In sacco degradation characteristics of energy feed sources in Brahman-Thai native crossbred steers

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In sacco degradability were determined in some commonly used energy feed sources in ruminant rations. Ingredients evaluated were; cassava chip, ground corn, broken rice, rice bran and rice pollard. *In sacco* studies were conducted in two rumen fistulae Brahman-Thai native crossbred steers. The steers were fed at 0.5% body weight of concentrate and rice straw on *ad libitum*. Nylon bags containing 5 g (as fed basis) of each feed was immersed in duplicate at each time point in the ventral rumen of each steer for 2, 4, 6, 12, 24 and 48 hours. The data were fitted to the equation $P = a+b\,(1-e^{-ct})$ and effective degradability's were calculated using a theoretical rumen out flow rate of k = 0.05/hour. It was found that the rapid soluble fractions (*a*) of DM (75.08%), OM (77.79%) and CP (60.06%) were highest ($P<0.01$) in cassava chip. The potentially degradable fraction (*b*) of DM (86.65%), OM (86.98%) and CP (82.56%) were highest ($P<0.01$) in broken rice. The rate *c* of DM (0.182 h^{-1}) and OM (0.178 h^{-1}) were fastest ($P<0.01$) in rice bran. The effective degradability of DM (83.82%), OM (81.59%) and CP (77.23%) were highest in cassava chip ($P<0.01$). It was concluded that energy sources vary in rumen degradability. This would provide information on combinations of energy and protein sources with similar ruminal degradation, and thus improve ruminant feeding values.

Key words: *in sacco*, energy feeds, rumen degradation, steers

Introduction

The ruminant requires energy for maintenance and production as well as to support the synthesis of ruminal microbial protein. Energy feed sources are very important dietary components; because more than 70-80% of the ruminant diet are energy feed sources (Nocek and Rusell, 1988). For correct formulation of rations, nutritionists must have accurate information regarding the nutrient value of available feeds. However, for many energy feeds, there is insufficient information available regarding the effect of sample of feed used on rumen

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degradability values and little research has characterized individual energy feeds. Moreover, protein degradability in feedstuffs is an important factor when assessing the value of feedstuffs according to modern ruminant feed evaluation system (NRC, 2001). Currently, many researchers have used degradability characteristic of feedstuffs for synchronization of energy and protein in the rumen (Sinclair *et al*., 1993, 1995; Herrera-Saldana *et al*., 1990; Huber and Herrera-Saldana, 1994; Witt *et al*., 1999; Shabi *et al*., 1998).

The rate and extent of degradability of energy feed sources are largely different (Chanjula *et al*., 2003). Aroeira *et al*. (1996) also reported that high rate and extent of degradation were observed in cassava when compared to cereal or corn grain. In addition the rate and extent of ruminal fermentation depends on type of grain and degree of processing (Arieli *et al*., 1995). Several tropical varieties of energy feed sources are available on the farm, but with limited nutritional evaluation (cassava chip, broken rice, corn, rice bran and cereal grain). The present study was conducted in order to determine *in sacco* dry matter (DM), organic matter (OM) and crude protein (CP) degradation characteristics of five energy feed sources locally available using Brahman-Thai native steers.

Materials and methods

Feedstuffs preparation and analysis

The feedstuffs: ground corn (GC), cassava chip (CC), broken rice (BR), rice bran (RB), and rice pollard (RP) were collected from the various feed mill and organizations (Kantharavichai dairy cooperation, Khonkaen dairy cooperation, Mahasarakham University feed mill, Khon Kaen University feed mill, Numhenghoad feed suppliers, Chareon Esan commercial feed mill, Songserm Kankaset feed supplier) in the North East of Thailand. All test feed samples (Table 1) were ground to pass through a 1 mm screen for nylon bag incubation and chemical analysis. The feedstuffs were analyzed for dry matter (DM), crude protein (CP) and ash (AOAC, 1990). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were assayed using the method proposed by van Soest *et al*. (1991).

In sacco degradation procedure

Two Brahman-Thai native crossbred beef steers with an average body weight of 250 ± 15 kg were fitted with permanent rumen cannula. Steers were offered rice straw on *ad libitum* and received concentrate at 0.5% BW (concentrate mixture: 49.80% cassava chip, 17.5% rice bran, 14.60% palm meal, 7.0% soybean meal, 1.40% urea, 0.4% salt, 1.0 % mineral mix and 8.30% sugarcane molasses). Ruminal degradation measurement using the nylon bag technique was carried out after two weeks adaptation period. Approximately 5 g (as fed basis) of each test feed was accurately weighed into synthetic bags with a mean pore size of 45 µm (Shabi *et al*., 1998). Bags plus the sample was placed into the rumen of two beef steers 30 min after the morning meal and retrieved after a period of 2, 4, 6, 12, 24 and 48 hours. After removal from the rumen, the bags were rinsed in pipe line fresh water and washed by hand under tap water until the water became clear. After washing, the bags were placed into a hot dry air force oven at 65°C for 48 hours and weighed. The content of water soluble material was determined, bags representing 0 hours degradation also underwent the same washing procedure as the incubated bags. Dried residues of each incubation time from each steer were pooled, then DM, OM and CP were analyzed; then DM, OM and CP disappearance values were calculated as the difference between weight of nutrients before and after incubation of each sample. The degradability data obtained for DM, OM and CP for each feed were fitted to the equation $P = a+b(1-e^{-ct})$ (Ørskov and McDonald, 1979). The effective degradability was calculated as $ED = a + b\{c/(c + k)\}$, where k = fractional passage rate (0.05/hour)

Statistical analysis

All data obtained were subjected to the analysis of variance (ANOVA) procedure according to the Complete Randomized Design using the general linear (GLM) of the SAS system (SAS, 1996). Probabilities less than 0.05 were considered to be significant. Treatment means were compared using Duncan's New Multiple Range test (Steel and Torries, 1980).

Results and discussion

Chemical compositions of energy feed sources

The chemical compositions of energy feed sources are presented in Table 1. Generally, wide variations existed in the chemical composition of the investigated feedstuffs. The CP content of ground corn obtained in this study was slightly lower than that reported by NRC (1994); Getachew *et al*. (2002); NRC (2001) and Department of Livestock Development (2004), but higher than that reported by Chanjula *et al*. (2003). However, the findings were similar to those reported by Vorachantra *et al*. (2004). In addition, NDF content of ground corn was higher than that reported by Getachew *et al*. (2002), but lower than that reported by NRC (2001) and Department of Livestock Development (2004).

Table 1. Chemical composition of energy feed sources.

Feedstuffs[1]	DM (%)	CP	Ash	NDF	ADF	ADL
		……………..%DM basis……………….				
GC	92.20±0.05	8.53±0.10	1.69±0.02	13.25±0.17	3.63±0.06	0.41±0.03
CC	93.40±0.39	1.89±0.07	2.01±0.08	6.93±0.68	6.35±0.22	1.87±0.13
BR	92.06±0.38	7.80±0.15	0.66±0.02	9.28±0.11	0.65±0.08	0.12±0.01
RB	91.70±0.06	14.26±0.32	6.31±0.07	20.29±0.24	8.12±0.10	2.61±0.008
RP	90.49±0.02	8.46±0.28	14.08±0.08	61.18±0.30	45.96±1.27	11.91±0.32

Where: DM = dry matter; CP = crude protein; NDF = neutral detergent fibre; ADF = acid detergent fibre; ADL = acid detergent lignin

[1]GC = Ground corn, CC = Cassava chip, BR = Broken rice, RB = Rice bran, RP = Rice pollard

The CP content of cassava chip was higher than that reported by Nitipot and Sommart (2003), but lower than that reported by Chanjula *et al*. (2003); Department of Livestock Development (2004) and Vorachantra *et al*. (2004). The NDF, ADF and ADL content was lower than that reported by Nitipot and Sommart (2003), but similar to that reported by Department of Livestock Development (2004).

The CP content of broken rice obtained in this study was slightly lower than that reported by Vorachantra *et al*. (2004). However, they were similar to those reported by NRC (1988); Nitipot and Sommart (2003) and Department of Livestock Development (2004). In addition ash, ADF and ADL was similar with reports by Nitipot and Sommart (2003). The NDF content was higher than that reported by Nitipot and Sommart (2003).

The CP content of rice bran obtained in this study was higher than that reported by Chanjula *et al*. (2003). It was similar to reports by Dewhurst *et al*. (1995); Vorachantra *et al*. (2004) and Department of Livestock Development (2004), but lower than that reported by NRC (2001). In addition, NDF and ADF content were lower than those reported by Dewhurst *et al* (1995); Chanjula *et al*. (2003) and NRC (2001).

The CP content of rice pollard obtained in this study was similar to ground corn and Department of Livestock Development (2004). The NDF and ADF were lower than reported by Department of Livestock Development (2004). In addition NDF, ADF and ADL content was highest as compared other energy feed source, it might have been contaminated with rice hull.

There are many factors that affect chemical composition such as stage of growth (Promkot and Wanapat, 2004) maturity and species or variety (von Keyserlingk *et al*., 1996; Agbagla-Dohnani *et al*., 2001), dried method and growth environment (Mupangwa *et al*., 1997) and soil types (Thu and Preston, 1999). These factors may partially explain differences in chemical composition between our study and others. The chemical compositions of energy sources were different by varieties of feedstuffs. Therefore, the chemical composition of energy feed sources should be fully considered for diet formulation.

Ruminal disappearances

Ruminal DM, OM and CP disappearance of five energy feed sources are shown in Figs 1, 2 and 3, respectively. Ruminal DM, OM and CP disappearances increased with rumen incubation time for all feed sources (0 to 48 hours). Cassava chip showed highest DM and OM disappearance at early incubation time (0-24 hours). However, DM and OM disappearance of broken rice was shown to be highest at 48 hours incubation time. Rice pollard showed the lowest DM, OM and CP disappearance during incubation time. The CP disappearance of rice bran was highest at 48 hours incubation times but at the early incubation time (0 to 24 hours) was shown to be the highest in the cassava chip.

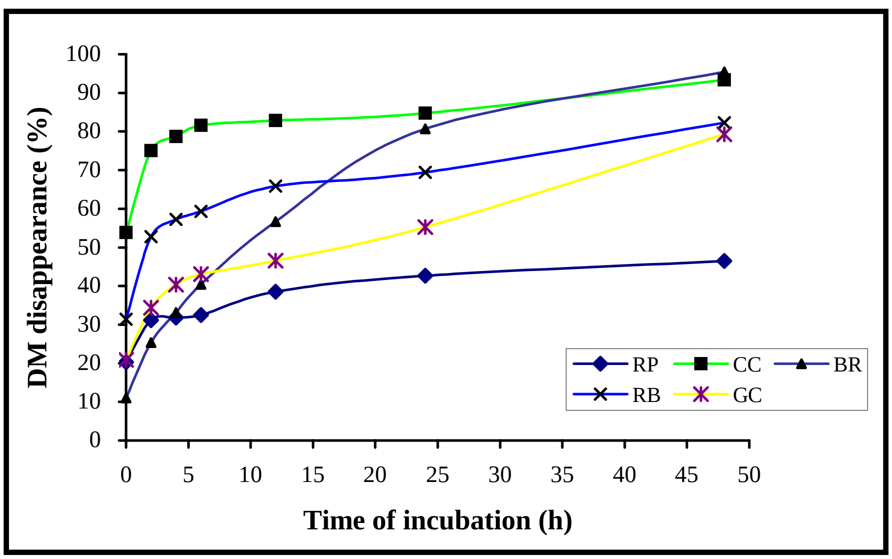

Fig. 1. *In sacco* dry matter disappearances of five energy feed source at various time of incubation (GG = Ground corn, CC = Cassava chip, BR = Broken rice, RB = Rice bran, RP = Rice pollard).

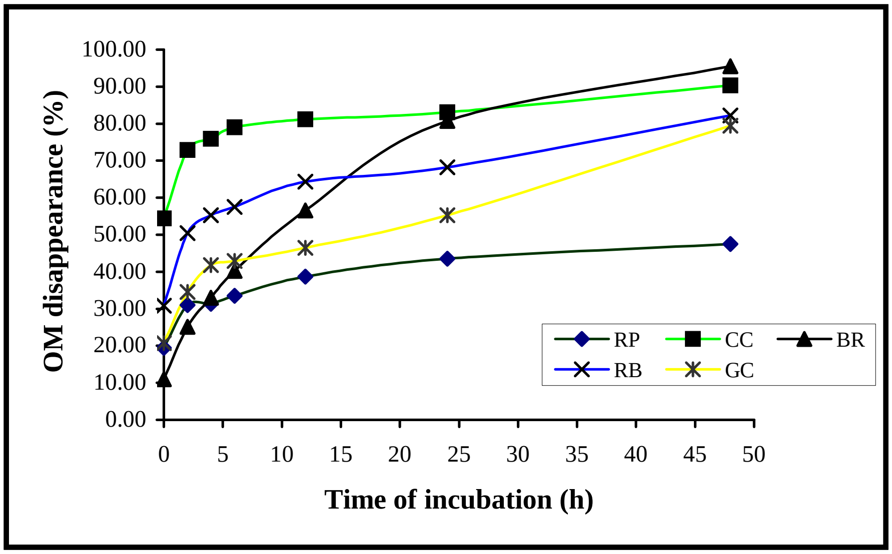

Fig. 2. *In sacco* organic disappearances of five energy feed source at various time of incubation (GC = Ground corn, CC = Cassava chip, BR = Broken rice, RB = Rice bran, RP = Rice pollard).

Degradability characteristics of DM, OM and CP for energy feed source

The rapidly soluble fraction (*a* fraction), potentially degradable fraction (*b* fraction), rate of degradation of *b* fraction (*c*) and potential degradation (*a*+*b*) are presented in Table 2. The rapidly soluble fraction of DM, OM and CP were the highest in the cassava chip (P<0.01) as compared to all feed sources. The result was in agreement with Chanjula *et al*. (2003), who found that the cassava chip had the highest rapidly soluble fraction as to compare other feed sources. Ørskov (1992) suggests that the fine particle would be rapidly fermented or else washed out of the nylon bag unfermented. In this experiment, cassava chip was a very fine dusty particle, which would be lost easily from the bag in the rumen. The lowest rapidly soluble fraction of DM, OM and CP were found in broken rice (P<0.01). This is possibly attributed to starch differences between broken rice and other feed sources. The result was in agreement with Cone *et al*. (1989), who found that source of starch had effect on degradability in rumens. The rapidly soluble fraction of dry matter for ground corn was higher than that reported by Nocek (1987) and Herrera-Saldana *et al*. (1990). The rapidly soluble fraction of dry matter and crude protein for rice bran was higher than those reported by Chanjula *et al*. (2003) and Ibrahim *et al*. (1995). Variation in this fraction between studies could be due to differences in feed particle size and processing method or differences in analytical techniques. In the present study, feeds were ground to 1 mm, which may have contributed to higher soluble fraction observed in some feeds. However, feed particle size did not affect rate of DM and N degradation in some studies (Nocek, 1985) but others (Figroid *et al*., 1972) have observed large differences in disappearance of substrate with difference in particle size.

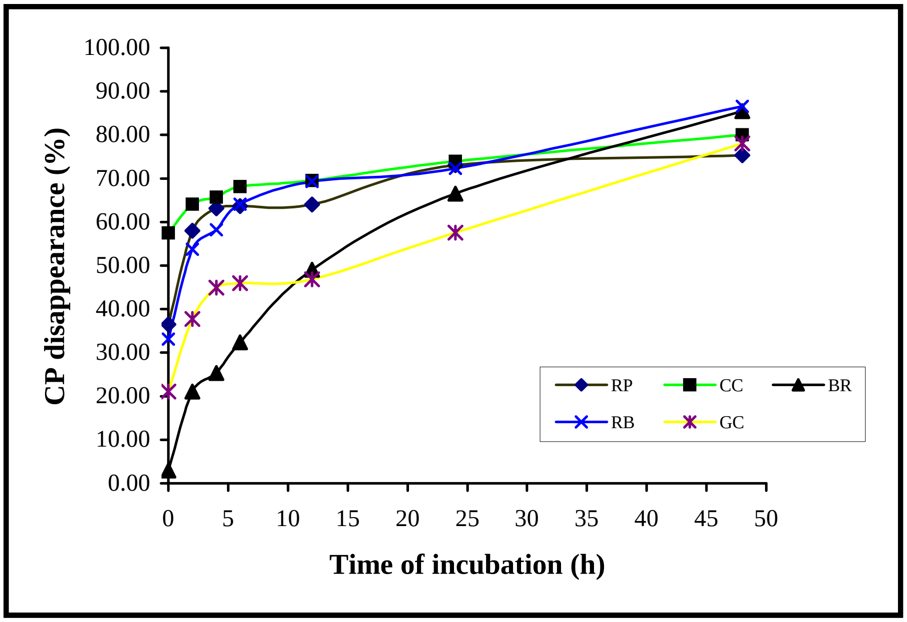

Fig. 3. *In sacco* crude protein disappearances of five energy feed source at various time of incubation (GC = Ground corn, CC = Cassava chip, BR = Broken rice, RB = Rice bran, RP = Rice pollard).

The potentially degradable fraction (*b*) of DM, OM and CP were the highest (P<0.01) on broken rice as compared to all feed sources. Lower potentially degradable fraction (*b*) of DM and OM than other feed was found in cassava chip and rice pollard. Cassava chip had lower (P<0.01) value for potentially degradable fraction (*b*) of CP than did the other energy source. Potentially degradable fraction (*b*) of DM and OM in this study was lower than those reported by Chanjula *et al*. (2003) for cassava chip and rice bran. However, potential degradation fraction (*b*) of DM and OM for corn ground was higher than that reported by Chanjula *et al*. (2003).

The rate of degradation of the potential degraded (*c*) of DM and OM (Table 2) were highest (P<0.01) in rice bran. The rate of DM degradation in this study was higher than that reported by Dewhurst *et al*. (1995) for rice bran. However, rapid fermentation of starch can cause rumen acidosis due to a build up of volatile fatty acids and drop in rumen pH (Garnsworthy and Wiseman, 2000). Deville *et al*. (1980) found that starch in rice bran and cassava chip appears to have the same degradation rate. However, in this experiment the rate of DM and OM degradation of rice bran and cassava chip were significantly different (P<0.01). Rice pollard had a higher (P<0.01) value for rate of degradation of fraction b (*c*) of CP than did the other feed. Lower rate of degradation of fraction b (*c*) of DM OM and CP than other feed was found in ground corn. The result was similar to findings by Chanjula *et al*. (2003). The protein matrix in corn endosperm is extremely resistant to digestion by rumen microorganism (McAllister *et al*., 1990). In addition thermal processing decreased ruminal DM and CP degradation rate in corn, barley, sorghum and wheat (Arieli *et al*., 1995).

The potential degradation (*a+b*) of DM, OM and CP (Table 2) were highest (P<0.01) in broken rice. However, Chanjula *et al*. (2003) found that the highest potential degradation was shown in the cassava chip. The potential degradation of DM, OM and CP for rice pollard was lower (P<0.01) than the other energy feed source. This result might have reflected the level of high lignin being present (Table 1). Feed with similar ruminal availabilities of crude protein and organic matter could be used in synchronizing nutrient supply for maximum microbial protein synthesis in ruminant (Sinclair *et al*., 1993, 1995; Shabi *et al*., 1998; Witt *et al*., 1999;). In our study, cassava chip and broken rice had high crude protein and organic matter availabilities; whereas, low crude protein and organic matter availabilities were observed in rice pollard.

There were high variations of *in sacco* degradability characteristic between energy feed sources. Numerous factors had effecting *in sacco* degradability were; bag pore size, sample size, grinding, diet of host animal, species of animal, sample preparation, incubation time and washing method (Olivera, 1998). Furthermore, chemical composition and processing of feedstuffs affected degradation characteristic (Huntington, 1997). Vitti *et al*., (1999) reported that *in sacco* dry matter disappearance was highly negatively correlated (P<0.01) with NDF, but positively correlated with phenolic compounds and reducing sugars. The starch in ground corn was slowly degraded, a result of the protein matrix being associated with starch granules (Rooney and Pflugfelder, 1989). Physical processing decreases the particle size of corn enhancing the rate and extent of ruminal digestion of starch (Kim *et al*., 1996). Energy feed sources in this study having a potential for ruminant feed, ranked from the highest to lowest were; cassava chip, broken rice, rice bran, corn ground and rice pollard respectively. However, at present broken rice is used for human feed and commercial monogastic feed.

Table 2. *In sacco* degradation characteristic and effective degradability of energy feed sources

Parameter	Treatment[1]					SEM
	GC	CC	BR	RB	RP	
DM disappearance						
a, %	29.01[c]	75.08[a]	13.11[e]	35.06[b]	23.11[d]	3.24
b, %	70.99[b]	22.21[d]	86.65[a]	39.88[c]	22.35[d]	5.66
c, h^{-1}	0.027[c]	0.032[c]	0.065[cb]	0.182[a]	0.107[c]	0.01
a +*b*, %	90.00[b]	97.29[a]	99.76[a]	74.94[c]	45.46[d]	4.37
EDDM, %	52.05[c]	83.82[a]	61.10[b]	66.20[b]	38.35[d]	2.40
OM disappearance						
a, %	36.80[c]	77.79[a]	12.95[e]	40.44[b]	22.12[d]	3.30
b, %	63.20[b]	22.21[d]	86.98[a]	36.58[c]	24.09[d]	5.46
c, h^{-1}	0.024[c]	0.033[c]	0.062[cb]	0.178[a]	0.114[b]	0.01
a +*b*, %	90.00[b]	99.11[a]	99.93[a]	75.78[c]	46.21[d]	4.18
EDOM, %	52.22[c]	81.59[a]	61.06[b]	64.95[b]	38.87[d]	2.40
CP disappearance						
a, %	29.75[c]	60.06[a]	6.77[d]	36.73[b]	36.48[b]	3.88
b, %	45.50[b]	19.81[e]	82.56[a]	42.81[c]	29.39[d]	5.83
c, h^{-1}	0.051[c]	0.065[c]	0.058[c]	0.156[b]	0.41[a]	0.03
a +*b*, %	75.20[b]	79.87[ab]	89.33[a]	79.54[ab]	65.87[c]	2.72
EDCP, %	52.79[c]	77.23[a]	51.25[c]	69.14[b]	62.67[b]	1.63

[a, b, c, d, e] Means within a row different superscripts differ (P<0.01)

Where: DM= dry matter, OM= organic matter, CP= crude protein, EDDM= effective degradability of dry matter, EDOM= effective degradability of organic matter, EDCP= effective degradability of crude protein,

[1]GC = Ground corn, CC= Cassava chip, BR= Broken rice, RB=Rice bran, RP= Rice pollard

a, *b*, *c* are constants in the exponential equation, $P= a+b(1-e^{-ct})$ Where *a* = the rapidly soluble fraction, *b* = the potentially degradable fraction, *c* = the rate of degradation of fraction *b*, *a*+*b*= potential degradation

Effective degradability of DM, OM and CP for energy feed sources

The effective degradability's of DM, OM and CP at an out flow rate of 5% per hour are shown in Table 2. The effective degradability of DM, OM and CP were significantly different among the test energy feeds (P<0.01). The effective degradation of DM, OM and CP calculated at an out flow rate of 5% per hour indicates that substantial amounts of DM, OM, and CP were degraded in the rumen, thus providing rumen degradable nitrogen and organic matter for rumen microbial protein synthesis. Effective degradability of DM, OM and CP for cassava chip was highest in the present study. The results agreed with those reported by Chanjula *et al*. (2003). Based on this study cassava is potentially an excellent source of fermentable carbohydrate for ruminants because the major carbohydrate of cassava is starch, which is fermented by amylolytic bacteria and protozoa (Kotarski *et al*., 1992). Comparisons between cereal species have shown that cassava starch is fermented more rapidly in the rumen than starch from corn, sweet potato, barley and wheat (Chanjula *et al*., 2003; Richard *et al*., 1991). The effective degradability of CP in this study was higher than that reported by Cone *et al*. (2002) for ground corn. However, effective degradability of CP for ground corn in this study was similar to NRC (1988). Effective degradability of DM and OM in this study was similar to the report of Chanjula *et al*. (2003) for rice bran. The higher fibre content (Table 1) of rice pollard compared to the other energy feeds probably resulted in lower DM, OM and CP degradability since high NDF and ADL result in lower fibre degradation (van Soest, 1988). Effective degradability of CP for broken rice used in the present study was lower than other feed. The important variation observed among samples for effective degradability of protein in energy feed sources is, according to the previous results, a consequence of several factors including type and quality of raw material, proportion of soluble added back, drying temperature and other processing conditions (Kaufmann and Lupping, 1982). Variation in ruminal protein degradation can be used in two ways, either to maximize substrate available for microbial growth and protein synthesis, or to enhance the intestinal amino acid supply.

Conclusion

The result demonstrated that ruminal disappearance characteristics of five energy feed sources differed among feedstuffs. Energy feed sources vary widely in their ruminal DM OM and CP degradation. The *a* fraction and effective DM, OM and CP degradability showed the highest value in the cassava chip. The *b* fraction of DM, OM and CP was the highest in broken rice. The fastest degradation rate (*c*) of DM and OM was observed in rice bran. Energy feed sources vary in rumen degradability. These data would potentially be used in synchronizing the rate of energy and nitrogen release in the rumen in order to improve ruminal fermentation and microbial protein synthesis.

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