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Silage Production from Cassava Peel and Cassava Pulp as Energy Source in Cattle Diets

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Abstract: Processing of the silage using cassava peel as energy source in dairy cow diets was studied. The experiment was conducted to investigate the chemical composition, degradability, lactic acid production and hydrocyanic acid content of various silages with varying cassava peel additions and ensiling times. The experiment was a 5×3 factorial design, completely randomized with factor A as the different formulated mixtures (0, 10, 20, 30 and 40% kg fresh weight of cassava peel) and factor B as the times of ensiling (14, 21 and 28 days). The results showed that cassava peel was appropriated to use as energy source in silage for dairy cows at 14, 21 and 28 days ensiling times. The content of hydrocyanic acid was at safety level for animals. The pH of all silages was in the range commonly accepted for international standard. The pH of good quality silage should approximately be 4.2. The DM degradability was increased as the addition level of cassava pulp in the silage increased. Lactic acid content of silage was highest at 14TH day ensiling time. The present study indicated that cassava peel and cassava pulp can be used as energy source in silage for dairy cows, particularly in Thailand where pastures are lacked during the dry period.

Key words: Cassava peel, cassava pulp, hydrocyanic acid, silage, cattle diets, Thailand

INTRODUCTION

Shortage of pasture and good quality feed sources normally occurs particularly during the dry season in Thailand. Moreover, concentrate meal play a major role in the cost of milk production accounting for 60-70%. Price of other feedstuffs used as energy source in the concentrate such as corn and cassava chip dramatically increased since, they are competed for ethanol production. Therefore, agro-industrial by-products such as cassava peel and cassava pulp becomes widely utilized. From cassava starch production 3% of cassava peel is obtained therefore, approximately 552,000 ton of cassava peel is produced per year.

This considered being a great volume for animal feed. In addition, cassava peel contained 62.5-71.0% Nitrogen Free Extract (NFE), 1.65-2.96 Mcal GE kg DM^{-1} and 1.03 Mcal DE kg DM^{-1} which are suitable for cattle feed. (Adegbola, 1980; Devendra, 1977; Nwokoro and Ekhosuehi, 2005). However, cassava or cassava peel contains a substance, cyanogenic glucosides which which are in the tissues of cassava especially the head and leaf. When tissue is destroyed, cyanogenic glucoside are disintegrated to hydrocyanic acid and becomes toxic to human and animal. If human receives only 1.4 mg of hydrocyanic acid per kg body weight, he will die. Concentration of hydrocyanic acid in cassava leaves vary but the average is approximately 180-200 mg kg^{-1} fresh leaves. Hydrocyanic acid content in leaves is less than in roots.

The analysis found that hydrocyanic acid in cassava tissue is approximately 15-50 ppm while in cassava peel is approximately 623 ppm. Hydrocyanic acid varies according to species (Soper *et al*., 1977) but can destroy or reduce the toxins by using heat or sunlight. In addition, fermentation will reduce the amount of hydrocyanic acid to a level that does not harm the animals. The objective of the present research was to demonstrate the use of cassava peel and cassava pulp as energy source feedstuffs in silage.

MATERIALS AND METHODS

Feedstuffs (Cassava peel, corn husk, cassava pulp and brewer' grain) were analyzed for chemical composition. Feed samples were composited and sub

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Table 1: Formulations of silage from various agricultural by-products

	Silage formulation (Kg fresh weight)				
Diets	1	2	3	4	5
Corn husk	42	42	42	42	42
Cassava peel	0	10	20	30	40
Cassava pulp	40	30	20	10	0
Brewers' grain	14	14	14	14	14
Molasses	3	3	3	3	3
Urea	1	1	1	1	1
Total	100	100	100	100	100

sampled were taken for further chemical analysis. After being dried (60°C) and ground to pass a 1 mm screen in a Wiley mill, feed samples were analyzed in duplicate for Dry Matter (DM) by drying a 1 g sample in duplicate at 60°C in a conventional oven for 36 h for ash by burning a 2 g sample at 500°C for 3 h in a muffle furnace for ether extract and Nitrogen (N) by the method of AOAC (1990) for Neutral Detergent Fiber with residual ash (NDF); Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) by the method of Goering and van Soest (1970) and degradation in the rumen by Nylon bag technique (Orskov *et al*., 1980).

The feedstuffs that had been subjected to laboratory analyses were used to formulate five different silages by varying level of cassava peel (0, 10, 20, 30 and 40 kg fresh weight) on a laboratory scale basis (Table 1). They were then thoroughly mixed and placed in airtight plastic bag and poly-ethylene bag respectively. These mixtures were ensiled for 14, 21 and 28 days.

The experimental design was thus, a 5×3 factorial arrangement giving a total of 15 treatments with four replications in each treatment. On the end of the respective ensiling time, samples were taken and freeze dried for DM determination. Dried samples were then ground and analyzed for ash, crude protein, crude fiber, fat concentration (AOAC, 1990) for NDF and ADF (Goering and van Soest, 1970) for pH using pH meter for acetate butyrate and lactate using Gas Chromatography (GC) (Ottenstein and Bartley, 1971) and for rumen degradability or in sacco digestibility using the method of Orskov *et al*. (1980) and Orskov and McDonald (1979). Analysis of hydrocyanic acid use the method described by Indira and Sinha (1969). All data measured were subjected to Analysis of Variance (ANOVA) using SAS procedures (Statistical Analysis System).

RESULTS AND DISCUSSION

Chemical composition and DM degradability of feedstuffs are shown in Table 2. Corn husks were high in dry matter which is probably because high ambient temperature during drying corn husk). Soper *et al*. (1977) using corn cobs sweet as roughages in dairy cows showed that corn cobs sweet contained 6.5% protein, 1.0% fat, 36.6% crude fiber, 68.2% NDF and 41.1% ADF. Corn husk in the present study had 1.0% protein, 34.3% fiber and 38.7% which were lower than reported by Soper *et al*. (1977).

Table 2: Chemical compositions of agricultural by-products used in the experiment (Mean±SE)

	Feedstuffs			
Results	Cassava peel	Cassava pulp	Corn husk	Brewers' grain
DM	25.19±0.36	22.97±0.82	94.07±0.04	91.23±0.06
CP	1.04±0.18	2.03±0.16	1.83±0.06	33.17±0.92
Fat	1.92±0.82	0.13±0.10	0.92±0.20	7.32±0.82
Ash	17.66±1.76	7.38±0.62	2.50±0.12	4.80±0.01
CF	10.79±0.48	12.28±0.98	34.27±2.50	13.11±0.10
NDF	70.97±0.04	61.36±0.01	85.85±2.74	50.31±2.48
ADF	18.73±1.62	14.68±0.14	38.73±0.46	16.65±0.64
ADL	7.15±0.24	5.16±1.28	15.85±0.24	9.18±0.24
NFC	3.41±0.44	24.81±1.72	9.70±2.44	8.62±5.38
NDIN	0.35±0.01	0.21±0.02	0.16±0.01	0.70±0.04
NDINCP	2.20±0.06	1.33±0.08	0.99±0.01	4.39±0.24
ADIN	0.19±0.02	0.37±0.02	0.15±0.02	0.55±0.02
ADINCP	1.18±0.10	2.31±0.12	0.93±0.06	3.44±0.10
HCN (ppm)	399.01±10.16	211.74±5.92	-	-
TDN_{1X} (%)[1/]	42.05±2.94	52.17±2.60	38.36±1.70	65.77±1.62
DE_{1X} (Mcal kg^{-1})[2]	1.88±0.04	2.08±0.14	1.58±0.06	3.80±0.26
DE_P (Mcal kg^{-1})	2.12±0.08	2.16±0.10	1.86±0.02	3.62±0.22
ME_P (Mcal kg^{-1})[3]	1.69±0.08	1.72±0.10	1.43±0.02	3.21±0.22
NE_{LP} (Mcal kg^{-1})[4]	1.00±0.06	1.02±0.08	0.81±0.02	2.07±0.16
dg[5]	58.1	60.7	38.8	57.4

[1]TDN_{1X} (%) = tdNFC+tdCP+(tdFA×2.25)+tdNDF − 7 ; [2]YDE_{1X} (Mcal kg^{-1}) = [(tdNFC/100)×4.2]+[(tdNDF/100)×4.2]+[(tdCP/100)× 5.6]+[(FA/100) ×9.4] - 0.3 Discount = [(TDN_{1X} - [(0.18×TDN_{1X}) - 10.3])×Intake)] TDN^{-}_{1X} DE_P (Mcal $kgDM^{-1}$) = DE_{1X} x Discount; [3]ME_p = [1.01×(DE_p) – 0.45]+ [0.0046×(EE - 3)]; [4]NE_{Lp} = ([0.703×ME_p (Mcal kg^{-1})] - 0.19)+ ([(0.097× Me_p+0.19)/97]×[EE - 3]); [5]dg are effective degradability of DM (%)

Cassava peel has higher dry matter than that reported by Adegbola (1980) (25.2 and 13.5%, respectively). Nwokoro and Ekhosuehi (2005), Devendra (1977) and Adegbola (1980) found that cassava peel had 4.3, 4.8 and 6.5% protein, respectively while ashes were 1.0, 4.2 and 6.5%, respectively. Cassava peel was low in protein (1.0%) and high in ash (17.7%). The percentage of fiber is close to Nwokoro and Ekhosuehi (2005) and Adegbola (1980) reports (10.8, 12.0 and 10.0%, respectively).

Cassava pulp showed less DM (22.8%) than those reported by Mueller *et al*. (1978) and Suksombat *et al*. (2007) (88.8 and 92.6%, respectively) while protein (2.0%) was similar to Preston. However, crude fiber (12.3%), NDF (61.4%) and ADF (14.7%) were higher than reported by Preston (5.0, 34.0 and 8.0%, respectively). Cassava contains relatively high crude fiber, NDF and ADF. The nutrient values of cassava peel are dependent on climatology, soil fertility, species, age of harvest, processing, etc. (Mueller *et al*., 1978). Brewers' grain is a source of protein feedstuff. It contained 33.2% CP which was higher than those reported by Suksombat and

Table 3: Dry Matter content (DM), chemical compositions in DM, HCN, TDN and degradability of silage after 14, 21 and 28 days of ensiling

Periods	Formula	HCN	DM	CP	Fat	Ash	CF	NDF	ADF	TDN_{1X} (%)[1/]	dg DM	dg CP
14 days	1	19.4900	39.7000	15.4000	1.4000	4.0000	21.2000	63.7000	25.2000	47.6000	56.2	66.6
	2	21.0000	38.5000	14.6000	1.9000	5.3000	20.7000	61.4000	25.8000	47.8000	57.0	63.2
	3	22.4900	38.1000	14.4000	2.3000	7.0000	22.2000	67.2000	27.6000	46.8000	55.7	71.1
	4	23.9800	41.0000	12.2000	1.7000	6.9000	25.5000	72.9000	32.6000	47.2000	52.1	63.9
	5	25.4600	40.9000	15.2000	2.5000	8.7000	23.0000	63.6000	26.8000	45.6000	50.5	62.4
21 days	1	11.6200	41.1000	13.4000	1.0000	3.6000	20.1000	64.5000	27.2000	52.7000	45.6	50.5
	2	14.4700	40.9000	12.3000	1.4000	4.8000	23.5000	68.6000	30.6000	52.9000	49.7	57.5
	3	17.3100	41.5000	13.1000	2.1000	6.1000	24.0000	69.0000	31.4000	51.4000	45.9	59.6
	4	20.1300	42.6000	12.0000	1.4000	8.6000	25.3000	68.9000	32.4000	51.4000	44.4	61.7
	5	22.9300	42.9000	13.4000	1.9000	7.0000	26.1000	70.5000	32.7000	48.5000	46.4	58.5
28 days	1	9.0900	38.5000	13.2000	0.8000	3.6000	23.4000	68.2000	30.0000	52.8000	50.9	62.6
	2	10.9300	41.8000	14.5000	2.8000	4.7000	23.9000	69.5000	30.8000	52.1000	50.5	61.4
	3	12.7600	42.1000	11.6000	1.7000	5.6000	23.8000	69.6000	32.1000	52.3000	50.9	50.8
	4	14.5700	43.5000	13.0000	1.2000	7.7000	25.0000	74.2000	32.8000	52.0000	46.5	61.7
	5	16.3700	43.5000	12.7000	2.1000	6.9000	25.7000	68.4000	32.0000	49.4000	52.1	63.6
SEM		0.8700	0.8600	0.3300	0.1600	0.3400	0.4200	0.8100	0.6400	2.5400		
Ensiled period		0.0001	0.0289	0.0001	0.1853	0.3033	0.0039	0.0007	0.0001	0.0001		
Formula		0.0067	0.4089	0.0029	0.0007	0.0001	0.0001	0.0001	0.0003	0.2355		
Ep×F		0.9844	0.9997	0.0077	0.2022	0.4678	0.0918	0.0342	0.3169	0.8974		

HCN, Hydrocyanic acid; DM, Dry Matter; CP, Crude Protein; CF, Crude Fiber; ADF = Acid-detergent Fiber, NDF = Neutral-detergent Fiber; dg DM, Degradability of DM; dg CP, degradability of CP; SEM, Standard Error of the Mean; EP, Ensiled Period; F, Formula. [1]TDN_{1X} (%) = tdNFC+tdCP+(tdFA×2.25)+tdNDF-7

Lounglawan (2004) and NRC (2001) (28.4 and 27.3%, respectively). Fat content was similar to the report of Suksombat and Lounglawan (2004) (7.3 and 8.0%, respectively) while crude fiber was 13.1% and NDF was 50.3% which is lower than reported by Suksombat and Lounglawan (2004) (15.2 and 62.2%, respectively). In consistent with Porter and Conrad (1975) who reported that the brewers' grain contained 13.0-15.0% crude fiber. However, the chemical composition of the brewers' grain is depended on the type of grain, performance of extracted carbohydrate soluble and the time used for extraction. The remaining brewers' grain in is most parts of the shell or husk of grain (Armentano *et al.*, 1986).

Degradation of DM (effective degradability of DM; dg DM) of cassava pulp was higher than the report of Suksombat *et al.* (2007) (60.7 and 56.8%, respectively). This is probably because cassava pulp has high soluble carbohydrate. The DM degradability of cassava peel was similar to that of cassava pulp. Brewers' grain had lower DM degradability than reported by Suksombat and Lounglawan (2004) (57.4 and 62.7%, respectively) while corn husk had very low DM degradability (38.8%) but was higher than in bagasse (21.2%) (Suksombat, 1999). Degradability of feed in ruminants is affected by many factors such as quality, quantity, physical form, particle size and passage rate (Moon *et al.*, 2003). Moon *et al.* (2003) found low digestibility of forest by-product silage relating to high crude fiber contents.

Chemical composition of five ensiled agricultural by-products and duration of fermentation (14, 21 and 28 days) is shown in Table 3. There were significant differences in HCN ($p<0.01$) between duration of fermentation. HCN was high in 14 days fermentation silage and then declined when time of ensiling increased (21 and 28 days fermentation). This is probably because during fermentation microorganisms can decompose the cyanogenic glucoside together with increasing silage temperature. Gomez and Valdivieso (1988) reported that after 26 weeks fermentation of cassava the amount of HCN decreased to 36% of DM ($p<0.05$) among periods of fermentation.

McDonald *et al.* (1991) found that DM of grass increased with increasing fermentation times which was probably due to loss of moisture and acids during fermentation. There were statistically significantly differences in CP content ($p<0.01$) between period of fermentation, formula and interaction between period of ensiling and formula.

This possibly caused by the decomposition of urea by urease and the ammonia loss during ensilage. Catchpoole (1962) reported that when grass was fermented, the percentage of CP decreased as compared to before fermentation. This could be due to microbial activity degrading CP and released large amount of ammonia.

A reduction in CP content from formula 1-5 is probably due to losses in ammonia from urea addition occurring during ensiling process. Johnson *et al.* (1967) found that urea treatment of corn silage tended to increase the formation of ammonia and reduce the content of crude protein. Fat and ash increased with increasing cassava peel addition. Because cassava peels had higher contents fat and ash than in cassava. NDF and ADF increased from formula 1-5 ($p<0.05$) NDF and ADF tended to increase as the level of DM increased. The degradation of DM in the rumen is shown in Table 3.

Table 4: pH, organic acids of silage after 14, 21 and 28 days of ensiling

			g kg^{-1} DM		
Ensiled periods	Formula	pH	Lactate	Acetate	Butyrate
14 days	1	4.2000	45.5000	27.4000	nil
	2	4.0000	46.0000	24.8000	nil
	3	4.0000	45.1000	23.1000	nil
	4	4.1000	46.2000	27.9000	nil
	5	4.0000	44.6000	32.1000	nil
21 days	1	4.2000	41.3000	23.4000	7.0
	2	4.0000	40.5000	29.9000	7.0
	3	4.0000	38.7000	35.5000	nil
	4	4.0000	42.4000	35.7000	nil
	5	3.9000	40.1000	32.6000	nil
28 days	1	4.2000	37.4000	34.8000	9.5
	2	4.0000	34.7000	36.4000	7.1
	3	4.0000	32.8000	39.5000	7.3
	4	4.0000	37.4000	41.5000	6.8
	5	3.9000	35.3000	37.8000	nil
SEM		0.0300	0.8600	1.5000	
Ensiled period		0.2407	0.0001	0.0001	
Formula		0.0001	0.2130	0.0601	
EP×F		0.9547	0.9714	0.2908	

SEM; Standard Error of the Mean, EP, Ensiled Period; F, Formula

DM degradability at 14th day fermentation period reduced when the level of cassava peel increased (0, 10, 20, 30 and 40%, respectively) however at fermentation period of 21st and 28th day, DM degradability reduced probably due to increased dry matter as the duration of fermentation increased. CP degradability was varied probably due to variation of protein levels in different formula.

Level of pH and Volatile Fatty Acids (VFAs) concentration are shown in Table 4. Formulation also had significant effects on pH but not on lactic acid and acetic yield. The pH of all silages was in the range commonly accepted for international standard. The good quality silage should have pH around 4.2 (Kung *et al*., 1998). The lactic acid production decreased while acetic acid increased with increasing time of ensiling ($p<0.05$). During the early stage of fermentation, the coliform bacteria are active. These organisms multiply until about the 7th day after ensilage and then decrease in numbers. Following this period, they are progressively replaced by the slower growing high acid-producing Lactobacilli. The pH of the silage drops as a result of high lactic and acetic acids produced. The result of the present study showed lower pH but higher lactic and acetic acid yields at 14th day than other periods of ensilage. Following the 1st 2 weeks of ensiling the pH increased while acid productions declined with increasing time of ensiling. A reduction of lactic acid with increasing time of ensiling can be attributed to the utilization of lactic acid produced by Lactobacilli during the early fermentation by other microorganisms (Woolford, 1984). Butyric acid yield could not be detected at 14th day fermentation but could be detected at 21st and 28th day fermentation periods.

CONCLUSION

The chemical compositions of agricultural by-products were in the same range generally reported in various studies. Cassava peel was found to be suitable to use as an energy source feedstuff in the fermentation of silage . However, cassava peel is low in protein and high in ash percentage, it must be used with high-protein feedstuffs as protein sources such as brewers' grain and urea. HCN was high at 14th day fermentation and then declined to the level that was not harmful to animals at 21st and 28th day fermentation. The pH of all silages was in the range commonly accepted for international standard. Lactic acid was highest at 14th day fermentation period and then declined at 21st and 28th day fermentation. This research indicates that some agricultural by-products have a high potential to improve quality and to utilize in various forms of dairy cattle's feeds particularly in the form of silage. Well-balanced nutrient ensiled by-products need to be fermented for at least 14 days provided that optimum levels of brewers' grain and molasses are added.

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