 1.0 of BW. All goats were injected with ivermectin (IDECTIN® The British Dispensary (L.P.) CO., Ltd., Bangkok, Thailand) with 1 mL dose per 50 kg of BW to kill parasites before starting the experiment. Goats were assigned to a Student T-test. Treatments were fermented discarded durian peel and grass as roughage feed sources. The goats were fed 2% BW of concentrate diet with a CP level of 16%.

Experimental Diets Preparation

The durian peels utilized in this experiment are from a durian processing facility situated in Ban Bukit, Cho I Rong District, Narathiwat Province, Thailand. The majority of these peels originated from native durian varieties that from the local and neighboring regions. The fermentation process took place at the Faculty of Agriculture's farm, Princess of Naradhiwas University. The durian peels were cut into dimensions of approximately 1.5-2.0 cm. Subsequently, the discarded durian peels were subjected to ferment alongside the specific additives, including 3% molasses, 3% brown sugar, 1% salt, 1% urea and 5% clean water. All these materials were dissolved in clean water, added to 200 L plastic buckets containing the discarded durian peels thoroughly mixed, and left to ferment for 21 days. The containers were tightly sealed and stored in a shaded area. Samples of the fermented durian peel were obtained from the top, middle, and bottom for measuring pH levels, color, and scent. The pH measurement followed the procedure outlined by Chen et al. (2017). Subsequently, the fermented discarded durian peel samples were collected, dried at 60°C for 72 hours, and ground into 1 mm pieces for the analysis of dry matter (DM), crude protein (CP), ash content, neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin, by AOAC (2016) and Van Soest et al. (1975) methodologies. The chemical composition of the fermented discarded durian peel is shown in Table 1. This analysis ensures that the fermented durian peel is suitable as silage in goat feeding. The formula for the fermented durian peel (Table 1) is cost-effective for fermentation with a cost of 1.45 Baht per kilogram.

The feed mixture comprises soybean meal, ground corn, cassava chips, molasses, and salt and is stored in tightly sealed containers. Concentrate diets will be prepared biweekly (Table 1) by combining soybean meal, ground corn, cassava chips, molasses, and salt in specified proportions. The preparation feed will then be packed tightly into sealed containers. Roughage *ad libitum* designed with the dietary treat-

Table 1. Ingredients and feed cost of goat feeding

Feedstuffs	Portion (Kg)
Soy bean meal	26.5
Corn ground	40.0
Cassava chips	30.5
Molasses	2.0
Salt	1.0
Total	100.0
Calculated protein	15.69
Price of concentrate diets (Baht/kg)	11.92

ments, fresh signal grass (*Brachiaria decumbens*) was used as the roughage feed source which was chopped into 1-1.5 inches and daily provided with allowing not more than 10 % refusals.

Data Collection, Analysis and Sampling Procedures

The samples of feed and feces were dried and ground to pass through a 1 mm diameter. The samples were analyzed for DM, CP, EE and ash according to a method of Association of Official Analytical Chemists (2012), NDF, ADF and ADL were analyzed according to methods of Van Soest et al. (1991). Goats were housed in individual pens and individually dietatry treatments. Feed intake of dietary treatment and roughage were measured separately and refusal recorded. The experiment was run for 105 days, the first 15 days for treatment adaptation and for feed intake measurement. Body weights were measured each 15 days during the sampling period prior feeding.

Statistically Analysis

The means of each parameter measured were analyzed by the analysis of variance procedure of SAS (1996) and means were compared using pair t-test.

Results

The Nutrients Composition of Diets

The chemical composition of the experimental feed is presented in Table 2. The chemical composition of the diet is a primary factor influencing the ability of animals to carry out activities and promote good growth. The concentrated feed in this experiment has a protein level of 16.97%, and the fermented durian peel has a protein level of 16.01%. Meanwhile, in this study, the grass had a low protein level of 6.12%, which is low-quality roughage feed compared to other studies.

Feed Intake and Growth Rate of Goat

From the study, the feed intake and growth rates of goats receiving in different roughages are shown in Table 3. The goats fed the fermented durian peel ingested significantly more than goats that ingested grasses as a roughage feed source. They consumed the fermented durian peel at the total of 1,920.40 g/h/d, while the group fed with grass consumed 1,355.60 g/h/d. When calculating the feed intake as metabolic body weight found that the goats receiving fermented durian peel were significantly ($P<0.05$) higher ingested (131.34 g/kg $BW^{0.75}$) than the goats receiving grass as roughage (109.83 g/kg $BW^{0.75}$). The percentage of feed intake relative to body weight was not significantly ($P>0.05$) different.

Table 2. The Nutritive values of experimental diets as dry matter basis

Chemical composition (%)	Trial diets		
	Concentrate	Grass	Fermented durian peel
Organic matter	83.22	19.82	68.20
Dry matter	80.98	88.11	79.74
Crude protein	16.97	6.12	16.01
Ether extracts	0.825	0.55	2.85
Ash	4.927	7.130	11.54
NDF	-	67.179	46.40
ADF	-	45.52	31.90
ADL	-	46.40	29.57
GE (Mcal/kg)	3,693.43	4,143.77	3,449.65

NDF= Neutral detergent fiber, ADF= Acid detergent fiber and ADL= Acid detergent lignin

Table 3. Feed intake and growth rate of goat that ingested in different roughage feed source

Goat performance	Roughage feed sources		Significantly
	Grass	FDP	
Intake			
DMI (g/h/d)	1,355.60±97.62	1,920.40±301.15	*
Concentrate	322.96±9.82	373.90±13.07	*
Roughage	1,032.6±89.48	1,550.60±290.46	ns
$BW^{0.75}$	109.83±3.33	131.34±7.36	*
%BW	6.87±0.36	7.17±0.31	ns
Body weight change			
Initial weight (kg/h.)	15.00±2.16	17.75±2.58	ns
Final weight (kg/h)	20.33±1.74	25.00±1.43	ns
Weight gain (kg/h.)	5.33±2.25	8.92±3.77	*
ADG (g/h/d)	61.80±15.07	108.14±7.11	*

* (P<0.05) and ns = non-significant

Table 4. Feed cost and economic worthiness of goat that ingested in different roughage feed source

Factors	Roughage feed source		Significantly
	Grass	FDP	
Total feed cost (Baht/head)	469.48±23.79	489.57±39.35	ns
FCG 1 kg (Baht/Kg)	99.89±15.76	54.85±3.22	*
Income (Baht/head)	1,008±214.87	1,635.00±107.54	*
Benefit (Baht/head)	605.15±207.59	1,145.70±99.18	*

* (P<0.05) and ns = non-significant, grass price as 2.50 Baht/Kg

FDP=fermented durian peel, FCG= feed cost per gain 1 kg

The weight changes of goats receiving in different roughages feed showed that goats receiving fermented durian peel had a higher weight (8.92 kg/h) compared to goats receiving grass (5.33 kg/h) as a significant statistical difference (P<0.05). This led to a higher daily growth rate of goats in the group receiving fermented durian peel (108.14 g/h/d) compared to goats receiving grass as roughage (61.80 g/h/d) with significant statistical difference (P<0.05).

Economic Viability of Goat Feeding

The economic viability of goat feeding over 3-months period is presented in Table 4. It was found that goats fed with fermented durian peel as roughage feed had a total feed cost (489.57 Baht/goat), while goats fed with grass as roughage feed had a total feed cost (469.48 Baht/goat), and the difference was not statistically significant (P<0.05). However, when analyzing the feed cost to increase body weight by 1 kg, it was observed that goats fed with fermented durian peel as roughage had a lower feed cost to increase body weight by 1 kg (54.85 Baht/goat) compared to goats fed with grass as roughage feed (99.89 Baht/goat), with statistical significance (P<0.05).

As for the revenue from sales, which is calculated based on the reference price in Narathiwat Province in the year 2565, the market price of live goats is 180

Baht per kilogram. Therefore, goats fed with fermented durian peel as roughage feed generate revenue of 1,635 Baht/goat (weight gain of 8.92 kilograms x market price of the live goat, 180 Baht/kg). This is higher than the revenue from goats fed with grass as roughage feed, which amounts of 1,008 Baht/individual. When considering the profit from the sale of goats in both groups, it is found that goats fed with fermented durian peel can yield in higher profits. After deducting the total feed cost, goats fed with fermented durian peel provide a profit of 1,145.70 Baht/individual, compared to 605.15 Baht/individual for goats fed with grass.

Discussion

The Nutrients Composition of Diets

The grass quality depends on cutting age, fertilizer application, and soil conditions (Santos et al., 2016). The grass used in this study was Signal grass at approximately 45 days of age and was grown in sandy soil, which might have resulted in lower nutrient accumulation. According to Hennessy (1980), the protein level from plant-based animal feed should not be less than 7%. If it is lower, it can affect various aspects of animal productivity. The grass used in this experiment has a high fiber content, but lower levels of ADF and ADL compared to the fermented durian peel. Similarly, the NDF level of the grass is higher than that of the fermented durian peel, as is the energy content in the grass compared to both the fermented durian peel and the concentrated feed. On the other hand, the protein level of the fermented durian peel in this study (16.01%) was high due to the addition of urea and sugar to serve as protein and energy sources for the microorganisms during the fermentation process. The improvement in the quality of the fermented durian peel increased the protein content. Additionally, the NDF (Neutral Detergent Fiber) content of the fermented durian peel was lower than that of grass led to an increase in the feed intake of the goats. A lower NDF and ADF content in treated discarded durian peel is due to acid hydrolysis action during fermentation and cellulase activity (So et al., 2021)

Feed Intake and Growth Rate of Goat

The quality of animal feed affects palatability and feed intake capacity which promote growth rate (Marsetyo et al., 2017). In this study, goats fed fermented durian peel were fed significantly higher than goats fed with grass. This might be due to the higher nutritional values, especially protein, derived from the fermented durian peel compared to fresh grass. This protein level is sufficient for the goats' requirements and benefits their growth (Huang et al., 2011; Cherdthong et al., 2014). Furthermore, the fermented durian peel used in this study was replaced by a source of high-quality roughage feed. This is attributed to their lower NDF content compared to grass. NDF content plays a role in determining the feeding ability of animals and lower NDF levels allow for increased feed consumption. In Addition, NDF levels of grass in the study were highly affected by nutrient accumulation. A study by Hennessy (1980) recommended that protein levels in plant-based animal feed should not be below 7% to avoid compromising animal productivity. Moreover, the quality of fiber in Signal grass used in this study might have caused lower feed consumption by the goats due to higher ADF (Acid Detergent Fiber) levels. A higher ADF content leads to decreased digestibility in the rumen, impacting nutrient breakdown. The ADL (Acid Detergent Lignin) content was also relatively high, further reducing digestibility and contributing to lower feed intake by the goats. Fermented durian peel possesses high nutritional value and digestibility. Therefore, differing qualities of roughage feed have a significant impact on the nutrient intake received by goats, particularly varying protein levels. Moreover, grass has a higher fiber content compared to fermented durian peel, leading to reduced digestibility and utilization of nutrients. Consequently, goats fed with grass may not receive sufficient nutrients for optimal growth, resulting in comparatively lower growth rates.

The experiment clearly illustrates that the quality of roughage feed sources influences goat growth and weight gain. In this study, goats fed with fermented durian peel had increased weight gain and growth rates due to the higher protein content in the fermented du-

rian peel (16.01%). This protein level is adequate for promoting growth rate and performance. According to the previous research by Tudsri et al. (2001), highlighting the benefits of high-quality roughage feed sources in enhancing production efficiency and feed intake. Additionally, Pralomkarn et al. (1995) found that post-weaning kids exhibited growth rates of up to 100 grams per day when provided with sufficient and appropriately protein-rich diets. Similar recommendations were given by NRC (1981) regarding protein requirements for optimal growth, which further supports the use of fermented durian peel as a high-quality roughage feed source. The inclusion of these durian peels enhances animals' production efficiency, as the nutrients from the durian peels and concentrate feeds provide the necessary nutrition for microbial activity in the rumen, promoting better digestion and improved feed consumption. Using high-quality roughage feed sources like fermented durian peel can significantly enhance livestock production efficiency. The combined effect of nutrient-rich fermented durian peel and concentrated feed helps support microbial populations in the rumen. Because the nutrients lead to improved digestion and increased feed intake and production yields (Mohammadabadi and Jolazadeh, 2017). Therefore, providing high-quality roughage feed to goats can be a valuable approach to enhancing overall production efficiency (Tudsri et al., 2001; Maksiri et al., 2017).

Economic Viability of Goat Feeding

In this study, goats that received fermented durian peel exhibited the highest weight gain and daily growth rates. When calculating the revenue and profits from selling goats fed with fermented durian peel, that was almost double the time compared to the group of goats fed with grass. Even though the overall feed cost for this experiment was higher, when considering the growth rates, it's evident that goats consuming fermented durian peel as roughage feed achieved significant weight gains. Furthermore, this group had lower feed conversion costs per 1 kg weight gain. This reduction in feed conversion costs reached up to 45.08%. Therefore, if cost reduction is a priority, producing feed locally using available agricultural resources or surplus materials could be considered. According to Semae (2015) found that using local ingredients or agricultural by-products can substantially decrease production costs and increase the profits.

Conclusion

In the study, goats consuming various types of roughage feed exhibited differences in productivity. Specifically, goats that consumed fermented durian peel as their roughage feed demonstrated the ability to consume more feed and digest nutrients more effectively when compared to goats that consumed grass. This resulted in a statistically significant increase in weight gain and growth rates among goats fed with fermented durian peel ($P<0.05$) as opposed to those receiving grass as their roughage feed. Consequently, it can conclude that goats provided with fermented durian peel as their roughage feed option could potentially yield profits up to twice and reduce feed costs by up to 45.08% when compared to goats in the group receiving grass as their roughage feed.

Conflict of Interest

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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