Kasetsart J. (Nat. Sci.) 40 : 430 - 435 (2006)

Nutritional Evaluation of Energy Feed Sources for Ruminant Using *In Vitro* Gas Production Technique

Songsak Chumpawadee[1], Kritapon Sommart[2], Thevin Vongpralub[2] and Virote Pattarajinda[2]

ABSTRACT

Five energy feed sources were used to evaluate for nutritive value using the *in vitro* gas production technique. The rumen mixed microbe inoculums were taken from fistulated Brahman-Thai native crossbred steers. The energy feed source treatments were 1) corn meal, 2) cassava chip, 3) broken rice, 4) rice bran and 5) rice pollard. The treatments were assigned to completely randomize design (four replications). The results indicated that soluble gas fractions (*a*) (-32.39, -50.98, -34.02, -21.67 and -3.39 mL, respectively), the fermentation of the insoluble fraction (*b*) (132.39, 150.98, 134.02, 119.09 and 62.66 mL, respectively), rate of gas production (*c*) (0.12, 0.19, 0.08, 0.11 and 0.06 %/h , respectively) and potential of extent of gas production (*a+b*) (164.79, 201.97, 168.05, 140.76 and 66.05 mL, respectively) were significantly different (P<0.01) among energy feed sources. The cumulative gas volumes at 24, 48 and 96 h after incubation were significantly different (P<0.01). Cassava chip exhibited the greatest gas production characteristics and gas volume. These results together with its locally available at an inexpensive cost cassava chip was one of the potential energy source for beef and dairy cattle.

Key words: *in vitro*, gas production, energy feeds, steers

INTRODUCTION

Energy content of ruminant feed sources is an important factor to take into consideration. Energy content should compose roughly seventy percent of feed ration (Chumpawadee, 2002). Cost, chemical composition and digestibility of energy feed source should be fully taken into account when formulate ruminant diet. Recently, the *in vitro* gas production technique has been proposed in use for determining fermentation kinetics of ruminant feed (Menke *et al*., 1979; Menke and Steingass, 1988; Blummel and ∅rskov, 1993; Theodorou *et al*., 1994; Tessema and Baars, 2004). Nitipot and Sommart (2003) also used the *in vitro* gas production technique to evaluate nutritive values of cassava starch industry by-products, energy feed sources and roughages, who found that cassava and cassava starch industry by-products had high potential to be used as a locally novel energy feed source for ruminants.

With respect to energy feeds source in Thailand, limited information is available on the kinetics of degradation. Therefore, the aim of this study was to evaluate nutritive values of energy feed sources for ruminants using the *in vitro* gas production technique.

[1] Division of Animal Production Technology, Faculty of Technology, Mahasarakham University, Mahasarakham 44000, Thailand.
[2] Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.
* Corresponding author, e-mail: songsakchum@yahoo.com

Received date : 04/08/05 Accepted date : 21/02/06

MATERIALS AND METHODS

Feedstuffs samples and chemical analysis

Five energy feed sources were collected from various feed mills and organizations (Kantharavichai dairy cooperation, Khonkaen dairy cooperation, Mahasarakham University feed mill, Khon Kaen University feed mill, 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 the *in vitro* gas production technique and chemical analysis. The feedstuff samples were analyzed to determine dry matter (DM), crude protein (CP) and ash content (AOAC, 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were assayed using the method proposed by Van Soest *et al*. (1991).

Experimental design

The experimental design was completely randomized (four replicates per treatment). The treatments included ground corn, cassava chip, broken rice, rice bran and rice pollard. Strict anaerobic techniques were used in all steps during the rumen fluid transfer and incubation period. Rumen fluid inoculums was removed before the morning feeding under vacuum pressure via the rumen fistula into a 2 liter glass flask and transferred into two pre-warmed 1 liter thermos flasks which were then transported to the laboratory. The medium preparation was as described by Sommart *et al*. (2000). Mixed rumen fluid inoculums were obtained from two fistulated Brahman-Thai native crossbred steers (weighing about 250±15 kg). The animals were offered rice straw on *ad libitum* and fed 0.5 % body weight of concentrate (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). The animals were fed twice daily, water and a mineral lick was available *ad libitum* for 14 days.

The feed sample of approximately 0.5 g on a fresh weight basis was transferred into a 50 mL serum bottle (Sommart *et al*., 2000). The bottles were pre-warmed in a hot air oven at 39°C for about 1 hour prior to injection of 40 mL of rumen fluid medium (using a 60 mL syringe) to each bottle. The bottles were stoppered with rubber stoppers, crimp sealed and incubated in a hot air oven set at 39°C.

The rate of gas production was measured by reading and recording the amount of gas volume after incubation using a 20 mL glass syringe connected to the incubation bottle with a 23 gauge, 1.5 inch needle. Readings of gas production were recorded from 1 to 96 h (hourly from 1-12 h, every 3 h from 13-24 h, every 6 h from 25-48 h and every 12 h from 49-96 h) after incubation periods. Amount of cumulative gas volume 2, 4, 6, 12, 24, 48, 72 and 96 h after incubations were fitted using the equation $y = a + b\,[(1-\mathrm{Exp}(-ct)]$ (∅rskov and

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 fiber; ADF = acid detergent fiber; ADL = acid detergent lignin

[1] GC = ground corn, CC = cassava chip, BR = broken rice, RB = rice bran, RP = rice pollard

McDonald, 1979), where *a*= the intercept, which ideally reflects the fermentation of the soluble fraction, *b*= the fermentation of the insoluble fraction, *c*= rate of gas production, (*a*+*b*)= potential extent of gas production, y= gas production at time 't'.

Statistical analyses

All data obtained from the trials were subject to the analysis of variance procedure of statistical analysis system (SAS, 1996) according to a completely randomized design. Means were separated by Duncan New's Multiple Range Test. The level of significance was determined at P<0.01.

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 crude protein content ranged from 1.89 % for cassava chip to 14.08 % for rice bran meal. Ash content ranged from 0.66 % for broken rice to 14.08 % for rice pollard. Neutral detergent fiber content ranged from 6.93 % for cassava chip to 61.18 % for rice pollard. Acid detergent fiber ranged from 0.65 % for broken rice to 45.98 % for rice pollard. Acid detergent lignin ranged from 0.12 % for broken rice to 11.91 % for rice pollard.

There are many factors that affect chemical composition of energy feed sources such as stage of growth, maturity, species or variety (von Keyserlingk *et al*., 1996; Agbagla-Dohnani *et al*., 2001 and Promkot and Wanapat, 2004), drying method, growth environment, (Mupangwa *et al*., 1997) and soil types (Thu and Preston, 1999). These factors may partially explain differences in chemical composition between this study and the others.

Gas production characteristics of energy feed source

Gas production from the fermentation of energy feed sources was measured at 2, 4, 6, 12, 24, 48, 72 and 96 h using *in vitro* gas production technique adapted to describe the kinetics of fermentation based on the modified exponential model y= *a*+*b* [(1-Exp(-*c*t)] (∅rskov and McDonald, 1979). The gas production characteristics are presented in Table 2 and Figure 1. The intercept (*a*) was lowest (P<0.01) in cassava chip, compared to all other feed sources. However, absolute *a* (|*a*|) is used to describe ideally reflects the fermentation of the soluble fraction. The absolute *a* was highest in cassava chip. The findings were similar to those report by Nitipot and Sommart (2003).

The gas volume at asymptote (*b*) described the fermentation of the insoluble fraction. The fermentation of the insoluble fraction of energy feed sources were significantly different (P<0.01). The fermentation of insoluble fractions of cassava chip, broken rice, corn meal, rice bran and rice pollard were; 150.98, 134.02, 132.39, 119.09 and 62.66 mL, respectively. The fermentation of the insoluble fraction was highest in cassava chip and lowest in rice pollard. The results suggest that cassava chip has the highest potential for use as ruminant feed when compared to the remaining energy feed sources.

Rates of gas production (*c*) expressed in %/h, ranked from the fastest to the slowest were cassava chip, ground corn, rice bran, broken rice and rice pollard, respectively. The rate of gas production was highest in cassava chip. These results were closely related to reports by Chanjula *et al*. (2003), who studied the *in sacco* technique. They also found that cassava chip had the highest rate of degradation when compared all other energy feed sources. Additionally, these results were similar to reports by Nitipot and Sommart (2003) who studied the *in vitro* gas production technique. They found that the rate of gas production of cassava chip was higher than that in corn meal, broken rice and other industrial by-products.

Potential extents of gas production (*a*+*b*) expressed in mL as ranked from the highest to the lowest were: cassava chip, broken rice, ground corn, rice bran and rice pollard, respectively. These findings were similar to reports by Nitipot and Sommart (2003), which found that cassava chip

Table 2 Gas production characteristics and gas volume of energy feed sources using gas production technique.

Parameters	Treatment[1]					
	GC	CC	BR	RB	RP	SEM
Gas production characteristic[2]						
a, mL	-32.39[c]	-50.98[d]	-34.02[c]	-21.67[b]	-3.39[a]	3.70
b, mL	132.39[b]	150.98[a]	134.02[b]	119.09[c]	62.66[d]	7.05
c, %/h	0.12[b]	0.185[a]	0.08[bc]	0.11[bc]	0.06[d]	0.01
a+*b*, mL	164.79[b]	201.97[a]	168.05[b]	140.76[c]	66.05[d]	10.62
Gas production (mL/0.5g)						
24 h	123.0[b]	150.38[a]	97.0[c]	91.88[c]	45.75[d]	8.55
48 h	159.12[b]	190.25[a]	144.0[b]	100.75[c]	54.62[d]	11.08
96 h	176.87[b]	205.37[a]	166.5[b]	107.5[c]	59.75[d]	12.13

a, b, c, d Means within a row with different superscripts differ at $P<0.01$

1 GC = ground corn, CC = cassava chip, BR = broken rice, RB = rice bran and RP = rice pollard

2 *a* = the intercept (mL), which ideally reflects the fermentation of the soluble fraction, *b* = the fermentation of the insoluble fraction (asymptote) (mL), *c* = rate of gas production (%/h), (*a*+*b*) = potential extent of gas production (mL)

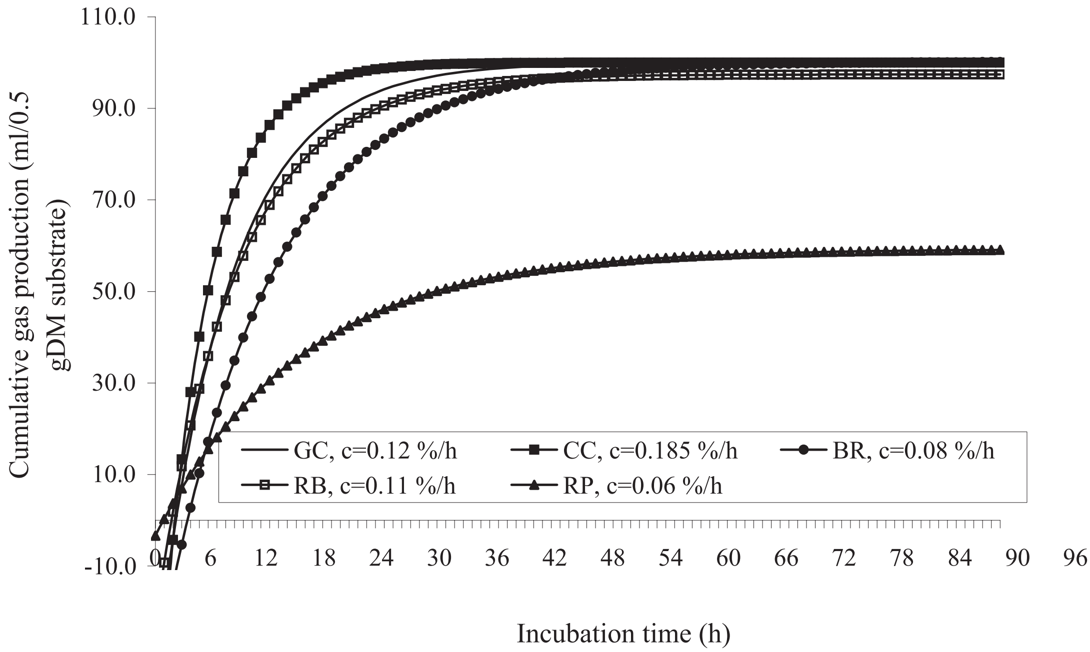

Figure 1 Cumulative gas volume estimated by y = a+b [(1-Exp(-ct)] (mL/0.5 gDM Substrate) throughout 96 h. (GC = ground corn, CC = cassava chip, BR = broken rice, RB = rice bran and RP = rice pollard).

had the highest potential gas production. It was possible that cassava chip also had the lowest NDF content. Thus, cassava chip is more easily degradable than other energy feed sources. The present study was in agreement with Sommart *et al*. (2000) and Nitipot and Sommart (2003) because energy feed source having lower NDF showed higher potential extent of gas production (Table 1 and Table 2).

Gas volume

Cumulative gas volumes 24, 48 and 96 h after incubation are shown in Table 2. The results indicated that cumulative gas volumes at 24, 48 and 96 h after incubation were significantly different (P<0.01). The gas volumes ranked from the highest to the lowest were: cassava chip, broken rice, ground corn, rice bran and rice pollard, respectively. Menke *et al*. (1979) suggested that gas volume 24 h after incubation was in direct relationship with metabolizable energy in feedstuffs. Sommart *et al*. (2000) suggested that gas volume was a good parameter to predict digestibility, fermentation end-product and microbial protein synthesis of the substrate by rumen microbes in the *in vitro* system. Additionally, *in vitro* dry matter and organic matter digestibility were shown to have high correlation with gas volume (Sommart *et al*., 2000; Nitipot and Sommart, 2003). Gas volume has also shown to have a close relationship with feed intake (Blummel and Becker, 1997) and growth rate (Blummel and ∅rskov, 1993).

CONCLUSIONS

Chemical composition and kinetics of gas production were different among the different energy feed sources. The potential extent of gas production, ranked from the highest to the lowest were cassava chip, broken rice, ground corn, rice bran, and rice pollard. Because cassava chip is available locally and inexpensive, it is the best potential energy source for beef and dairy cattle.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to Mr. Pay Rodthong for taking care of the animals and the Department of Agricultural Technology, Faculty of Technology Mahasarakham University and Department of Animal Science, Faculty of Agriculture, Khon Kaen University for supporting experiment facilities. The financial support for this research was partially provided by 'The Khon Kaen University's Graduate Research Fund, Academic Year 2003'.

LITERATURE CITED

Agbagla-Dohnani, A., P. Noziere, G. Clement and M. Doreau. 2001. *In sacco* degradability chemical and morphological composition of 15 varieties of European rice straw. **Anim. Feed Sci. Technol**. 94: 15-27.

AOAC. 1990. **Official Methods of Analysis**, 15th Edition. Association of Official Analytical Chemists, Arlington, Virginia, USA.

Blummel, M. and E.R. ∅rskov. 1993. Comparison of *in vitro* gas production and nylon bag degradability of roughages in predicting feed intake in cattle. **Anim. Feed Sci. Technol**. 40: 109-119.

Blummel, M. and K. Becker. 1997. The degradability characteristics of fifty-four roughages and roughage neutral detergent fibers as described by *in vitro* gas production and their relationship to voluntary feed intake. **Br.J. Nutr**. 77: 757-768.

Chanjula, P., M. Wanapat, C. Wachirapakorn, S.Uriyapongson and P.Rowlinson. 2003. Ruminal degradability of tropical feed and their potential use in ruminant diets. **Asian-Aust. J.Anim. Sci**. 16: 211-216.

Chumpawadee, S. 2002. **Applield Animal Nutrition**. Department of Agricultural Technology, Faculty of Technology, Mahasara Kham University. 273 p.

Department of Livestock Development, Ministry of Agricultural and Cooperative. 2004.**Table of chemical composition of feedstuffs**. Chumnum Sahakorn HeangpatdhesThai Ltd.

Menke, K.H., L. Raab, A. Salewski, H. Steingrass, D. Fritz and W. Schneider. 1979. The estimation of the digestibility and metabolizable energy content of ruminant feeding stuffs from the gas production when they are incubated with rumen liquor. **J. Agri. Sci**. 93: 217-222.

Menke, K. and H. Steingass. 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. **Animal Research and Development**. 28: 7-55.

Mupangwa, J.F., N.T. Ngongoni, J.H. Topps and P. Ndlovu. 1997. Chemical composition and dry matter of forage legumes *Cassia rotundiforlia cv*. Wynn, *Lablab purpureus cv.* Highworth and Macroptilium atropurpureum cv. Siratro at 8 weeks of growth (pre-anthesis). **Anim. Feed Sci. Technol**. 69: 167-178.

Nitipot, P. and K. Sommart. 2003. Evaluation of ruminant nutritive value of cassava starch industry by products, energy feed sources and roughages using *in vitro* gas production technique. In : **Proceeding of Annual Agricultural Seminar for year 2003, 27-28 January**, KKU. 179-190.

NRC. 2001. **Nutrient Requirements of Dairy Cattle**. (7th rev.ed.) National research council, National Academy Press. Washington, DC.

Promkot, C. and M. Wanapat. 2004. Ruminal degradation and intestinal digestion of crude protein of tropical resources using nylon bag and three-step *in vitro* procedure in dairy Cattle. In : **Proceedings of the Agricultural Seminar, Animal Science/Animal Husbandry**. Held at Sofitel Raja Orchid Hotel 27-28 January 2004.

∅rskov, E.R., and I. McDonald. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage **J. Agric. Sci. (Camb) 92**: 499-504.

SAS. 1996. **SAS User's Guide**: Statistics, Version 6.12th Edition. SAS Institute Inc. Cary, NC.

Sommart, K., D.S. Parker, P. Rowlinson and M. Wanapat. 2000. Fermentation characteristics and microbial protein synthesis in an *in vitro* system using cassava, rice straw and dried ruzi grass as substrates. **Asian-Aust. J.Anim. Sci**. 13(8): 1084-1093.

Theodorou, M.K., B.A. Williams, M.S. Dhanoa, A.B. McAllan and J. France. 1994. A simple gas production method using a pressure transducer to determine the fermentation kinetics of ruminant feeds. **Anim. Feed Sci. Technol**. 48: 185-197.

Tessema, Z., and R.M.T. Baars. 2004. Chemical composition, *in vitro* dry matter digestibility and degradation of Napier grass (*Pennisetum Purpureum* (L) Schumach.) mixed with different levels of *Sebania Sesban* (L.) Merr. **Anim. Feed Sci Technol**. 117: 29-41.

Thu, N.V. and T.R. Preston. 1999. Rumen environment and feed degradability in swamp buffaloes fed different supplements**. Livestock Research for Rural Development**. 11(3): 1-7.

Van Soest, P.J., J.B. Robertson and B.A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. **J.Dairy Sci**. 74: 3583-3597.

von Keyserlingk, M.A.G., M.L. Swift, R. Puchala and V. Shelford. 1996. Degradability characteristics of dry matter and crude protein of forages in ruminants. **Anim. Feed Sci. Technol**. 57: 291-311.