Feed intake and growth performance of goats supplemented with soy waste

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Abstract – The objective of this work was to evaluate the effects of supplemental feeding of soy waste on the feed intake and growth rate of goats. Twenty male crossbred (Boer x local) goats were assigned to two isonitrogenous diet groups: one of commercial pellet and the other of soy waste. The commercial pellet (1.0%) and soy waste (0.8%) were provided on the dry matter basis of body weight (BW) per day, to the respective group of each diet. The soy waste group had lower daily intakes of total dry matter (0.79 vs. 0.88 kg) and organic matter (665.71 vs. 790.44 g) than the group fed pellet; however, the differences on daily intakes for grass (0.62 vs. 0.64 kg), crude protein (96.81 vs. 96.83 g), and neutral detergent fibre (483.70 vs. 499.86 g) were not significant. No differences were observed between groups for BW gain. The feed conversion ratio and feed cost per kilogram of BW gain were lower for the group fed soy waste than for the one fed pellet. Goats fed supplemental soy waste have a lower total dry matter intake, feed conversion ratio, and feed cost per kilogram of body weight gain than those fed commercial pellets.

Index terms: *Pennisetum purpureum*, commercial pellet, crude protein, feed conversion ratio, neutral detergent fibre.

Consumo de alimento e desempenho produtivo de cabras suplementadas com resíduos de soja

Resumo – O objetivo deste trabalho foi avaliar os efeitos da alimentação suplementada com resíduos de soja sobre o consumo alimentar e a taxa de crescimento de cabras. Vinte machos de cabras cruzadas (Boer x local) foram designados a dois grupos de dieta isonitrogenada: um de pélete comercial e outro de resíduos de soja. O pélete comercial (1,0%) e os resíduos de soja (0,8%) foram fornecidos, com base na matéria seca da massa corporal por dia, ao grupo respectivo a cada dieta. O grupo da dieta com resíduos de soja apresentou menor consumo diário de massa de matéria seca total (0,79 vs. 0,88 kg) e de matéria orgânica (665,71 vs. 790,44 g) do que o grupo alimentado com pélete; no entanto, as diferenças de consumo diário de gramínea (0,62 vs. 0,64 kg), proteína bruta (96,81 vs. 96,83 g) e fibra em detergente neutro (483,70 vs. 499,86 g) não foram significativas. Não se observaram diferenças entre os grupos quanto ao ganho de massa corporal. A taxa de conversão alimentar e o custo do alimento por quilograma de ganho de massa corporal foram menores no grupo alimentado com resíduos de soja do que no alimentado com pélete. Cabras suplementadas com resíduo de soja apresentaram menores consumo total de matéria seca, conversão alimentar e custo da ração por quilograma de peso vivo do que as suplementadas com ração comercial.

Index terms: *Pennisetum purpureum*, pélete comercial, proteína bruta, taxa de conversão alimentar, fibra em detergente neutro.

Introduction

One of the main constraints in the ruminant production in South-East Asia is the lack of natural pastures, due to land topography. Farmers are using more concentrates than roughages on ruminant feeding, which increases the production cost. Agricultural by-products are considered as an alternative feed for ruminant as for economic and environmental concerns. Soy waste is a by-product, which is leftover when tofu, soy milk, soy sauce, soy milk powder, dried tofu and soy juice are made from soybean. It is also known as soybean curd residue, soybean-curd lees, tofu-cake, okara or ampastahu. Soy waste is the main residue of

soybean products, and it is often considered as waste, which is mostly dump and burn; it is also used as feed for ruminants, due to its high nutritional value and excellent functional properties (Harjanti et al., 2012; Rahman et al., 2013).

There is a considerable number of tofu factories in Malaysia, which are mostly located in urban and peri-urban areas. Although a portion of produced soy waste is used as feed for ruminants, the rest is simply thrown away into the river or burnt, due to lack of proper usage. The use of soy waste as ruminant feed is viable and economical to farmers who live near factories or suppliers, due to the relatively low price of this by-product, while cost might be increased with long-distance transport because of time and labour. There are three ways of using soy waste as ruminant feed as follows: raw soy waste; ensiled soy waste with other feeds; and dried soy waste (Amaha et al., 1996). Kim et al. (2012) reported that feeding of totally mixed ration containing up to 35% raw soybean curd residue enhanced dry matter intake and growth rate of steers without deterioration of meat quality. Feeding of soybean curd residue silage for sheep also showed a positive nitrogen balance, and resulted in similar plasma amino acid and glucose kinetics with commercial concentrate when formulated at the same energy intake (Harjanti et al., 2012). Xu et al. (2001) showed that increasing the glucogenic propionate concentration in the rumen of sheep had no negative effects on ruminal fermentation, when soybean curd residue silage was fed.

Farmers have an interest in long-term feeding of soy waste for low cost because of its high nutritive value containing 11.2 MJ kg^{-1} metabolisable energy, 23.8% crude protein, and 1.16% calcium (Dong et al., 2005). However, there are limited data on soy waste utilisation and on its long-term feeding impact on the responses in goats, as this species shows a more selective eating behaviour than other ruminants. Li et al. (2013) suggested that there are still several gaps to be filled as for the use of soy waste.

The objective of this work was to evaluate the effects of supplemental feeding of soy waste on the feed intake and growth rate of goats.

Materials and Methods

All the experimental procedures, including animal care, management, and sampling were performed according to the Guidelines for Animal Experiment, University of Malaya, Malaysia. This study began on June 7, 2012 with crossbred (Boer × local) goats, and was conducted at the Goat Farm of Rumpun Asia Sdn. Bhd. (3°28' N and 101°38' E), Batang Kali, Malaysia.

Twenty crossbred male goats, with 22.6±2.03 kg (mean±SEM) initial body weight (BW), and approximately 1 year old, were randomly selected and divided into the following two dietary treatment groups: 1, commercial pellet supplementation; and 2, soy waste supplementation. Before the commencement of the experiment, goats were treated for internal parasites with Bomectin as prescribed by the manufacturers (Bomac Laboratories Ltd., Auckland, New Zealand). Before data collection, goats were adapted to the feeding management for 14 days, when they fed Napier grass (*Pennisetum purpureum*) ad libitum, and commercial pellet (FFM Marketing Sdn. Bhd., Selangor, Malaysia) at 1.0% of BW. The commercial pellet was composed by the following ingredients: maize, wheat, wheat bran, rice bran, soy bean meal, sesame meal, molasses, limestone, dicalcium phosphate, salt, and feed additives.

Goats in both groups fed on Napier grass ad libitum, and the refusal rate was of about 10% throughout the experimental period. Commercial pellet and soy waste were fed to groups 1 and 2 at a rate of 1.0 and 0.8% (on a dry matter basis) of BW per day, respectively. The amounts of pellet and soy waste were determined for individual goats on the basis of their BW, and adjusted biweekly to account for BW changes. The chemical composition of Napier grass, soy waste and commercial pellet are shown in Table 1. According to National Research Council (2007), the total dietary metabolisable energy (ME) and crude protein (CP) should be 7.76 MJ per day and 98.13 g per day, respectively, to meet the requirements of a goat weighing 22.6 kg, and growing at 100 g per day. In the present study, ME intake from daily offered pellet and soy waste (excluding Napier grass) for group 1 and group 2 were 2.81 and 1.91 MJ, respectively. Similarly, CP from daily offered pellet and soy waste (excluding Napier grass) for group 1 and group 2 were 36.0 and 37.4 g, respectively.

The commercial pellet and soy waste were offered in one-morning meal throughout the feeding period which lasted for 91 days. Amounts of feed offered and refused were recorded daily to estimate feed intake.

Subsamples of offered feed and residues were taken weekly for dry matter (DM) determination. To monitor BW change, goats were weighed every 15 days, before feeding in the morning. The average daily gain was calculated by dividing the initial and final BW differences by total days of feeding trial. Throughout the feeding trial, goats were kept in individual pens (1×1 m).

Napier grass was established at the Goat Farm and fertilised with goat manure at 300 kg N ha^{-1} annually. Grass was harvested daily at approximately 2 months maturity, then, it was chopped mechanically to 5-7 cm length, and offered to animals as fresh basis. Soy waste was supplied by a supplier from a local soybean processing centre at every 7-day interval, stored in airtight, plastic containers.

The feeds and refusals were oven dried at 70°C for 48 hours for dry matter (DM) determination. Dried feeds were milled to pass through a 1 mm sieve using a Wiley mill, and stored in plastic bottles for analysis. Nitrogen (N) and ash were determined according to Helrich (1990). The content of organic matter (OM) was calculated by subtracting ash from 100. The CP content was calculated as N×6.25. Neutral detergent fibre (NDF) was determined as described by Van Soest et al. (1991). Calcium concentration was determined by flame atomic spectroscopy method (The University of Tokyo, 1978).

The average DM intake, feed conversion ratio and feed cost for each goat were obtained every 15 days repeatedly over the feeding period. Data on these parameters were subjected to Student's t test (Snedecor & Cochran, 1994), using repeated measures, at 5% probability. Data on BW of each goat were also analysed using Student's t test at 5% probability.

Results and Discussion

Goats fed 1% pellet or 0.8% soy waste of BW in DM basis consumed all the offered supplemental feed (Table 2). Goats on the soy waste group had lower intakes of total DM (0.79 vs. 0.88 kg per day) and OM (665.71 vs. 790.44 g per day) than those fed pellet, respectively; however, the intake differences for grass (0.62 vs. 0.64 kg per day), crude protein (96.81 vs. 96.83 g per day), and neutral detergent fibre (483.70 vs. 499.86 g per day) were not significant.

Goats on the soy waste group had lower total DM intake than the ones on the pellet group, which could be due to the low amount of supplied soy waste. To make the diets isonitrogenous for both groups, goats of the pellet group were fed 1.0% pellet, whereas goats of the soy group were fed 0.8% soy waste, due to this diet's high-nitrogen content (21.99%). Although goats of the soy waste group fed on a low amount of soy waste, their grass intake was similar to that of goats of the pellet group. This might be due to the higher moisture content of soy waste compared to that of the pellet diet (78 and 12%, respectively). If DM content of feed ingredients is low, the volume of water in the rumen increases and, probably, causes a depressive effect on the food intake level, due to the ruminal fill, despite of the high ingredient digestibility (Meissner & Paulsmeier, 1995). High moisture content of feeds increases the bulkiness of diets, and is negatively related to the capacity of the reticulo-rumen (Forbes, 1995). However, DM intake of cattle fed diets containing soy waste was significantly higher than those fed diets containing wet brewer's grain, according to Kim et al. (2012), who also reported that soy waste has a subtle flavor and savory taste which might be improved

Table 1. Chemical composition of Napier grass, soy waste, and commercial pellet.

Parameter	Napier grass	Soy waste	Commercial pellet
Dry matter (g kg^{-1})	200.0	220.0	880.0
Crude protein (g kg^{-1} dry matter)	95.5	219.9	150.0
Organic matter (g kg^{-1} dry matter)	889.5	660.0	933.0
Neutral detergent fibre (g kg^{-1} dry matter)	694.0	305.0	241.0
Calcium (g kg^{-1} dry matter)	3.4	11.6	11.5
Metabolisable energy (MJ kg^{-1} dry matter)(1)	7.45	11.2	11.7

(1)Calculated value [ME (MJ kg^{-1} dry matter)] = 0.016 DOMD (g digestible organic matter kg^{-1} dry matter). Source: The nutrition of goats (1998).

Table 2. Mean of dry matter and nutrient intake by goats fed commercial pellet or soy waste groups(1).

Parameter	Commercial pellet group	Soy waste group
Grass intake (kg per day)	0.64±0.04a	0.62±0.02a
Commercial pellet intake (kg per day)	0.24±0.01	-
Soy waste intake (kg per day)	-	0.17±0.01
Total dry matter intake (kg per day)	0.88±0.02a	0.79±0.01b
Total crude protein intake (g per day)	96.83±3.36a	96.81±1.77a
Total organic matter intake (g per day)	790.44±31.31a	665.71±16.46b
Total NDF intake (g per day)	499.86±24.42a	483.70±12.84a

(1)Means±SE followed by equal letters within rows do not differ, by the Student's t-test, at 5% probability. NDF, neutral detergent fibre.

the feed palatability. Total CP and total NDF intakes did not differ between soy waste and pellet groups because both diets were formulated as isonitrogenous. In addition, soy waste contained higher NDF than pellet. However, total OM intake was lower (665.71 g per day) in the soy waste group than in the pellet one (790.44 g per day), and this could be attributed to the low OM content in soy waste.

Both groups were not different with respect to the initial (range 22.1–23.0 kg) and final (28.6–30.3 kg) BW (Table 3). Consequently, there were no differences in BW gain between groups. However, the feed conversion ratio and feed cost per kilogram of BW gain were lower for the soy waste group than for the pellet one, and the differences were significant.

In comparison to pellet group, similar BW change was observed for the soy waste group. This might be attributed to the high nutritional characteristics of soy waste, including ME and CP contents. Knaus et al. (2002) reported that N absorption and N retention increased, when soy protein-based diets were fed to steers. Kim et al. (2012) also reported that dietary soybean curd residue could improve the growth rate of cattle. In the present study, the total dietary ME and CP intakes per goat, per day, were 7.55 MJ and 96.83 g for the pellet group, and 6.54 MJ and 96.81 g for the soy waste group, respectively. These ME and CP intakes were comparatively lower than the total dietary ME (7.76 MJ) and CP (98.13 g) requirements of a goat weighing 22.6 kg and growing at 100 g per day, according to National Research Council (2007). As a result, the weight gains attained in all groups of this study were below the potential for growing goat for growth and fattening. The dietary ME intake was lower in group 2 (6.54 MJ) than in group 1 (7.55 MJ), but similar BW change was observed for these two groups.

Table 3. Daily average body weight (BW) gain, feed conversion ratio (FCR) and feed cost of goats fed Napier grass supplemented with commercial pellet or soy waste[1].

Parameter	Pellet group (mean±SE)	Soy waste group (mean±SE)
Initial BW (kg)	22.1±3.56a	23.0±2.40a
Final BW (kg)	28.6±4.70a	30.3±2.58a
Total BW gain (kg)	6.5±1.14a	7.3±0.70a
BW gain (g per day)	71.4±12.53a	80.2±7.72a
FCR (kg DM kg^{-1} BW gain)	12.26±0.21a	9.89±0.14b
Feed cost (RM) for 91 days		
Napier grass	16.32±0.15a	16.00±0.14a
Commercial pellet	7.85±0.18	-
Soy waste	-	5.53±0.07
Total	24.17±0.38a	21.53±0.29b
Feed cost kg^{-1} BW gain (US dollars)[2]	3.72±0.0.6a	2.95±0.04b

[1]Means followed by equal letters within rows, do not differ, by Student's t-test, at 5% probability. [2]The costs (US dollars) of 100 kg of fresh feeds were: Napier grass, 5.64; commercial pellet, 31.35; and soy waste, 7.84.

Similarly to the obtained results in the present study, Harjanti et al. (2012) reported that soybean curd residue silage could be used to replace commercial concentrate in the diet of sheep. In their study, the dietary soybean curd residue silage ensured a positive N balance, and plasma amino acid and glucose kinetics were similar to the ones of the commercial concentrate, when diets were formulated at the same energy intake. In this study, the feed conversion ratio of goats was lower for the soy waste group than for the pellet one, which indicates that supplementation of soy waste improves the feed conversion ratio of the animals, and this is in line with the report of Kim et al. (2012), who reported that the dietary soybean curd residue improved the digestibility of nutrients. Feed cost per kilogram of BW gain in the soy waste group was lower (2.95 vs. 3.72 US dollar) than that of the pellet group. Soy waste would be useful for the low-cost animal feeding (Kim et al., 2012). Wang et al. (2004) reported that the feed cost of cattle fed soy waste (okara) was lower than that of cattle fed soybean meal; in addition, these authors also observed that there were no differences between groups fed soy waste and soybean meal as for milk yield, milk fat percentage, feed intake and daily BW gain. Ramsey (2012) reported that replacing commercial pellet with up to 20% soy waste in the diet did not compromise the growth and performance of post-weaning crossbred Boer goats.

For its nutritive value, soy waste is a relatively cheap feed resource because it is considered as an industrial waste which is often incinerated, due to deterioration (Amaha et al., 1996). Livestock farms in the areas of soybean processing factories would benefit from the use of the low-cost feeding of soy waste. Soy waste as a supplement feed ingredient in the diet of goat may help farmers to profit from this by-product, whose utilisation could help sustain the factories and minimise the environmental pollution. Since the feed intake of goats is affected by soy waste supplementation, further research is necessary on the reproductive performances of this agro-industrial by-product by animals.

Conclusion

Goats fed supplemental soy waste have a lower total dry matter intake, feed conversion ratio, and feed cost per kilogram of body weight gain than those fed commercial pellets.

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