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Effects of Non Forage Fiber Sources in Total Mixed Ration on Feed Intake, Nutrient Digestibility, Chewing Behavior and Ruminal Fermentation in Beef Cattle

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Abstract: The objective of this study was to determine the effect of non forage fiber sources in a total mixed ration on feed intake, nutrient digestibility, chewing behavior and ruminal fermentation. Five Brahman-Thai native crossbred steers with an average initial body weight of 188±16.56 kg were randomly assigned in a 5×5 Latin square design. During each of five 21 days periods, the animals were fed 5 total mixed rations that varied in the non forage fiber sources, rice straw as fiber sources (rt-TMR, control), tomato pomace as fiber source (tp-TMR), palm meal as fiber source (pm-TMR), dried brewer gain as fiber source (db-TMR), soybean hulls as fiber source (sh-TMR). The results showed that feed intake, crude protein digestibility, chewing time, total number of chew and ruminal fermentation were significantly different among treatments ($p<0.05$). The palm meal as a fiber source in the total mixed ration has negative effect on feed intake and chewing behavior, although enhanced by 5% of long hey fiber. However, tomato pomace, dried brewer gain and soybean hulls can be used as fiber sources in TMRs, when enhanced with 5% of long hey fiber.

Key words: Non forage fiber sources, total mixed ration, digestibility, chewing behavior, feed intake

INTRODUCTION

In recent years, feeding cattle a Total Mixed Ration (TMR) has become widely accepted. The benefits of a TMR include increased milk production, enhanced use of low cost alternative feed ingredients, ability to control the forage concentrate ratio, lower incidence of metabolic and digestive disorders and reduced labor input for feeding. Silage, forage and hay are conventional roughage found in TMR. Long hay, however, when added to the TMR, becomes a problem for mixing machines, as such; it is recommended to reduce the particle size of long hay prior to adding it to the machine. Chopping long hay to reduce particle size is expensive and time consuming.

Non forage fiber sources are alternative feedstuffs for ruminant. Various non forage fiber sources, such as tomato pomace, soybean hulls, palm meal, leucaena meal, coconut meal, mung bean meal and dried brewer grain have been used in the diets of ruminant to supplement conventional forage. The degradation characteristics of non forage fiber sources are the same as forage (Chumpawadee *et al*., 2005). The fiber source of TMR is very important because it can affect feed intake, chewing activity, digestibility and production. Soybean hulls appeared to be mixed in a total mixed ration of about 20-25% and they did not affect dry matter intake and production (Grant, 1997). Additionally, tomato pomace can be fed at 100% as replacement forage for dairy cows and beef cattle (Sanitwongnaayutaya, 2005). Therefore, non forage fiber sources should be considered to replace conventional forage in TMRs.

With respect to non forage fiber sources in tropical zones, limited information is available on its use as a fiber source of TMR. The aim of this study was to investigate feed intake, nutrient digestibility, chewing behavior and ruminal fermentation in beef cattle fed different non forage fiber sources.

MATERIALS AND METHODS

Preparation of TMRs: Non forage fiber sources and others were collected from various feed mills and organizations in the Northeast of Thailand. All feed samples were ground to pass through a 1 mm screen for

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chemical analysis. The feedstuff samples were analyzed for Dry Matter (DM), Crude Protein (CP) and ash (AOAC, 1990), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) (Van Soest *et al*., 1991), the data used for feed formulation. Five TMRs were formulated, to have similar Total Digestible Nutrient (TDN), CP, NDF and ADF, but differ in fiber source (Table 1).

Animals and feeding: Five Brahman-Thai native crossbred steers with initial body weights of 188±16.56 kg were used. The animals were dewormed using ivermectin and injected with AD3E vitamin-complex prior to undertaking the experiment. They were housed in individual pens and fed *ad libitum* at 7.00 and 19.00 h. Drinking water and mineral lick were offered and available at all times. Animals were randomly allocated to one of five treatments in 5×5 Latin square design with 21 days periods. The dietary treatments were rice straw-TMR (rt-TMR, control), tomato pomace-TMR (tp-TMR), palm meal-TMR (pm-TMR), dried brewer gain-TMR (db-TMR) and soybean hulls-TMR (sh-TMR). The experiment was carried out at the Division of Animal Science, Faculty of Veterinary and Animal Sciences, Mahasarakham University, Thailand, from November 20, 2007 to March 1, 2008. The animals were weighed at the beginning and end of each period.

Sample collection and preparation: The TMRs were randomly collected prior to analysis. Composite samples of the TMR were ground to pass through a 1 mm screen and the analyzed for DM, ash and CP (AOAC, 1990) NDF, ADF, ADL (Van Soest *et al*., 1991) and Acid Insoluble Ash (AIA) (Vankeulen and Young, 1977).

Fecal samples were collected by rectal sampling at 10.00 h for three consecutive days and composted. The feces were placed into an oven at 65°C for 72 h, weighed and ground to pass through a 1 mm screen and the analyzed for DM, ash, CP, NDF, ADF and AIA. The AIA content in feed and fecal were used to calculated digestibility (Schneider and Flatt, 1975).

Rumen fluid (100 mL) was collected at the end of each sampling period at 0, 2, 4 and 6 h post feeding by stomach tube connected to a vacuum pump. Ruminal pH was measured immediately after sampling using a pH meter (Handy Lab 1, CG842 Schott). Rumen fluid samples were then filtered through four layers of cheesecloth. Fifty milliliters of rumen fluid were acidified with 5 mL of 6 N HCI and centrifuged at 16,000 g for 15 min and the clear supernatant was stored in plastic tubes at -20°C prior to ammonia nitrogen analysis using the micro Kjeldahl method. Volatile Fatty Acid (VFAs) were determined by Gas Chromatography (GC-14, Shimasu Japan) fitted with a Flame Ionization Detector (FID) and a packed column 5% Thermon-3000, Shincarbon A 60/80. Nitrogen was

Table 1: Feed formulation and chemical composition of dietary treatments

	Dietary treatments[1]				
Ingredients	rt-TMR	tp-TMR	pm-TMR	db-TMR	sh-TMR
Rice straw (chopped hay 5 cm)	30.0	-	-	-	-
Tomato pomace	-	50.0	-	-	-
Palm meal	-	-	50.0	-	-
Dried brewer gain	-	-	-	50.0	-
Soybean hulls	-	-	-	-	50.0
Rice straw (long hay)	-	5.0	5.0	5.0	5.0
Cassava chip	40.0	28.0	26.0	28.0	26.0
Sugar cane molasses	6.0	5.5	5.5	5.0	5.0
Rice bran	20.0	10.0	10.6	10.5	11.0
Salt (NaCl)	0.5	0.5	0.5	0.5	0.5
Lime stone	0.5	0.5	0.5	0.5	0.5
Urea	2.6	0.1	2.1	0.5	1.7
Mineral mixed	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0
Chemical composition					
DM (%)	96.5	94.9	93.5	93.9	92.5
Ash (%)	9.6	10.6	7.0	10.6	8.5
CP (%)	13.0	12.8	14.4	14.3	15.0
NDF (%)	36.4	35.4	37.4	39.1	42.7
ADF (%)	29.2	28.4	29.4	35.9	34.8
ADL (%)	8.4	11.7	7.2	5.6	4.4
Total digestible nutrient (TDN (%))*	66.6	65.9	67.4	66.6	65.9
ME (Mcal kg^{-1})*	2.4	2.4	2.6	2.6	2.7
Calcium (Ca) (%)*	0.4	0.4	0.5	0.4	0.5
Phosphorus (P) (%)*	0.3	0.4	0.3	0.4	0.2

DM: Dry Matter; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin; ME: Metabolizable Energy, *Calculated value; rt: rice straw as fiber source; tm: tomato pomace as fiber source; pf: palm meal as fiber source; db: dried brewer gain as fiber source; sh: soybean hulls as fiber source

used as the carrier gas at 40 mL min^{-1} and the oven temperatures was maintained at 220°C, injection and FID temperatures were fixed at 260°C.

Blood samples were collected from the jugular vein at the same time as rumen fluid sampling, using 10 mL heparinized vacationers. The tube was gently inverted a couple of times and then kept in an ice box and later centrifuged at 5,000 g for 10 min. The plasma was then transferred into a storage tube and labeled with date and animal identification and stored at -20°C until analysis of Blood Urea Nitrogen (BUN) using the Stanbio Urea Nitrogen (BUN) (Liqui-UV®) procedure No. 2020.

On day 18 and 19 of each period, chewing behaviors were monitored visually at all times. Total chewing time was calculated by the sum of eating time and ruminating time. Eating chew and ruminating chew were measured by counting.

Statistical analysis: All data obtained from the trials were subjected to the general linear models procedure of Statistical Analysis System (SAS, 1996) according to a 5×5 Latin square design. Means were separated by Duncan new's multiple range test. The level of significance was determined at $p<0.05$.

RESULTS AND DISCUSSION

Chemical composition of TMRs: The ingredients composition and chemical composition of TMRs are shown in Table 1. TMRs contained similar concentrations of DM, ash, CP and TDN. However, NDF and ADF content in sh-TMR were slightly higher than others TMRs. The higher content was probably soybean hulls containing high fiber according to Chumpawadee and Pimpa (2008).

Feed intake and nutrient digestibility: Table 2 shows the feed intake and digestibility of the TMRs. There are many dietary factors that may influence dry matter intake in ruminant, such as physical characteristics, ingredients and nutrient composition. In this study, dry matter intake was influenced by the fiber source in TMRs, especially pm-TMR. Dry matter intake of pm-TMR expressed as kg DM day^{-1}, BW (%) and g kg^{-1} $BW^{0.75}$ was lower ($p<0.05$) than the other TMRs, probably due to the palm meal that has a fine particle size thus affecting feed intake. Generally, non forage fiber sources are small in particle size and the physical effective NDF is much lower. Present study used 5% rice straw as long hay to enhance the effective fiber as a way of protecting the health of the animals. Animals fed pm-TMR remained negatively affected on feed intake. These findings indicate that pm-TMR had low physical effective NDF. Additionally, the animals fed pm-TMR had lower chewing time, when compared with the control (rt-TMR) (Table 3). However, the animals fed tp-TMR, db-TMR and sh-TMR did not differ from rt-TMR (control).

It demonstrates that tomato pomace, dried brewer gain and soybean hull can be used as a fiber source in TMRs. The NRC (1989) recommends a minimum of 25% NDF in total dietary DM, when used as traditional forage and concentrate combinations. Grant (1997) recommends, when using non forage fiber sources as a fiber source, the NDF should up to 7-10% from NRC recommendations. In addition, Gencoglu and Turkmen (2006) observed that dry matter intake was affected by effective fiber, but not by forage source. Therefore, the physical characteristics of TMRs should be considered when formulating TMRs.

Digestibility of DM, OM and NDF were not significantly different ($p>0.05$) between the treatments. The results are in agreement with previous studies, Milis and Liamadis (2007) that observed DM, OM and NDF digestibility were not affected by a non forage fiber source. The current finding disagrees with *in vitro* studies on the affect of non forage fiber sources as a fiber source in TMRs (Chumpawadee and Pimpa, 2008), who found that IVDMD and IVODM were significantly different ($p<0.05$) among treatments. The sh-TMR gave the highest IVDMD and IVOMD, probably due to the different conditions of *in vitro* and *in vivo*. However, crude protein digestibility was significantly different ($p<0.05$) between treatments. Many factors nature of protein source providing the rumen undegradable protein (Milis and Liamadis, 2007) and protein fraction (Chumpawadee *et al*., 2007). Fernandez *et al*. (2003) reported protein source in TMRs affected protein digestibility. In this study, pm-TMR had the highest crude protein digestibility, possibly due to the protein fraction of pm-TMR having a large proportion of non protein nitrogen (Table 1).

Table 2: Feed intake and nutrient digestibility in beef cattle fed difference TMRs

	Dietary treatments[1]					
Parameters	rt-TMR	tp-TMR	pm-TMR	db-TMR	sh-TMR	SEM
Dry matter intake						
kg day^{-1}	5.7[a]	5.5[a]	3.2[b]	5.3[a]	5.9[a]	0.2
BW (%)	2.8[a]	2.7[a]	1.5[b]	2.5[a]	2.8[a]	1.3
g kg^{-1} $BW^{0.75}$	106.2[a]	102.8[a]	58.9[b]	93.7[a]	107.6[a]	5.2
Nutrient digestibility						
DM	55.5	51.6	56.5	50.6	53.8	2.1
OM	60.4	55.6	59.6	56.2	56.4	2.1
CP	60.1[b]	57.3[c]	74.7[a]	55.7[c]	63.8[b]	2.8
NDF	50.1	50.5	55.3	51.3	53.5	2.5

DM: Dry Matter; CP: Crude Protein; NDF: Neutral Detergent Fiber; Means in the same row with different superscripts differ ($p<0.05$)

Table 3: Eating and ruminating behavior in beef cattle fed difference TMRs

	Dietary treatments[1]					
Parameters	rt-TMR	tp-TMR	pm-TMR	db-TMR	sh-TMR	SEM
Chewing time (min day^{-1})						
Eating	171.6^{a}	138.0^{b}	137.2^{b}	196.4^{a}	169.2^{ab}	6.4
Rumination	254.6^{ab}	299.2^{a}	209.8^{ab}	274.4^{ab}	182.2^{b}	21.4
Total	426.2^{ab}	437.2^{ab}	347.0^{c}	470.8^{a}	351.4^{c}	22.8
Chewing time (min kg^{-1} NDF intake)						
Eating	119.6^{a}	77.7^{b}	135.6^{a}	92.5^{b}	67.8^{b}	6.7
Rumination	177.8^{ab}	167.1^{ab}	213.8^{a}	130.4^{ab}	72.4^{b}	18.5
Total	297.4^{ab}	244.8^{abc}	349.4^{a}	222.8^{bc}	140.2^{c}	23.1
Eating rate (g DM min^{-2})	33.9^{abc}	39.6^{a}	23.6^{c}	27.6^{bc}	36.3^{ab}	1.9
Rumination efficiency (g DM min^{-3})	23.3	23.9	23.7	25.5	37.0	3.2

[1]rt: rice straw as fiber source; tp: tomato pomace as fiber source; pm: palm meal as fiber source; db: dried brewer gain as fiber source; sh: soybean hulls as fiber source; [2]DM intake (g day^{-1})/eating time (min day^{-1}); [3]DM intake (g day^{-1})/rumination time (min day^{-1}); SEM: Standard Error of the Means; Means in the same row with different superscripts differ ($p<0.05$)

Chewing behavior: Chewing behavior variables were significantly affected by fiber source in TMRs (Table 3), except for rumination efficiency, defined as g DM min^{-1}, which was not significant among treatments. Total daily chewing time was similar in animals that consumed rt-TMR, tp-TMR and db-TMR; While animals that consumed pm-TMR and sh-TMR had reduced chewing times. The reduced chewing time was probably due to non forage fiber sources with small particle size and less physical effective NDF that may have affected total chewing time. Generally, total chewing time decreases as dietary forage NDF (Beauchemin, 1991) or particle size decreases (Grant *et al*., 1990). Additionally, chewing time and rumination times approximated the lower values reported by Yang and Beauchemin (2006); Oshita *et al*. (2008). When expressed in per kilogram of NDF intake, the animals fed pm-TMR had the highest chewing time. It possibly means that the feed intake of animals fed pm-TMR was lower than animals feeding on other TMRs (Table 2) resulting in more chewing time (min kg^{-1} NDF intake) and less eating rate (g DM min^{-1}). The results are in agreement with Beauchemin *et al*. (1991), who reported that rumination time per unit of NDF intake increases, when non forage fiber sources were incorporated into low forage diets. Grant (1997), also suggested that cows may possess an adaptive mechanism whereby they ruminate more effectively under conditions of limited amounts of effective forage NDF.

The number of eating chews, number of rumination chews, number of chews per min rumination time, ruminated boli, number of chews per bolus and number of boli per min rumination time were not significantly affected by fiber sources in TMR (Table 4). The number of total chews, number of chews per kg NDF intake, number of chews per min eating time and ruminated boli number per kg NDF intake were significantly affected by fiber source in TMRs. The number of chews was reduced when animals were fed pm-TMR and sh-TMR. Additionally, chewing time was also reduced in animals fed pm-TMR and sh-TMR. It was expected that when using palm meal and soybean hull as fiber sources in TMRs, the two would negatively affect chewing activity, although they were enhanced with 5% of long hey fiber.

Ruminal fermentation and blood urea nitrogen: Concentrations of NH_3-N, TVFAs and pH in rumen fluid were used to monitor the ruminal fermentation pattern (Table 5). The pH was not altered by the fiber source in TMRs ($p>0.05$). The rt-TMR had similar pH as tp-TMR and pm-TMR, but was slightly higher than those with db-TMR and sh-TMR. When monitoring the pH pattern at 0, 2, 4 and 6 h after feeding, the pH values were relatively stable at 6.5-6.9 and all treatment means were within the normal range that has been reported as optimal pH (6.0-7.0) for microbial digestion. The results are in agreement with *in vitro* studies (Chumpawadee and Pimpa, 2008) that observed pH was not markedly affected by fiber sources in TMRs. Generally, non fiber sources have small particle size. It was expected that they negatively affect chewing activity, rumen condition and digestion. Less mastication may reduce their saliva excretion leading to less buffering capacity in the rumen may influence crude protein digestibility: protein levels in the ratio (Kawashima *et al*., 2003), protein source and (Grant, 1997). In spite of the fact that the animals fed pm-TMR had less chewing activity (Table 3), their ruminal pH was not altered.

Ammonia nitrogen concentration was significantly different ($p<0.05$) among treatments. The results are in agreement with *in vitro* studies (Chumpawadee and Pimpa, 2008) that observed NH_3-N concentration was influenced by fiber source in TMRs. The difference in NH_3-N concentrations among treatments may have been related directly to urea and degradability of protein in the TMRs. However, NH_3-N concentration was in the optimal range for rumen ecology, microbial activity (Perdok and Leng, 1990; Wanapat and Pimpa, 1999). At 0-6 h after

Table 4: Eating, ruination chews ruminated boli and boli characteristics in beef cattle fed difference TMRs

	Dietary treatments[1]					
Parameters	rt-TMR	tp-TMR	pm-TMR	db-TMR	sh-TMR	SEM
No. of chews day^{-1}						
Eating	9746.2	7476.4	8739.4	9339.2	9251.6	401.5
Rumination	11598.2	12852.4	9268.6	11822.6	8203.2	943.4
Total	21344.4^{a}	20328.8^{a}	18008.0^{b}	21161.8^{a}	17454.8^{b}	1331.0
No. of chews kg^{-1} NDF intake						
Eating	7656.0^{ab}	5454.0^{bc}	8794.0^{a}	4639.0^{c}	3899.0^{c}	562.0
Rumination	9766.0^{a}	7754.0^{ab}	11278.0^{a}	6111.0^{ab}	4009.0^{b}	1103.0
Total	17422.0^{ab}	13208.0^{abc}	20072.0^{a}	10750.0^{bc}	7908.0^{c}	1580.0
No. of chews min^{-1} eating time	57.0^{ab}	53.7^{ab}	62.7^{a}	48.66^{b}	54.7^{ab}	2.0
No. of chews min^{-1} rumination time	45.5	42.4	44.2	43.0	46.0	0.8
Ruminated boli (No. day^{-1})	250.4	264.2	214.0	211.6	156.0	21.0
Ruminated boli (No. kg^{-1} NDF intake)	174.8^{ab}	149.6^{ab}	221.2^{a}	99.8^{ab}	62.4^{b}	20.8
No. of chews bolus^{-1}	44.74	52.3	44.0	53.3	55.2	1.3
No. of boli min^{-1} rumination time	1.0	0.9	1.0	0.8	0.8	0.03

[1]rt: rice straw as fiber source; tp: tomato pomace as fiber source; pm: palm meal as fiber source; db: dried brewer gain as fiber source; sh: soybean hulls as fiber source; [2]DM intake (g day^{-1})/eating time (min day^{-1}); [3]DM intake (g day^{-1})/rumination time (min day^{-1}); Means in the same row with different superscripts differ ($p<0.05$)

Table 5: Blood urea nitrogen, ruminal pH, ammonia nitrogen and volatile fatty acid in beef cattle fed difference TMRs

	Dietary treatments[1]					
Parameters	rt-TMR	tp-TMR	pm-TMR	db-TMR	sh-TMR	SEM
Blood urea nitrogen (mg (%))						
0 h	6.0^{b}	4.8^{c}	8.0^{a}	7.6^{a}	6.2^{b}	0.45
2 h	7.5^{a}	5.6^{c}	8.2^{a}	8.4^{a}	6.2^{b}	0.44
4 h	7.2^{b}	5.4^{c}	8.8^{a}	7.6^{a}	6.8^{b}	0.50
6 h	7.8^{a}	4.6^{c}	8.0^{a}	7.2^{a}	6.6^{b}	0.47
Average	6.8^{b}	5.1^{c}	8.2^{a}	7.7^{a}	6.5^{b}	0.44
pH						
0 h	7.0	6.9	7.1	6.8	6.5	0.07
2 h	6.6	6.6	6.5	6.5	6.4	0.05
4 h	6.7	6.7	7.0	6.7	6.4	0.08
6 h	6.8	6.8	6.7	6.8	6.6	0.06
Average	6.9	6.8	6.8	6.7	6.5	0.04
Ammonia nitrogen (NH_3-N) (mg%)						
0 h	8.1^{b}	5.2^{c}	14.3^{a}	7.9^{b}	6.1^{b}	1.06
2 h	9.2^{b}	7.8^{b}	12.3^{a}	7.3^{b}	4.3^{c}	1.14
4 h	6.2^{b}	5.3^{c}	15.7^{a}	8.4^{b}	6.6^{b}	1.70
6 h	7.7^{b}	6.3^{b}	10.8^{a}	10.9^{a}	9.0^{a}	1.28
Average	7.8^{b}	6.2^{c}	13.3^{a}	8.6^{b}	6.5^{c}	1.30
Volatile fatty acids (4 h post feeding)						
TVFA (mM)	48.0^{a}	49.4^{a}	44.5^{c}	46.7^{b}	49.7^{a}	2.58
Acetate (%)	74.0^{a}	74.0^{a}	64.6^{b}	66.8^{b}	67.7^{b}	1.56
Propionate (%)	18.1^{b}	19.2^{b}	25.0^{a}	23.1^{a}	23.2^{a}	1.82
Butyrate (%)	6.3	5.9	8.4	7.9	6.5	0.85
Iso-butyrate (%)	1.2	0.8	1.6	1.7	2.0	0.01
Varerate (%)	0.4	0.1	0.4	0.5	0.6	0.02
C2:C3	4.1^{a}	3.9^{a}	2.6^{b}	2.9^{b}	2.9^{b}	0.71

[1]rt: rice straw as fiber source; tm: tomato pomace as fiber source; pm: palm meal as fiber source; db: dried brewer gain as fiber source; sh: soybean hulls as fiber source Means in the same row with different superscripts differ ($p<0.05$)

incubation pm-TMR had the highest NH_3-N, when compared with other TMRs. When ammonia nitrogen is high, it indicates that the soluble fraction of protein is also high. There was high correlation between BUN and NH_3-N concentration in the rumen (Church, 1972). Thus, animals fed pm-TMR also had high BUN (Table 5). Protein degradation is more rapid than synthesis or imbalance of fermentable energy and nitrogen available, so ammonia will accumulate in the rumen fluid and absorb into the blood and be carried to the liver and converted to urea. Therefore, using palm meal as a fiber source in TMR should be avoided. Remarkably, NH_3-N concentration of tp-TMR and db-TMR were low at all times of sampling. It may have been that the urea level in both TMRs was lower than others. In addition, the protein in tomato pomace and dried brewer grain had low degradability

(Chumpawadee *et al*., 2007). Although, NH_3-N concentration of all TMRs was different with rt-TMR (control), it was within the normal range. Therefore, it can be used as a non forage fiber sources replacement dietary forage.

Total volatile fatty acid concentrations and VFA profile at 4 h post feeding are shown in Table 5. Total volatile fatty acid concentrations were significantly different ($p<0.05$) among treatments. The results are in agreement with *in vitro* studies (Chumpawadee and Pimpa, 2008) that observed TVFAs concentration was influenced by fiber source in TMRs. The TVFAs production of tp-TMR and sh-TMR are the same with rt-TMR and difference from pm-TMR and db-TMR, this result might have been influenced by carbohydrate fraction in TMRs. Ruminal acetate content of animal fed rt-TMR and tp-TMR were higher than other TMRs ($p<0.05$).

Conversely, ruminal propionate content of animal fed rt-TMR and tp-TMR were lower than other TMRs. The rate and extent of carbohydrates degradation in the rumen were affected VFAs production (Cheng *et al*., 1991). Keady and Mayne (2001) also suggest that VFAs concentration is similar when the animal fed diets contained a similar carbohydrate composition. In this study, different sources of fiber in TMRs were used, thus, VFA concentration and VFA profile were also different.

CONCLUSION

Based on this study, it can be concluded that the non forage fiber sources in TMRs have affected feed intake, crude protein digestibility, chewing behavior and ruminal fermentation. The animals fed pm-TMR had negative effect on feed intake and chewing activities, although enhanced with 5% of long hey fiber. Tomato pomace, dried brewer gain and soybean hulls can be used as fiber sources in TMRs, when enhanced with 5% of long hey fiber.

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