Feed intake and apparent nutrient digestibility of non-lactating Dorper sheep fed with total mixed ration based on local feedstuffs

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Abstract

The deficiencies and imbalance of nutrients are aggravated furthermore by the fact that most of the high-quality feedstuffs are imported products, mainly corn and soya bean meal (SBM). Practical and cost-effective feeds must therefore be identified by using locally available feed resources, mainly from agro-industrial by-products. Some of the local feed resources that can replace imported raw materials, especially corn and SBM, are palm kernel cake (PKC), copra meal, rice bran and palm fatty acid distiller (PFAD). The purpose of this study was to evaluate the feed intake and apparent nutrient digestibility of Dorper ewes fed with TMR (Total mixed ration) based on local feed resources. Nine non-lactating Dorper ewes were randomly and equally allocated into three treatment groups: i) TMRA (purple guinea grass silage + concentrate based on local feedstuffs + 1% PFAD), ii) TMRB (purple guinea grass silage + concentrate based on local feedstuffs + 1.5% PFAD) and iii) TMRC (purple guinea grass silage + concentrate based on imported feedstuffs) in a 17-day feeding trial based on Complete Randomized Design. The respective groups were separately fed the three formulated TMR. All TMR were fed based on 2.5% of the mean live weight of the animals. The intakes of CP, CF and EE were higher in TMRA compared to the other two treatments. Whereas, the apparent digestibility of CP and EE in TMRA were higher ($P<0.05$) compared to TMRB and TMRC. It is concluded that TMRA that contain PKC, rice bran, copra meal and PFAD has higher digestibility in CP and EE compare to TMRC (based on imported feedstuffs). Thus, the inclusion of local feed resources in animal feed can improve nutrient digestibility particularly CP and EE in the ruminant.

Keywords: feed intake, apparent digestibility, Dorper sheep, TMR

Introduction

A limited supply of good quality feeds has been identified as one of the factors causing inert growth in the domestic ruminant livestock industry. About 60% of these resources are imported, which include corn, soybean meal (SBM) and mineral and vitamin supplements. Extensive and continuous use of these resources in local livestock rations has increased the price of feeds. Abdul Ghani (2016) reported the importation of soybean as a source of protein has increased from 643,000 tons to 650,000 tons between 2015 to 2016 and the depreciation of the Malaysian Ringgit also led to the increase in soybean price. The high feed cost of imported ingredients is also due to global commodity price fluctuations. Thus, it is important to find locally available feed resources to substitute imported ingredients, either fully or partially.

About 5.1 million ha of land in Malaysia is currently used for oil palm planting (EPU, 2014), producing several by-products that have been shown to have the potential to be used widely as feeds for ruminants (Wan Zahari and Mohd Farid, 2011). Among these oil palm by-products, palm kernel cake (PKC), palm oil mill effluent (POME), decanter cake, oil palm fronds (OPF) and oil palm trunk (OPT) have been identified to be viable feedstuffs for ruminants (Wan Zahari and Mohd Farid, 2011). Additionally, palm fatty acid distillates (PFAD) produced by oil-palm refineries is used as an energy source for livestock. Copra meal or copra cake is coconut by-products, while rice bran and rice straw are rice industry by-products. PKC, rice bran and copra cake are a good sources of protein and these materials can be used to partially replace the imported SBM.

In terms of nutritional value, each feedstuff has its limitations if given singly to the animals. Therefore, by mixing these by-products, a complete and balanced diet in the form of a total mixed ration (TMR) can be developed for livestock feeding. A mixture of PKC, copra meal and rice bran has the potential to be used as ingredients in the TMR as most of these materials are readily available and contain a reasonable amount of nutrients (especially protein and minerals), apart from energy for ruminant feeding.

A limited number of studies has been carried out on TMR based on locally available agro-industrial by-products for lactating Dorper ewes. Also, there is a limited study that uses more than one local by-product in a TMR. Although the majority of these resources are low in crude protein and high in crude fibres, fortification with PFAD can further improve their nutritional value. Thus, this study was aimed at evaluating the feed intake and apparent nutrient digestibility of Dorper ewes fed with TMR based on local feed resources.

Materials and Methods

Dietary formulation and treatment groups

The digestibility study was conducted at MARDI Serdang, Selangor using nine non-lactating Dorper ewes, between 2 to 3.5 years of age. The animals were randomly and equally allocated to three treatment groups based on Completely Randomized Design (CRD). The treatments were as follows:

a) TMR A: Given TMR feed that contained local by-products with 1% of PFAD.
b) TMR B: Given TMR feed that contained local by-product with 1.5% of PFAD.
c) TMR C (Control): Given TMR feed that contained imported feedstuffs.

Each TMR was formulated for early lactating ewes of 50 kg body weight (BW) based on the NRC (2007). The TMR were isocaloric and isonitrogenous with the estimated energy and CP content of 10 MJ ME/kg DM and 16% CP, respectively. The composition of the concentrates is shown in Table 1.

Table 1. Composition of concentrate mixture of TMR treatments

Ingredients	TMRA (%)	TMRB (%)	TMRC (%)
Corn	25	16	35
Soybean hull (SBH)	-	-	40
Wheat pollard (WP)	-	-	20
Copra meal	22	25	-
Palm kernel cake (PKC)	22	29	-
Rice bran	25	15	-
Dicalcium phosphate (DCP)	1.5	1.1	2
Molasses	3	3.5	3
Salt	1	1	1
Mineral-Vitamin premix	1	1	1

Notes: TMRA: Concentrate mixture based on local feedstuffs++ + Grass silage + 1% PFAD, TMRB: Concentrate mixture based on local feedstuffs++ + Grass silage + 1.5% PFAD and TMRC (Control): Concentrate mixture based on imported@ feedstuffs + Grass silage only.

Animal feeding and management

The ewes were placed in the individual metabolic cages. All animals were treated with Ivomec® (Boehringer Ingelheim) injection 0.5ml per 25kg BW for internal and external parasites before the trial began. Apart from formulated concentrate, the animals were given purple guinea grass silage. The ratio of Purple Guinea Silage to each TMR was 60:40 and the amount of feed, in terms of dry matter percentage (DM) was based on 2.5% of body weight (average 50 kg). Each ewe received 600 g/ head of concentrate and 1.7 kg of purple guinea grass silage. The purple guinea grass silage was a combination of 6 weeks of purple guinea grass and 3% of molasses on a wet basis. Three hundred grams of concentrate were mixed with 850 grams of purple guinea silage and given to ewes twice a day at 0800 and 1600 hrs. Drinking water was given *ad libitum* throughout the study period. The amount of feed given was increased by 10% of the quantity offered if no refusal feed was recorded by weekly adjustment.

Feed intake and digestibility trial

The digestibility trial was conducted for 17 days of feeding with ten days of the adaptation period. Feed intakes were recorded daily throughout the digestibility trial. The amounts of feed offered and refused were weighed and recorded daily for each animal. Feed intake was determined as the difference between feed offered and feed refused. The faecal output was weighed and recorded daily each morning before the feeding time. About 10g of feed and faeces were collected each day every morning for dry matter (DM) analysis. The samples were then dried in an oven at 60°C for 48 hours for the determination of DM%. All samples were stored in a refrigerator at 40°C. At the end of the digestibility trial, the samples were pooled and composite samples were taken for crude protein (CP), ether extract (EE), and crude fibre (CF) determination using proximate analysis.

The apparent digestibility coefficient was calculated following Rahman *et al.* (2016):

Nutrient Digestibility =

$$\frac{[\text{Nutrient Intate} - \text{Nutrient in faeces}] - \text{DM in total faeces}}{[\text{Nutrient Intake} - \text{Nutrient in faeces}]} \text{X100}$$

Statistical Analysis

Data were analyzed statistically using the statistical software programme SAS 9.4 (SAS Institute Inc., Cary, NC, USA). Differences in feed intake and apparent nutrient digestibility between the treatment groups were determined using procedure GLM. Any differences between treatment groups were further analyzed using Turkey's test. The values were expressed as mean ± standard error. A p-value of less than 0.05 was considered statistically significant.

Results and Discussion

Nutrient content of the TMRs

The nutrient content of TMRs in the current study is shown in Table 2. The mean for CP content in TMRA, TMRB and TMRC was 11.23%, 11.72% and 11.07%, respectively. The gross energy (GE) values for the TMRA, TMRB and TMRC were 15.84, 15.61 and 16.09 MJ/kg DM. Using the value of DE from the digestibility study and assuming ME = 0.82 DE (Pond *et al.,* 2004), the mean value of ME for the three treatments was 7.27 MJ/kg. Thus, the TMRs in this study met the ME and CP requirements for maintenance of ewes, 7 MJ/kg ME and 8% CP (NRC, 2007). In TMRC, the primary energy sources were corn, soybean hull (SBH), wheat pollard (WP) and molasses. In contrast, apart from molasses, the energy sources for TMRA and TMRB were PFAD, copra meal, PKC and rice bran. These ingredients are also rich in CP, except PFAD and molasses. PKC contains between 10.5 - 11.5 MJ/kg of ME for ruminants. PKC also has 16 - 18% of CP, 13 - 16% of CF and 4 - 6% of fats (Wan Zahari and Alimon, 2006; Wong and Wan Zahari, 2007; Abdeltawab, 2018). PKC's nutrient composition was higher than copra meal but lower than groundnut cake and fish meal (Chin, 2002; Alatise, 2018). Copra meal usually has 12-13.5 MJ/kg and 19-21%, 13-19%, 8-10% of ME, CP, CF and fats, respectively (Wallace et al., 2010). Even though the nutrient content of copra meal is comparable to PKC, copra meal is insufficient in essential amino acids, such as lysine and sulphur (Sundu et al., 2006; Pascoal et al., 2006). Rice bran was reported to contain 9.7% of CP, 3245 Kcal/kg of GE, 7.67% of fat, and 29.25% of fibre (Wolayan and Mandey, 2019). PFAD was reported to contain about 9000 Kcal/kg of energy value and over 90% of digestibility (Wan Zahari and Mohd Farid, 2011).

Table 2. Nutrient content of total mixed ration (TMR) for Dorper ewes (mean ± sd).

Parameter (%)	TMRA (n=3)	TMRB (n=3)	TMRC (n=3)
Dry Matter	74.88 ± 0.37	74.18 ± 0.33	65.6 ± 0.67
GE (MJ/kg DM)	15.84 ± 0.07	15.61± 0.05	16.09 ± 0.09
Crude Protein	11.23 ± 0.51	11.72 ± 0.48	11.07 ± 0.4
Ether Extract	2.02 ± 0.07	2.1 ±0.05	1.95 ± 0.08
Crude Fiber	31.46 ± 1.87	36.3 ± 1.09	26.35 ± 1.22
NDF	61.24 ± 1.01	65.54 ± 1.16	55.95 ± 1.70

Notes: TMR A: Concentrate mixture based on local feedstuffs++ + Grass silage + 1% PFAD, TMR B: Concentrate mixture based on local feedstuffs++ + Grass silage + 1.5% PFAD and TMR C (Control): Concentrate mixture based on imported@ feedstuffs + Grass silage only.

Recent research found that the inclusion of 22% of rice bran in the TMR resulted in 17.33% and 12.46% of CP and CF content (Naik et al., 2018) compared to 11.23% and 36.3% when rice bran was included at 25% (TMRA) and 11.72% and 31.46% when rice bran was included at 15% (TMRB). However, this is not a fair comparison, since other ingredients, especially copra meal and PKC, which are high in CF, had also been attributed to dietary CP and CF. It is known that the nutrient content of PKC, copra meal and rice bran often vary, partly due to the methods of processing (Naik et al., 2018). Crude fibre content was highest in TMRB as compared to TMRA and TMRC with values of 36.3%, 65.54% and 41.6%, respectively. Increased CF and NDF concentrations in both TMRA and TMRB are understandable as these were primarily due to the inclusion of copra meal, PKC, and rice bran in the formulations. In TMRC, these ingredients were devoid of soybean hulls and wheat pollard as substitutes for copra meal, PKC and rice bran.

The NDF is used to measure the amount of feed, specifically the fibrous portion that the animal can consume, as there is a limit to how much feed at one time can fit into an animal's digestive organ. The feed intake and time for rumination are also determined by the amount of NDF in the ration (Beauchemin, 1991). Usually, the fibre that is low in cellulose, lignin and hemicellulose can take up less stomach space and will provide the animal with an immense amount of energy (Micheal. 2019). Fibres that are high in these materials take up more room and provide the animal with fewer resources to use (Pond et al., 2004). Hence, the concentration of NDF in feeds is negatively correlated with energy concentration. Therefore, the lower content of NDF in TMRC (55.95%) also corresponds to higher dietary energy concentration as compared to the other two treatment rations (TMRA and TMRB) with the range of 61.24 – 65.54%.

Nutrient intake and apparent digestibility of the TMRs

The results from the current study are depicted in Table 3. Total DMI among the treatments showed significant differences ($P<0.05$) with the means of 1.34, 1.19 and 1.30 kg/head/ day, respectively. The DMI of TMRA, TMRB and TMRC were 2.68%, 2.38% and 2.6% of body weight (50 kg) of the ewes. The DMI for maintenance for ewes weighing 50 kg as suggested by the NRC was 2%, indicating that DMI obtained in the present study was in accordance as that recommended by the NRC (NRC, 2000). Feed physical characteristics, nutrient balance, correlative effects between feed components, environment-related factors and the animal characteristics (size and breed) may contribute to DMI of the feed (Hadgu, 2016).

Table 3. Nutrient intake and apparent digestibility by Dorper ewes fed different TMR (mean ± sd).

Parameters	TMRA (n=3)	TMRB (n=3)	TMRC (n=3)
Intake			
Dry Matter (kg/head/day)	1.34 ± 22.83[a]	1.19 ± 38.65[b]	1.3± 35.48[ab]
Gross Energy (MJ/kg)	214.9± 3.53[a]	188.4± 5.99[b]	212.2± 5.47[a]
Crude Protein (g/kg)	174.2± 2.10[a]	161.7± 3.89[b]	162.2± 2.77[b]
Ether Extract (g/kg)	36.68± 0.34[a]	34.63± 0.3[b]	34.43± 0.25[b]
Crude Fiber (g/kg)	634.6± 11.0[a]	512.0± 11.13[b]	445.2± 8.85[c]
NDF (g/kg)	877.1± 15.11[a]	707.0± 24.59[b]	877.2± 24.37[a]
Apparent Digestibility (%)			
Dry Matter	75.81 ± 0.84	71.84±1.24	82.33 ± 1.48
Gross Energy	76.65±0.82[a]	72.29±1.21[b]	75.82±1.41[ab]
Crude Protein	86.59 ± 0.50[a]	82.31± 0.75[b]	83.66± 0.93[b]
Ether Extract	99.68 ± 0.005[a]	94.91 ± 0.18[c]	99.25 ± 0.04[b]
Crude Fiber	98.50±0.03[a]	97.9± 0.46[b]	98.46± 0.44[a]
NDF	75.83± 0.83[a]	69.26 ± 1.37[b]	76.30 ± 1.43[a]

Notes: TMRA: Concentrate mixture based on local feedstuffs++ + Grass silage + 1% PFAD, TMRB: Concentrate mixture based on local feedstuffs++ + Grass silage + 1.5% PFAD and TMRC (Control): Concentrate mixture based on imported@ feedstuffs + Grass silage only. [a,b,c] means with different superscripts differ significantly at P<0.05

The high content of CF, NDF and EE might have led to the depression of DMI in TMR B (1.19 kg/day) compared to TMRA and TMRC with mean values of 36.3%, 65.54% and 2.1%, respectively. Although not significant, due to the unpalatability factor and susceptibility to rancidity, the inclusion of copra meal in TMRB can lower the DMI (Oliveira et al., 2010). However, the replacement of 50% of soybean meal with copra meal in the goat's diet had increased the intake of DM (Paengkoum, 2011). Expeller-pressed PKC with higher fat when used as the main component in the ration, was reported to reduce DMI (Nunes et al., 2011; Silva et al., 2013). The inclusion of PKC at 43.2% and 39.2% of the total ration was recorded to increase the ration's DMI (Pinho et al., 2016). Also, in agreement with Leonardi et al. (2005), the inclusion of PFAD in the diet, especially in TMRB, did not boost the DMI.

Feed intake is recognized as a primary factor for livestock efficiency. In ruminants, the DMI is determined by a chemostatic mechanism involving the absorption from the rumen of volatile fatty acid (VFA) which sends the animal a signal to begin or stop feeding and at the level of the digestive system; rumen filling. A high fibre diet is digested at a slow rate which results in decreased DMI. The nutrient deficiency that decreases the function of the rumen microbes is another factor that decreases the DMI. Environmental factors such as feeding room, timing and feed frequency and feed freshness may contribute to DMI (Povey et al., 2016). High CF in TMRB can also lead to the lowest DMI among the treatments in this study.

The TMRA showed a significantly (P<0.05) higher intake of CP, CF and EE compared to the other two treatments. The result from the present study is in contrast to Neto et al. (2014) who reported that the inclusion of PKC in dairy cows ration had reduced the DMI and CP intake and increased the EE intake. A study by Oliveira et al. (2010) reported that inclusion of PKC above 7.5% in sheep feed reduced the DMI and nutrient digestibility, thus, lowering the sheep performance (Oliveira et al., 2010). However, Red Sokoto goats fed with a supplement that contained 4% PKC had improved the milk yield (Otaru et al., 2011). TMRB had significantly ($P<0.05$) the lowest intake of GE with means of 188.4± 5.99 MJ/kg compared to TMRA and TMRC with means of 214.9± 3.53 and 212.2± 5.47, respectively. A combination of factors including the lowest DMI and GE content (Table 1), might have led to the lowest GE intake in TMRB.

There was no significant difference ($P>0.05$) in DM digestibility among the treatment groups. The nutrient digestibility of CP and EE was significantly high in the TMRA group, with a mean of 86.59± 0.50% and 99.68 ± 0.005%, respectively. Overall, all of the treatments displayed a high percentage of nutrient digestibility in this analysis. However, relative to TMRA and TMRC, TMRB diet had the lowest digestibility. Depending on the type of diet, the digestibility values recorded for CP, EE and CF typically varied from 40 to 60%. Besides, in the present trial, the forage given in the form of silage to concentrate ratio was 40: 60 and the digestibility of nutrients were expected to be very high at this ratio.

Ruminant animals easily digest ingredients such as corn, wheat pollard and soybean hull as used in TMRC. Though ingredients such as PKC, copra meal and rice bran are less digested by ruminant animals, PKC, copra meal and rice bran, however, have been reported to contain by-pass protein that can improve the digestibility of certain nutrients, especially CP and EE (Rahman et al., 2013, Dung, 2014; Criscioni and Fernandez, 2016). Orden et al. (2014) indicated that CP digestibility was enhanced by the inclusion of copra meal and rice bran in the goat diet. The use of molasses and PKC in TMR can also prolong the protein degradability of rumen. Rahman et al. (2013) stated that by turning the PKC as a by-pass protein, molasses protect the nitrogen in PKC from microbial usage. Molasses were included in all TMRs, as seen in Table 1, but only TMRA and TMRB had PKC in the TMR. The diet from TMRA was shown to be high in CP digestibility in line with this research.

The inclusion of rice bran in TMRA was higher compared to TMRB that could also affect the digestibility of CP. Dung (2014) reported the highest NH3-N of rice bran compared to corn; however, to improve CP's digestibility, it must be mixed with other ingredients. Research by Criscioni and Fernandez (2016) also stated that goats fed with rice bran diets had high CP and EE digestibility, which is consistent with this research. Almost all starch in rice bran avoided the fermentation of rumen and carried the fat and by-pass protein directly to the duodenum (Elliot et al., 1996). The inclusion of dietary fat, such as PKC had increased EE digestibility, which occurred in ewes fed with TMRA which is in agreement with Abubakr et al. (2013) and Manso et al. (2006). High-fat diets tended to limit the degradability of fibre and fermentable substrates by covering the food particles with fat and prohibiting the bacteria from binding (Palmquist and Jenkins, 1980). The inclusion of rice bran in TMRA and TMRB diets did increase the digestibility of EE as RICE BRAN have by-pass fat, as agreed by Criscioni and Fernandez (2016). Due to the long retention period of feed in the reticulo-rumen, high digestibility of NDF can be obtained (Aregheore et al., 2003; Abubakr et al., 2013; Min, 2018).

Conclusion

It can be concluded that TMRA which was based on local feedstuffs, had improved the digestibility of CP and EE compared to

TMRC which used imported feedstuffs. Thus, PKC, copra meal, rice bran and PFAD can be the alternative feedstuffs to replace soybean hulls and wheat pollard without any adverse effect on the nutrient intake and digestibility of the Dorper ewes.

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