THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Doctor of Philosophy (Animal Science)

DEGREE

Animal Science — **FIELD**

Animal Science — **DEPARTMENT**

TITLE: Effects of Fermented by Products (FBP) as Roughage Source in Dairy Cow

NAME: Miss Thaintip Kraiprom

THIS THESIS HAS BEEN ACCEPTED BY

______________________________ **THESIS ADVISOR**

(Associate Professor Sornthep Tumwasorn, Ph.D.)

______________________________ **THESIS CO-ADVISOR**

(Associate Professor Somkiert Prasanpanich, Ph.D.)

______________________________ **THESIS CO-ADVISOR**

(Mr. Phongthorn Kungmun, Ph.D.)

______________________________ **DEPARTMENT HEAD**

(Associate Professor Somkiert Prasanpanich, Ph.D.)

APPROVED BY THE GRADUATE SCHOOL ON ______________________________

______________________________ **DEAN**

(Associate Professor Gunjana Theeragool, D.Agr.)

THESIS

EFFECTS OF FERMENTED BY PRODUCTS (FBP) AS ROUGHAGE SOURCE IN DAIRY COW

THAINTIP KRAIPROM

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Doctor of Philosophy (Animal Science)
Graduate School, Kasetsart University
2013

Thaintip Kraiprom 2013: Effects of Fermented by Products (FBP) as Roughage Source in Dairy Cow. Doctor of Philosophy (Animal Science), Major Field: Animal Science, Department of Animal Science. Thesis Advisor: Associate Professor Sornthep Tumwasorn, Ph.D. 157 pages.

The aims of this thesis were to study the nutritive values and fermentation characteristics of difference by product to produce fermented by-product (FBP) as roughage source for dairy cows. In Experiment I and II, FBP was composed of bagasse, vinasse, pineapple peel, corn cob and corn husk. The odor of butyric acid was not detected and showed a good quality of silage. The DM, CP, ADF, NDF, pH, lactic acid, acetic acid and butyric acid of FBP were 22.89, 7.72, 44.41, 72.61, 3.87, 4.98, 5.37 and 0.99%, respectively. The storage of FBP could be kept up to 2 months with good quality. Experiment III used 15 multiparous Holstein Friesian lactating dairy cows in mid lactation and were randomly allocated to three treatments (T1 = rice straw and 1 kg of vinasses (RS+V); T2 = sweet corn waste silage (SCWS); T3 = FBP. The completely randomized design was employed in this study and results revealed that DM intake of cow fed with rice straw and vinasses and FBP were significant higher than cows fed with SCWS ($P<0.05$). The digestibility of DM, OM, CP, NDF and ADF were significantly higher ($P<0.05$) in cows fed FBP and SCWS than cows fed with RS+V. Experiment IV studied the *in vitro* gas technique trial to investigate the effect of different proportion of FBP with rice straw on *in vitro* fermentation. The dietary treatments were ratio of FBP and rice straw (RS) were: T1 = FBP and RS as 60:40 on DM basis; T2 = FBP and RS as 50:50 on DM basis; T3 = FBP and RS as 40:60 on DM basis; T4 = rice straw only. The ration of concentrate and roughage were 60:40%. Cumulative gas production at 72 h after incubation of T2 were 60.64 ml/200 mgDM and higher ($P<0.05$) than that of T3 and T4 (53.12 and 52.96 ml/200 mg DM). Experiment V compared different proportions of FBP with RS in sixteen of 87.5% Holstein Friesian dairy heifers with an average initial body weight 246.33±13.03 kg. Four treatments were: T1 = heifers fed FBP: RS at the ratio 60:40 (DM basis); T2 = heifers fed FBP: RS at the ratio 50:50 (DM basis); T3 = heifers fed FBP: RS at the ratio 40:60 (DM basis); T4 = heifers fed rice straw *ad* lib). The result from revealed that the total DM intake in T3 yielded the highest responds. The DM, OM, CP, NDF, ADF and EE digestibility were increased with increasing levels of FBP in the diets. Experiment VI studied the effects of FBP and RS on milk yield, milk composition and fatty acid profile in dairy cow. Fifteen dairy cows with 75-87.5% Holstein Friesian blood were used with an average initial body weight of 407.33±53.48 kg in mid lactation and 111.25±25.12 DIM. Cows were randomly allocated to 3 treatments: T1 = dairy cows fed FBP and RS at the ratio 50:50 (DM basis) *ad lib*; T2 = dairy cows fed SCWS and rice straw at the ratio 50:50 (DM basis); T3 = dairy cows fed RS *ad lib*) under completely randomized design. The result revealed that the milk yield and 4% FCM from cow in T1 was found to be the highest ($P<0.05$) and showed normal blood metabolite and rumen ecology.

___________________________ ___________________________ ___ / ___ / ___

Student's signature Thesis Advisor's signature

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Associate Professor Dr. Sornthep Tumwasorn, my supervisor for guidance, assistance, advice and encouragement. I would like to express my appreciation to Associate Professor Dr. Somkiert Prasanpanich and Dr. Phongthorn Kongmun, members of my advisory committee, for their kind advice, suggestion and comments during the course of my work and preparation of the thesis. I am indebted to the staff of the Dairy Farming Promotion Organisation of Thailand (DPO.), Muaklek, Saraburi especially Mr. Sour Sriwichai for the suggestions while feeding cows in the farm.

I am grateful to the support of the Commission on Higher Education of Thailand for supporting the grant fund under the program "Strategic Scholarships Fellowships Frontier Research Network for the Ph.D. Program". I would like to thanks Prince of Songkla University, Pattani campus to support me throughout the Ph.D. program. Moreover, I would like to thanks Kasetsart University and all graduate students for their help in many activities during my study. My deepest gratitude all went to my parents, my brother for their understanding and support during the study.

Thaintip Kraiprom
June 2013

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	ii
LIST OF FIGURES	vi
LIST OF ABBREVIATIONS	vii
INTRODUCTION	1
OBJECTIVES	4
LITERATURE REVIEW	5
MATERIALS AND METHODS	37
Materials	38
Methods	39
RESULTS AND DISCUSSION	63
CONCLUSION AND RECOMMENDATIONS	116
Conclusion	116
Recommendations	117
LITERATURE CITED	118
APPENDIX	152
CURRICULUM VITAE	157

LIST OF TABLES

Table		Page
1	Average milk composition (%) of different breeds.	6
2	Quantitative composition of milk	10
3	Principle fatty acids in milk fat	12
4	Main raw materials for alcohol production in Italy	13
5	The chemical composition of vinasses as dry matter basis (g/100g.)	16
6	The Chemical composition of bagasses as dry matter basis	18
7	The chemical composition of corn stem, corn husk and corn cob as dry matter basis	19
8	Ensiled characteristics and chemical composition of sweet corn residues (DM)	20
9	The chemical standard of silage	24
10	Typical concentrations of common fermentation end products in corn silage, high moisture (HM) corn and grass silages	25
11	Chemical composition of agro-industrial by product	26
12	Chemical composition (% of DM) of sweet corn cob and husk (SCH) and ensiled sweet corn cob and husk (ESCH) without or with Ipil Ipil leaves (IL)	27
13	Apparent digestibility of ensiled sweet corn cob and husk (ESCH) with or without Ipil-Ipil leaves (IL) in 4 native beef cattle	27
14	Chemical composition of the grass silage and maize silage (g/kg of DM)	29
15	Mean silage dry matter (DM) intake, milk yield, milk composition and live weight change for cows on the four experimental treatments	29
16	Mean of milk production and composition between cows fed different treatments	31

LIST OF TABLES (Continued)

Table		Page
17	Mean and range of Thyroxine (T4) and Triiodothyronine (T3) hormone in the serum of an animal	34
18	The characteristics of FBP-Mixed, FBP- corn and FBP-pineapple at 30 days of ensiling	63
19	Chemical composition and fermentation characteristics of FBP-Mixed, FBP- corn and FBP- pineapple at 30 days of ensiling	64
20	The ingredients and chemical composition (% of dry matter) of FBP	67
21	The characteristics of FBP-Mixed, FBP- corn and FBP-pineapple with different fermented period	68
22	Chemical composition and fermentation characteristics of FBP with different fermentation periods	69
23	Chemical composition (% of dry matter) of dietary treatments used in the experiment	72
24	Effect of difference fiber source on feed intake and live weight change in lactating dairy cows	73
25	Effect of difference fiber source on nutrient digestibility and digestibility nutrient intake in lactating dairy cows	74
26	Blood-urea nitrogen, Blood glucose, Triiodothyronine and Non-Esterified Fatty acid of lactating cows receiving different fiber sources	76
27	Effect of difference fiber source on milk yield and milk composition in lactating dairy cows	79
28	Body weight change and average daily gain of lactating cows receiving different fiber sources	80

LIST OF TABLES (Continued)

Table		Page
29	Effect of difference fiber source on the variable costs, income and economic return during the experimental period	81
30	Chemical composition of feed used in this study (on dry matter basis)	82
31	The gas volume and values of kinetic parameter from fermentation of the ratio roughage source	83
32	*In vitro* true digestibility (IVDMD), *In vitro* organic matter digestibility (IVOMD), Volatile fatty acids (VFAs) and ammonia nitrogen (NH_3-N) in different levels roughage source	88
33	The chemical composition of diets used in the experiment	90
34	Effect of difference fiber source on feed intake in dairy heifers	91
35	Effect of difference fiber source on nutrient digestibility and digestibility nutrient intake in dairy heifers	93
36	Effect of difference fiber source on blood glucose, blood urea nitrogen, Triiodothyronine and NEFA of dairy heifers	95
37	Effect of difference fiber source on live weight change and average daily gain of heifer cows	96
38	The chemical composition (% of dry matter) of diets used in the experiment	98
39	Fatty acid composition of concentrate and different fiber sources	99
40	Dry matter intake of lactating dairy cows receiving different fiber sources	100
41	Blood-urea nitrogen, Blood glucose, T3 and milk urea nitrogen of lactating cows receiving different fiber sources	101
42	Volatile fatty acids (VFAs) and methane (CH_4) production of lactating cows receiving different fiber sources	105
43	Ruminal microorganism population of lactating cows receiving different fiber source	106

LIST OF TABLES (Continued)

Table **Page**

44	Milk yield and milk composition in lactating dairy cows receiving different fiber sources	108
45	Fatty acid of milk fat in lactating dairy cows receiving different fiber sources	110
46	Effect of difference fiber source on nutrient digestibility and digestibility nutrient intake in lactating dairy cows	112
47	Body weight Change and average daily gain of lactating cows receiving different fiber sources	114
48	Variable costs, income and economic return of lactating cow receiving different fiber source	115

Appendix Table

1	Physical quality analysis standard of Silage characteristics	153

LIST OF FIGURES

Figure **Page**

1	The Process of ethanol production from molasse	14
2	Industrial fermentation process leading to vinasse generation	15
3	Percentage of by-products from sugarcane ready to use as cattle feed	17
4	Change of product at fermentation process	23
5	Change of microorganism at fermentation process	24
6	Change of microorganism at fermentation process	44
7	Adaptation and data collection period	52
8	The gas volume estimated by $y = a+b\ [1\text{-}exp^{(-ct)}]$	86

LIST OF ABBREVIATIONS

ADF	=	Acid Detergent Fiber
ADG	=	Average Daily Gain
ADL	=	Acid Detergent Lignin
AIA	=	Acid Insoluble Ash
BG	=	Blood Glucose
BUN	=	Blood Urea Nitrogen
BW	=	Body Weight
C	=	Carbon dioxide
^{o}c	=	degree Celsius
C2	=	Acetic acid
C3	=	Propionic acid
C4	=	Butyric acid
CF	=	Crude Fiber
CH_4	=	Methane
CLA	=	Conjugated linoleic acids
cm	=	centimeter
CO_2	=	Carbon dioxide
CP	=	Crude Protein
CRD	=	Completely Randomized Design
DIM	=	Day In Milk
DM	=	Dry matter
DMRT	=	Duncan new multiple range test
DOMD	=	Digestibility organic matter
EE	=	Ether Extract
FA	=	Fatty acid
FCM	=	Fat Corrected Milk
GC	=	Gas Chromatography
H_2SO_4	=	Sulfuric Acid
HCl	=	Hydrochloric Acid

LIST OF ABBREVIATIONS (Continued)

IVTD	=	*In vitro* organic matter disappearance
IVOM	=	*In vitro* True Digestibility
kg	=	Kilogram
kg/d	=	Kilogram per day
LAB	=	Lactic acid bacteria
LCFA	=	Long Chain Fatty Acid
mg%	=	milligram percentage
M	=	Molar
ME	=	Metabolizable Energy
ml	=	milliliter
MUN	=	Milk Urea Nitrogen
NC	=	non soluble carbohydrate
NFE	=	Nitrogen Free Extract
NEFA	=	Non Esterified Fatty Acid
NaOH	=	Sodium hydroxide
NDF	=	Neutral Detergent Fiber
NFE	=	Nitrogen Free Extract
NH_3-N	=	Ammonia-Nitrogen
OM	=	Organic Matter
PUFA	=	Poly Unsaturated Fatty Acid
RDP	=	Ruminal Degradable Protein
RUP	=	Ruminal Undegradable Protein
SD	=	Standard Deviation
SEM	=	Standard Error of the Means
SFA	=	Short Chain Fatty Acid
SNF	=	Solid Not Fat
T_3	=	Triiodothyronine hormone
T_4	=	Thyroxine hormone
TD	=	True digestibility
TDN	=	Total Digestible Nutrient

LIST OF ABBREVIATIONS (Continued)

TS	=	Total Solid
TVFAs	=	Total Volatile Fatty Acid
VFA	=	Volatile Fatty Acid
WSC	=	Water Soluble Carbohydrate

EFFECTS OF FERMENTED BY PRODUCTS (FBP) AS ROUGHAGE SOURCE IN DAIRY COW

INTRODUCTION

Thailand is a tropical country situated between 5º 37′ and 20º 27′ north and 97º 22′ and 105º 37′ east. Climate condition in Thailand is influenced by tropical monsoons and generally has high temperature and humidity (Thai Meteorological Department, 2004). Dairy cattle population in Thailand is increasing which affect on the increasing demand of feeds. Tudsri and Swasdiphanich (1993) reported that Thai farmers owned on average area for such farming is only 0.40-4.80 ha per farm. This amount of area can not support sufficient feed for dairy cattle producing high milk production particularly during a long time dry season. A major constraint to increasing livestock productivity in developing countries is the scarcity and fructuating quantity and quality of the year-round supply of conventional feeds. An important of non-conventional feeds is by-product feedstuffs which are obtained during harvesting or processing of a common in which human food or fiber is derived.

Ruminants in the tropics are fed on low quality roughages, especially agricultural crop-residues and by-products from agro-industry such as rice straw, sugarcane tops and corn stover (Wanapat, 1999). Agro-industrial by-products are an important source of feed for ruminants and commonly used in cattle and buffalo diets in Thailand. These by-products are generally used as energy and protein source. Pineapple peel, corn stover, corn husk and baggasse from canning factories have been widely fed for dairy cattle (Sruamsiri *et al*., 2007).

Hadalgo (2009) reported that vinasses (condensed molasses solubles) is a new by-produce from ethanol plant and leftover following ethanol recovery. For every gallon of ethanol produced up to 13 gallons of vinasses (Pereira, 2008). Vinasses has a 93% water and 7% solid compound with a low to high dark compound, high concentrate of potassium, calcium, magnesium, sulphur and Non Protein Nitrogen

(NPN) (mainly betaine, glutamic acid and ammonia) and low fiber may be represented almost totally by the glucans and mannans present in the walls of the yeast used in the process. Although the chemical composition of vinasses can vary depending on the process by which it is obtained (e.g. drying, adding nitric acid, or adding sulfuric acid). In several tropical countries, vinasses is an additive for feeding of ruminant and non-ruminant (Tumwasorn, 2007; Hadalgo, 2009). López-Campos *et al*. (2011) reported that can be used the addition of 100 or 200 g vinasses/kg of concentrate for fattening lambs could reduce feed intake and growth rate but increased the feed:gain ratio.

Fodder conservation has the main objective of ensuring feed availability during periods of scarce feed supply (Mohd Najib *et al*., 1993). The silage has the way to preserve fodder for ruminant. The main objective of silage making is to conserve feed reserve for feeding during times of feed deficiency. Successful silage fermentation depends on anaerobic conditions and low pH. The low pH is usually accomplished through the fermentation of sugars in the crop to lactic acid by lactic acid bacteria, which decreases plant enzyme activity and prevents the proliferation of detrimental anaerobic microorganism, especially clostridia and enterobacteria (Yang *et al*., 2004).

Pineapple waste silage and leaves from baby corn canning factories have been used for cattle fattening and on dairy farms (FAO, 2002). Sweet corn residue contains 220±14.1 g/kg dry matter, 98±14.1 g/kg crude protein, 594 g/kg neutral detergent fiber, 374 g/kg acid detergent fiber and 9.8 MJ/kg metabolizable energy (Jaster *et al*., 1983). The low DM content of corn residue limits its length of storage. Ensiling might be a viable option to increase the economic value of sweet corn residue. Corn silage is forage for cows due to its high energy and low fiber content (Johnson *et al.*, 2002). However, the problem of poor quality corn silage can cause a low milk production (Coa *et al.*, 2010).

Fermented By Products (FBP) is by mean of silage as roughage source for ruminants. The FBP is composed of by-product from agro-industrial waste and agricultural by product (corn cob, corn husk, pineapple peel, vinasses and baggases). Suwannasin (2009) reported that FBP 7% crude protein and could be developed to 12% crude protein with the addition of anhydrous ammonia added when feeding FBP supplemented to rice straw in mid-lactation dairy cow, it could improve production efficiency and yielded higher economic return to farmers.

Rice straw is the main crop residue which farmers in Thailand usually store for use as ruminant feed. However, rice straw is low nutritive value with low of protein (2-5%DM), high fiber and lignin content (NDF>50%), low DM digestibility (<65%) (Wanapat *et al*., 1985). Suksombat (1996) reported that can be used roughage mixed (ground maize cob, cassava chip, ground leucaena leaves, molasses and urea) with vary ration of bagasse and rice straw. These result showed that no effect on milk yield and milk composition in dairy cow. While Sruamsiri *et al*. (2007) reported the ensiled pineapple wastes with rice straw (90:10) has 17.23% DM, 5.76% CP, 76.51% NDF and 44.56%ADF. The utilization of less traditional feeds such as by product combined with roughage sources may provide farmers with a variety of feeding options. By-product feeds are produced by a number of food processing industries, and such resources may impact traditional ruminate feeding practices by reducing the amount of concentrates fed to ruminants, providing feeding options when there is a scarcity of feed and reducing feed cost (Nkosi, 2009).

The objectives of this experiment were to evaluate fermented by-products (FBP) as roughage source in combination with rice straw on dry matter intake, ruminal fermentation characteristics, digestibility, milk yield and milk composition, blood metabolite, body weight change in dairy heifers and lactating crossbred Holstein Frisian cow.

OBJECTIVES

The experiments reported in this thesis were aimed, in general, to assess

1. To determine the nutritive values and fermentation characteristics of difference by-product sources to make FBP

2. To determine the effect of storage period of FBP on nutritive values andfermentation characteristics

3. To compare the effect of feeding FBP and other roughage sources on performance in dairy heifer

4. To compare the different proportion of FBP with rice straw on gas production and true digestibility

5. To compare the effect of feeding FBP on milk yield and milk composition, ruminal characteristic, digestibility and blood metabolites in dairy cow

LITERATURE REVIEW

1. Milk yield and Milk composition in dairy cow

A lactation pattern for an individual cow starts after calving. Milk production normally increases from the beginning to the peak of lactation in 60 to 90 days and then it decreases until the cow is dried off (Wood, 1967). Persistency of lactation is the ability of a milk animal to maintain milk production at a high level after reaching the peak yield. High persistency is associated with a slow rate of decline in yield following peak milk yield and low persistency is associated with a rapid rate of decline (Appuhamy *et al*. 2007). Lactation stage is one of the major factors influencing yield and composition of milk in cattle (Ibeawuchi and Dangut 1996).

The lactation pattern and milk yield could be influenced by genetic effects (Ferris *et al*., 1985; Rekaya *et al*., 2000) and non-genetic effects (Rekik *et al*., 2003).

1.1 Factors affecting milk composition

A number of factors affecting milk composition have been reported. The factors include feed and feeding practices, breed, seasons, lactation period, lactation number, milking technique and health condition (Davison *et al*. 1996).

1.1.1 Stage of lactation affects on milk protein and fat percentages very similarly. The highest amount of protein and fat in milk is found just after freshening, in colostrums. Levels drop to their lowest point between 25 and 50 days after calving and peak at 250 days as milk production begins to decrease.

1.1.2 Age tend to cause both milk fat and protein to decline as the animal becomes older. Milk fat falls about 0.2% each year from the first to fifth lactation likely as a result of higher production and more udder infections. Protein decrease 0.02 to 0.05% each lactation.

1.1.3 Season affect on milk fat and milk protein. The hot, humid month depress fat and protein content. There is a gradual increase of protein and fat in milk through the fall and peak levels occur in the colder month of winter. As temperatures increase through the spring, component levels are gradually decreased. These changes may be affect to feed intake, which are lower in summer due to change in weather and temperature.

1.1.4 Mastitis infections reduce fat and casein but increase blood protein. Somatic cell count (SCC) also is elevated during mastitis. The component value is reduced, plus in some federal orders there is deduction for SCC over 350,000. Milk fat and protein can occur from mechanical errors.

1.1.5 Different breeds of cattle have vary in average component levels (Table 1). Holsteins have the lowest fat and protein content, while Jersey and Guernsey breeds have the highest. Because Holsteins produce more milk, they generally have a higher total yield of fat and protein than other breeds.

Table 1 Average milk composition (%) of different breeds.

Breed	Fat	Protein	Lactose	Mineral	SNF	TS
Holstein	3.70	3.10	4.90	0.70	8.45	12.40
Brown Swiss	4.00	3.60	5.60	0.70	8.99	13.30
Ayrshire	4.10	3.60	4.70	0.70	8.52	13.10
Guernsey	5.00	3.80	4.90	0.70	9.01	14.40
Jersey	5.10	3.90	4.90	0.70	9.21	14.60

Source: Ensminger (1993)

1.1.6 Nutrition and feeding practices are most likely to cause problems of milk yield and milk composition. Milk fat depression can be alleviated within 7 to 21 days by changing the diet. Milk protein changes may take 3 to 6 weeks or longer. Milk fat can be changed by 0.1 to 1.0 percentage point, while protein is seldom altered more than 0.1 to 0.4 points by nutritional changes. Digestion of fiber in the rumen produces the volatile fatty acid (VFAs) acetate and butyrate. Butyrate provides energy for the rumen wall, and much of it is converted to beta-hydroxybutyrate in the rumen wall tissue. About half of the fat in milk is synthesized in the udder from acetate and beta-hydroxybutyrate. The other half of milk fat is transported from the pool of fatty acids circulating in the blood. Theses can originate from body fat mobilization, absorption from the diet, or from fats metabolized in the liver. Rumen microbes convert dietary protein into microbial protein, which is a primary source of essential amino acids for the cow. Theses amino acids are used by the mammary gland to synthesize milk proteins. Glucose is required to provide energy to support this protein synthesis. Glucose is either formed the VFA propionate in the liver, or absorbed directly from the small intestine. If too little propionate is absorbed from the rumen, the cow will have to breakdown amino acids and convert them to glucose (a process called gluconeogenesis); this can reduce the supply of amino acids available to make milk protein.

1.1.7 Body condition is essential so that high producing cows. If body stores are minimal, yields of milk and milk components will suffer. On the other hand, excessive body condition increase the risk of metabolic problems and calving difficulty. Weight loss in early lactation can increase milk fat content for the short period of time. Both thin and fat cows tent to have low milk fat in later lactation.

1.1.8 Energy effects as energy intake or ration energy density increase and/or fiber decrease, milk fat content will be reduced, while protein is increased. In contrast, as ration fiber levels increase and/or energy is reduced, milk protein is depressed and milk fat is increased. Lack of energy intake or lower ration digestibility may reduce milk protein by 0.1 to 0.4%. This reduction may result from underfeeding concentrates, low forage intake, poor quality forage, failure to balance ration for protein and minerals, or inadequately ground or prepared grains. Shifting rumen fermentation so that more propionic acid is produced to increase milk protein and decrease fat content. However, excessive energy intake, such as overfeeding concentrate, may reduce milk fat content and increase milk protein. Normal protein levels can be expected when energy needs are being met for most of the cows.

1.1.9 Protein effects a deficiency of crude protein in the ration may depress protein in milk; marginal deficiency could result in a reduction of 0.0 to 0.2%, while more severe restriction of diet crude protein would have greater impact. However, feeding excessive dietary protein does not increase milk protein, as most of the excess in excreted. Dietary protein has little effect on milk fat levels within normal ranges. Diet protein type also could affect milk protein levels. Use of non protein nitrogen (NPN) compounds, like urea, as protein substitutes will reduce protein in milk by 0.1 to 0.3%.

1.1.10 Concentrate intake such as an increase of concentrates cause a decrease in fiber digestion and acetic acid production. This creates an increase of propionic acid production. Propionic acid production encourages a fattening metabolism that is in opposition to milk fat. Addition of buffers to some rations may help to prevent acidosis; this will not change milk protein, but will increase milk fat content. The non fiber carbohydrate (NFC) portion of the diet is highly digestible and can influence both fat and protein in milk. Excessive amounts of NFC can depress fiber digestibility, which reduces the production of acetate and leads to low milk fat (1% or more reduction). At the same time, greater propionic production allows higher milk protein levels of 0.2 to 0.3%. Generally an NFC of 32 to 38% of ration dry matter is recommended to optimize production of milk fat and protein.

1.1.11 Forage level and physical form which Balance rations for lactating cows to contain at least 40 to 45% of ration dry matter from forage. Low forage intake can cause a major reduction in the fat content of milk due to low fiber levels. Several potential reasons for low forage intake are adequate forage feeding, poor quality forage and low neutral detergent fiber (NDF) content in forage that was cut too young. Forage NDF intake should be 0.9% of body weight daily. The low forage levels contribute to acidosis and laminitis. Protein and fat content also can be changed due to the physical form of forage being fed. Much of this is related to ration sorting and failure to provide a consistent diet throughout the day. Coarsely chopped silage and dry hay are the most common causes of sorting. At the other hand, very finely ground diets negatively affect rumen metabolism and depress fat and protein production.

1.1.12 Added Fat or oil Adding fat to the ration can affect milk component levels depending on the amount and source of fat. Fat is generally toxic to rumen microbes and may reduce fiber digestibility when fat from natural source exceeds 5% of ration dry matter. If rumen inert or bypass fat is used, total fat content may safely reach 6 to 7%. At low levels of dietary fat, milk fat content could increase slightly or show no change at all. Milk fat is reduced at higher levels, especially with polyunsaturated oils. If fat or oil is rancid, milk fat content decrease. Milk protein content may be decreased by 0.1 to 0.3% in high fat (Heinrichs, *et al*. 2011).

1.2 The composition of milk

Milk is the most unique and ideal food for all mammals including human. The composition of milk veries greatly as a consequence of numerous factors such as species, breed of animal (Ghosh and Ananta Krishnan, 1965), climate, lactation. The principal constituents of milk are water, fat, proteins, lactose, and minerals. Milk, also contains trace amounts of other substances such as pigments, enzymes, vitamins, phospholipids, and gases (Table 2). Teller *et al*. (1993) reported that higher milk protein content and protein yield due to increase nitrogen flow in the duodenum. They also suggested that higher molar proportion of propionic in the rumen may contribute to a higher milk protein content and protein yield. Milk fat is a mixture of different fatty acid esters called triglycerides, which are compounds of an alcohol called glycerol and various fatty acids. Fatty acids make up about 90% of milk fat. Dietary factors can greatly affect the composition of milk of dairy cows, and nutrition offers the most effective means of rapidly altering the composition of milk. Among milk components (fat, protein, lactose, minerals, and vitamins), fat and protein are the two most subjected to changes due to dietary manipulation (Parodi, 1997).

Table 2 Quantitative composition of milk

Main constituent	Limits of variation (%)	Mean value (%)
Water	85.50 – 89.50	87.50
Total solids	10.50 – 14.50	13.00
Fat	2.50 – 6.00	3.90
Proteins	2.90 – 5.00	3.40
Lactose	3.60 – 5.50	4.80
Minerals	0.60 – 0.90	0.80

Source: Dairy Handbook (1996)

Milk fat acid is originated from two sources, *de novo* synthesis and the uptake of preformed fatty acid (FA). Substrates for *de novo* synthesis are acetate and β-hydroxybutyrate produced during rumen fermentation. They are used by mammary epithelial cells for the synthesis of short and medium chain FA (4:0 to 14:0) plus a portion of the 16 carbon FA in milk fat. The remainder of the 16 carbon and all of the longer chain FA are derived from mammary uptake of circulating long chain FA that arise from digestive tract absorption and the mobilization of body fat reserves. In the dairy cow *de novo* synthesis and the uptake of preformed FA contribute approximately equally to milk FA (Bauman and Griinari, 2003). Milk fat is composed by two major groups of fatty acids. About 50 to 70% of the milk FA are those with long carbon chains (equal to or greater than 16 C). The other 30 to 50% are FA with less than 14 C (short and medium chain FA). Long chain FA are originated from dietary sources or from mobilization of adipose tissue and they are taken up by the mammary cells and incorporated into milk fat. The short chain fatty acids are synthesized *de novo* by the mammary gland from precursors such as acetate and butyrate. Generally, when milk fat is depressed, the FA that decrease are those with less than 16 C (Palmquist et al., 1993). This indicates that milk fat suppression is characterized by a decrease in *de novo* synthesis by the mammary gland. Dietary lipid is extensively metabolized in the rumen and this has a major impact on the profile of FA available for absorption and subsequent use by body tissue. FA in dietary lipids are mainly esterified and two major transfortmation occur when they enter the rumen (Palmquist et al., 2005). The first is hydrolysis of the ester linkages to yield free FA and the second is the biohydrogenation of unsaturated FA (UFA). Biohydrogenation involves only a few of the rumen bacteria species and they carry out these reactions as a protective mechanism against the toxic effects of PUFA. Linoleic acid (C18:2 n-6) and linolenic acid (C18:3 n-3) are the main PUFA in ruminant diets and their biohydrogenation results in stearic acid (C 18:0) being the major FA in outflow from the rumen and absorption from the small intestine. During the biohydrogenation process, transitory FA intermediates are also produced and some escape via rumen outflow and are subsequently absorbed. Two such FA that were initially identified are trans-11 C18:1 (Transvaccenic acid: VA) and cis-9, trans-11 conjugated linoleic acid (rumenic acid; RA) (Bauman and Lock, 2006). Conjugated linoleic acid (CLA) refer to mixture of positional and geometric isomers of linoleic acid (cis-9, cis-12 C18:2) with two conjugated double bonds at various carbon positions in the fatty acid chain. It is formed as an intermediate during biohydrogenation of linoleic acid by linoleic acid isomerase from the rumen bacteria *Butyrivibrio fibrisolvens* (Kritchevsky, 2000) or from the endogenous conversion of trans-11, C18:1 another intermediate of linoleic or linolenic acid biohydrogenation by Δ^9-desaturase in the mammary gland (Corl *et al.* 2001). Dietary increase of linoleic acid (C18:2) and linolenic acid (C18:3) is one of the feeding strategies for increasing the CLA concentration in milk which is the main precursor of CLA. The main sources of linoleic acid for feeding animals are cerials, oil seeds, oil etc (Kelly *et al*., 1998).

Table 3 Principle of fatty acids in milk fat

Fatty Acid	% of total fatty acid content	Melting point °C
Saturated		
Butyric acid	3.00 – 4.50	- 7.90
Caproic acid	1.30 – 2.20	- 1.50
Caprylic acid	0.80 – 2.50	+ 16.50
Capric acid	1.80 – 3.80	+ 31.40
Lauric acid	2.00 – 5.00	+ 43.60
Myristic acid	7.00 – 11.00	+ 53.80
Palmitic acid	25.00 – 29.00	+ 62.60
Stearic acid	7.00 – 13.00	+ 69.30
Unsaturated		
Oleic acid	30.00 – 40.00	+ 14.00
Linoleic acid	3.00 – 4.00	- 5.00

Source: Dairy Handbook (1996)

2. Vinasses

Fernández *et al*. (2009) reported that vinasses is a co-product generated by the fermentation of molasses to obtain alcohol, citric acid, yeasts, and other substances in the sugar industry. Vinasse provides NPN (mainly betaine, glutamic acid and ammonia). The distillation industries utilizing as raw materials several agricultural or agro-industial products and by products (Table 4). General scheme of molasse based industrial fermentation process is given in Figure 1. The leftover residue from ethanol production from molasses is called vinasses. The concentrated vinasse (CV) results from the thermal concentration of dilute vinasse (DV) (Parnaudeau *et al.*, 2008) (Figure 2).

Table 4 Main raw materials for alcohol production in Italy

Source	Products or by-product
Sugar industry	Beet molasses
	Cane molasses
Wine industry	Wine
	Wine lees
	Pressed grapes
Agricultural	Potatoes
	Carobs
	Other fruits

Source: Adaptation from Robertiello (1982)

In Thailand, Tumwasorn (2007) studied the chemical composition of vinasses from molasses and molasses as per details in Table 5. The chemical composition of vinasse can vary depending on the process by which it is obtained (e.g. drying, adding nitric acid or adding sulfuric acid) (Troccon and Demarquilly, 1989; Stemme *et al*., 2005). Vinasses can be used as a source of protein, fat, fiber, minerals for animal feed such as pigs, poultry and ruminant animal (GEA Wiegand GmbH, 2011). Vinasses has low fiber content may be represented almost totally by the glucans and mannans in the walls of the yeast used in the process (Hadalgo, 2009). For cattle, vinasses can be fed in fresh liquid, in condensed or in dried form, either alone or absorbed in citrus meal, maize cobs, bagasses, and other suitable material (Tumwasorn, 2007). In addition, Vinasses components are glycerol, lactic acid, ethanol, and acetic acid (Decloux and Bories, 2002; Dowd *et al*., 1994).

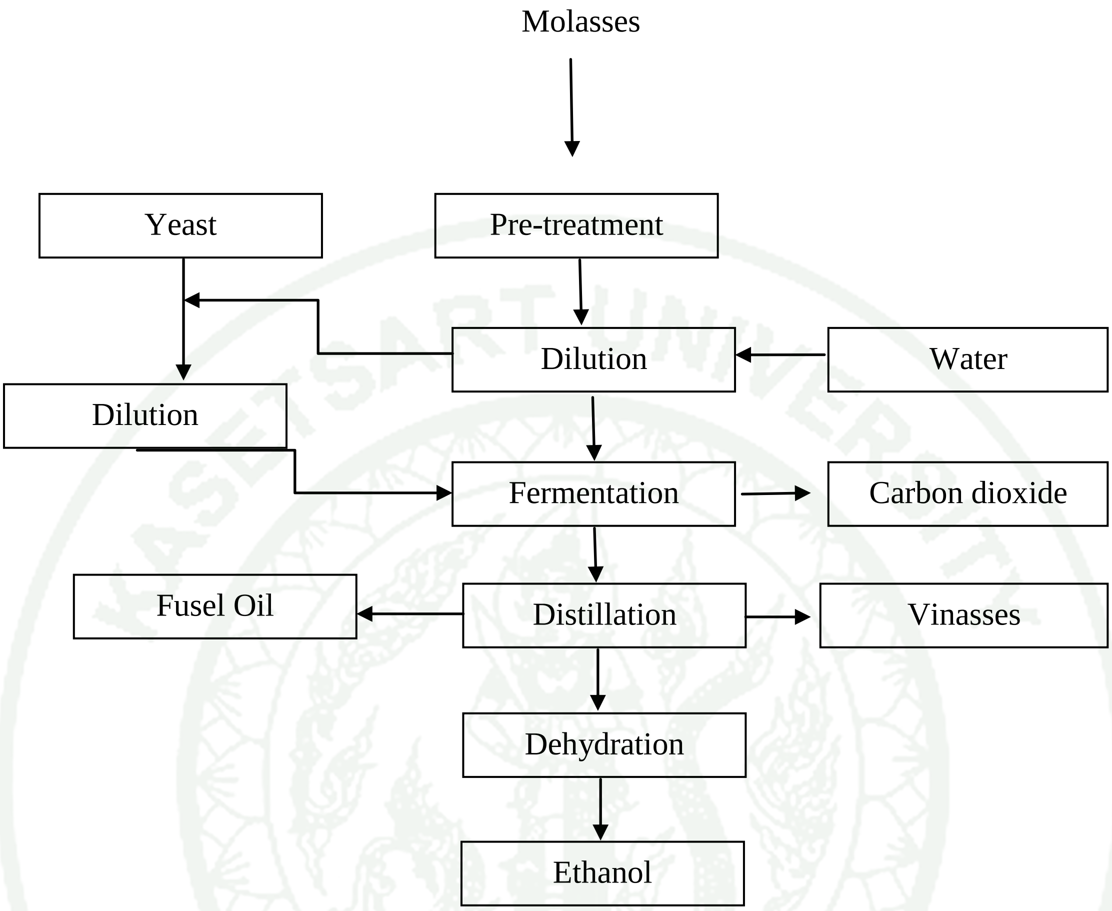

Figure 1 The Process of ethanol production from molasses

Source: Ministry of energy (2009)

López-Campos *et al*. (2011) reported that lambs fed 100 g and 200 g of vinasses per kg of concentrate and received barley straw as roughage source which reduce plasma glucose concentration and increase plasma urea. Furthermore, the addition of 100 g or 200 g of vinasses per kg of concentrate could reduce feed intake and growth rate and increase feed/gain ratio. The decrease in daily BW in group of lamb fed vinasse could be due to reduction in the energy intake. Indeed, the plasma concentration of glucose was less in the lambs that received vinasse, which could suggest a decrease in the contribution of glucose or glycogenic substrates. The increase of plasma urea in group of lambs fed vinasse because of the nitrate concentration in the vinasse transformed into ammonia in the rumen, which can be used by ruminal microorganisms for protein synthesis or absorbed through the ruminal wall to reach the liver and be transformed into urea (Cawley and Collings, 1977). Thus, lambs fed 200 g of vinasses per kg of concentrate showed the greatest concentration of urea in to the plasma. Furthermore, Fernández *et al* (2003) observed that supplementing cereal straw with vinasse increased the total intake and decreased the BW loss in sheep in comparison with animals that did not consume this co-product. In another study, the ewes received a diet based barley straw and supplement with vinasse would have improved the supply of protein, increasing the degradability of straw in the rumen and the voluntary intake.

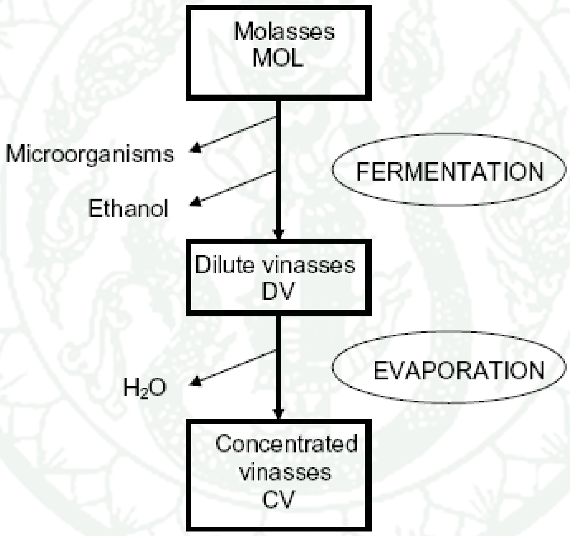

Figure 2 Industrial fermentation process leading to vinasse generation

Source: Parnaudeau *et al*. (2008)

Table 5 The chemical composition of vinasses as dry matter basis (g/100g.)

Items	Molasses	Vinasses
Dry matter (g/100g.)	78.98	35.56
Crude protein (g/100g.)	5.06	12.43
Ether extract (g/100g.)	0.44	0.51
Carbohydrate (g/100g.)	87.76	67.00
Ash (g/100g.)	8.62	20.05
Phosphorus (mg/100g.)	0.06	244.94
Potassium (g/100g.)	2.13	4.64
Iron (mg/kg.)	105.34	247.26
Copper (mg/kg.)	8.26	4.10
Magnesium (g/100g.)	85.10	176.07
Calcium (g/100g.)	1.21	2.09
Gross energy (cal./g)	3,683.00	3,223.00

Source: Tumwasorn (2007)

3. Bagasse

Many fibrous by product have a substantial potential value as animal feedstuffs. Ruminants, especially, have the unique capacity to utilize cellulose, because of their microbes (Boucqué and Fiems, 1988). By products from sugarcane plantations and the sugar industry are sugarcane tops, sugarcane leave, bagasse and molasses. Bagasse is the highly fibrous remaining after sugarcane is pressed to remove sucrose. Bagasses have been developed and its accumulation presents a waste problem for the sugar industry (Rivers, 1988). Bagasse is not commonly used as cattle feed due to its high lignin and cellulose content. Chemical or combined chemical and physical treatments are generally more effective. Chemical treatment is required to improve its nutritive value of baggase (Kongngoen *et al.*, 1993).

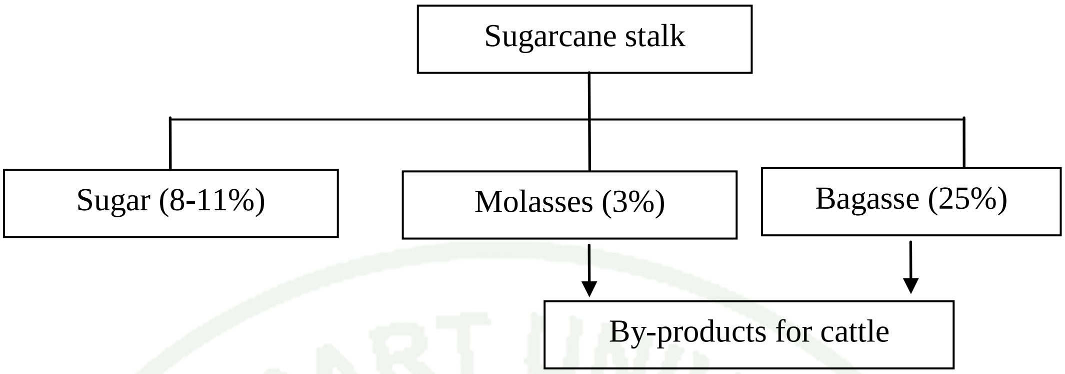

Figure 3 Percentage of by-products from sugarcane ready to use as cattle feed

Source: Kongngoen *et al.* (1993)

Sugar cane is widely planted in Thailand to deliver to sugar mill for sugar production. It is easy to establish, grows, quickly and is abundant in Thailand. It ripening age corresponds with the period of low pasture availability, eliminating the need for storage and related equipment and facilities. Additional advantages of sugar can include high biomass level and nutritional value (Suksombat and Meankrathoke, 2005) Sugarcane bagasse are high lignocellulose. Roughly three quarters of straw is cellulose plus hemicelluloses. Bagasse also contains more than 60% of its dry matter in the form of cellulose and hemicellulose but its degradability is very poor. One of the main reasons for this depression in degradability is the presence of lignin which protects carbohydrates from attach by the rumen microbes. Sugarcane bagasse contains around 50% cellulose, 27.9% hemicelluloses, 9.8% lignin and 11.3% cell contents (Kewalramani *et al*. 1988). Furthermore, Kongngoen *et al.* (1993) reported that bagasse has 46-52% moisture, 43-52 % crude fiber and 2-6 % soluble solids (brix) and Kukwan (2000) reported that the chemical composition of bagasse was shown in Table 6.

Table 6 The Chemical composition of bagasses as dry matter basis

Items	bagasses
DM	55.50
CP	1.40
EE	0.50
CF	41.70
Ash	1.70
NDF	87.60
ADF	54.60
GE	1,760.00

Source: Kukwan (2000)

Research on feeding whole sugar cane to lactating dairy cow is very limited. Pate (1981) fed fresh chopped sugar cane to growing-finishing steer and showed that increasing levels of sugar cane in the diet resulted in less DM intake which would limit rate of gain. It is known that sugar cane fiber has a low intake. Kawashima *et al*. (2002) fed chopped sugar cane together with rice straw or rice straw as roughage source for dairy cattle and found no significant difference in milk yield between the two groups.

4. Cornhusk and corncob

The main waste from corn production that is available for roughage source is the corn stover (the stalk and leaves after harvesting), the corn husk, the leaves and the cobs. It is commonly found in corn factory (sweet and baby corn production) that the stover is usually harvested and chopped for use as roughage for dairy cattle. Sweet corn residue is a by-product from processing of sweet corn for human consumption. It is contained for 60-70% of the initial harvest yield and consists of husk leaves, cobs, discarded kernels and small amounts of stalk (Fritz *et al*. 2001). For dairy production, corn stover could be used as a roughage source both in its fresh and in ensiled from. Stover form baby corn production has a higher nutritive value than corn stover from sweet corn production (Kongngoen *et al*., 1993). The residue, such as stover or cob and husk can be used as roughage for ruminant. However, the low protein but high fiber content is the limitation of the utilization. The quality of residue from corn production may be improved by physical treatment, such as steaming under pressure or chemical treatment with acid and alkaline (Saha, 2003). The chemical composition of corn stem, corn husk and corn cob were show in Table 7.

Table 7 The chemical composition of corn stem, corn husk and corn cob as dry matter basis

Items	Corn stem	Corn husk	Corn cob
DM	22.80	28.00	27.50
CP	6.50-9.10	6.53	7.10-8.01
EE	1.00-3.20	1.01	2.20-2.24
CF	30.50-36.20	36.25	23.57
NFE	47.60	-	-
Ash	9.70	-	-
NDF	68.20-69.30	68.19	69.30-71.80
ADF	38.20-48.10	48.13	28.20-33.60
Lignin	5.30	-	5.60

Note: (-) mean data not detect.

Source: Department of Livestock Development (2011)

Sweet corn residue was well ensiled as indicated by low pH, low WSC (water soluble carbohydrate) and ammonia concentrations and high lactic acid concentration. The chemical composition of sweet corn residue compared sweet corn residue ensiled was presented in Table 8. The CP content was similar for sweet corn by product, average 9.70 % of DM basis. Both by-products contained similar level of ash, NDF and ADF.

Table 8 Ensiled characteristics and chemical composition of sweet corn residues (DM)

Chemical composition (%)	As collected	Ensiled
DM	24.30	23.90
Ash	3.60	3.40
CP	9.90	9.60
NDF	57.10	58.20
ADF	30.10	28.30
pH	-	3.45
Lactic acid	-	0.51
WSC	-	0.71
Ammonia nitrogen	-	1.40

Source: Mustafa *et al*. (2004)

5. Pineapple peel

Pineapple, one of the important economic plants, is usually consumed fresh, or as pineapple juice, fruit pulp or canned. Pineapple residue is a by-product of the pineapple processing industry and consists basically of the residual pulp, peels, and skin with high moisture content. By-products can account for a large proportion (70-75% w/w) of a crop.Whilst the pineapple crop production in Thailand was 2.5 million tons in 2008 (OAE, 2009), much of this in areas of Petchaburi and Prachuap Khiri Khan provinces ($1.0x10^6$ tons) it resulted in $1.6x10^6$ to $1.7x10^6$ tons of processing wastes. These residues, like many other agricultural wastes, can cause serious environmental problems from both solid wastes and their effluents (Correia *et al.*, 2004). Pineapple waste is a by-product from pineapple production and cannery plants, consisting of the crown, core, peel, leaves and waste from flesh trimming. Farmers currently use pineapple waste as cattle feed because of its palatability. This waste is high in moisture content and soluble carbohydrate, so it decays very quickly. Drying and ensiling are preservative methods that are commonly accepted by farmers.

Ensiling pineapple waste or pineapple waste mixed with rice straw can retain its nutritive value very well. Dried pineapple waste and ensiled pineapple waste can be used as supplemental roughage and can be replaced 50% of roughage in the total mixed ration for dairy cattle without adversely affecting animal production (Choopheng *et al*., 2005; Jitramano *et al*., 2005). Suchart *et al.* (2011) reported that dry matter intake in cattle were fed 100% ensiled pineapple (PA) waste, 65% PA and 35% pangola hay (HAY), 35% PA and 65% HAY and 100% HAY was not significantly different among treatments (P>0.05). Apparent digestibility of DM, OM, CP, NDF and ADF in cattle fed only PA as roughage source was higher (P<0.05) than in cattle fed only HAY. Ruminal temperature, pH and ammonia-nitrogen concentration were not different among treatments (P>0.05). Acetic acid, propionic acid and butyric acid concentrations were not significantly different (P>0.05) among dietary treatments. Furthermore, Blood urea-nitrogen was similar among dietary treatments. In conclusion, PA is promising to use as a roughage source for Southern Thai native cattle.

6. Silage

Fodder conservation has the main objective of ensuring feed availability during period scarce feed supply (Mohd Najib *et al*., 1993). Fodder conservation can be achieved in three ways by sun-drying, artificial drying and addition of acids or fermentation. Silage is defined to be forages, crop residues or agricultural and industrial by products preserved by acids, either added or produced by natural fermentation by anaerobic bacteria in the absence of air (T' Mannetje, 1999). The main objective of silage making is to conserve feed reserve for feeding during times of feed deficiency. Silage is a forage preservation method based on a spontaneous lactic acid fermentation under anaerobic conditions. Ensiling is based on anaerobic fermentation of water soluble carbohydrate (WSC) into lactic acid, and volatile fatty acid (VFA) by lactic acid bacteria (LAB). Due to the production of these acids the pH of the ensiled material decrease and spoilage microorganisms are inhibited. Air is also detrimental during storage because it stimulates the growth of yeasts that metabolize lactic acid, which results in loss of nutrients (Woolford, 1990). Once the fresh material has been stacked and covered it exclude air, the ensiling process can be divided into 4 stages (Weinberg and Muck, 1996).

Phase 1, aerobic phase. This phase normally only take a few hours in which the atmospheric oxygen present between the plant particles is reduced, due to the respiration of the plant material and aerobic and facultative aerobic microorganisms such as yeasts and enterobacteria. Furthermore, plant enzymes such as proteases and carbohydrase are active during this phase, provided the pH is still within the normal range for fresh forage juice (pH 6-6.5) (Weinberg and Muck, 1996).

Phase 2, fermentation phase. This phase starts when the silage becomes anaerobic, and it continues for several days to several weeks, depending on the properties of the ensiled forage crop and the ensiling conditions. If the fermentation proceeds successfully lactic acid bacteria develop, and become the predominant population during this phase. Due to the production of lactic acid other acids the pH decrease to 3.8-5.0 (Weinberg and Muck, 1996).

Phase 3, stable phase. As long as air is prevented from entering the silo, relatively little occurs. Most microorganisms of phase 2 slowly decrease in numbers. Some acid tolerant microorganisms survive this period in an almost inactive state, others such as clostridia and bacilli survive as spores. Only some acid tolerant protease and carbohydrates and some specialized microorganisms, such as *Lactobacillus buchneri* continue to be active at a low level (Weinberg and Muck, 1996).

Phase 4, feed-out phase or aerobic spoilage phase. This phase starts as soon as the silage gets exposed to air. During feed-out this is unavoidable, but it can already start earlier due to damage of the silage covering. The process of spoilage can be divided into two stages. The onset of deterioration is due to the degradation of preserving organic acids by yeasts and occasionally acid bacteria. This will cause rise in pH, and thus the second spoilage stage is started, which is associated with increasing temperature, and activity of spoilage microorganisms such as bacilli. The last stage also includes the activity of many other (facultative) aerobic microorganisms such as moulds and enterobacteria. Aerobic spoilage occurs in almost all silages that are opened and exposed to air. However the rate of spoilage is highly dependent on the numbers and activity of spoilage organisms in the silage. Spoilage losses of 1.5-4.5% dry matter loss/day can be observed in affected areas. These losses are in the same range as losses that can occur in airtight silos during several months of storage (Honig and Woolford, 1980). The change of product ensiling was shown in figure 4.

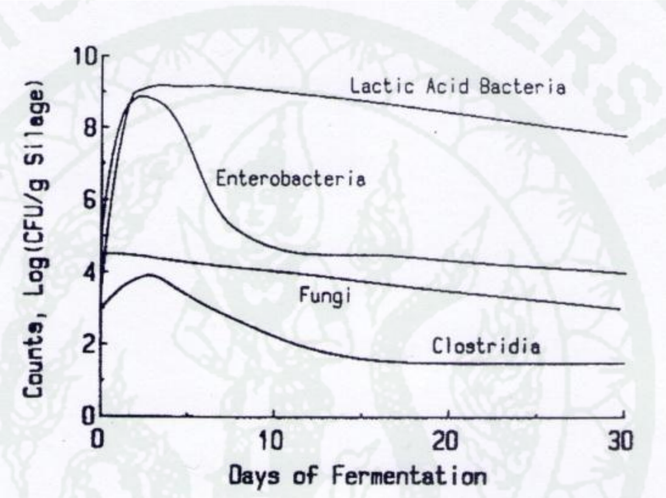

Figure 4 Change of product at fermentation process

Source: Muck (1991)

The pool of naturally occurring lactic acid bacteria consists of both homolactic and heterolactic bacteria (Pahlow *et al*., 2003). Homofermentative LAB produce two molecules of lactic acid from the fermentation of WSC, whereas heterofermentative LAB produce one molecule of lactic acid and molecule of other products (acetic, propionic, ethanol) (Kung and Ranjit, 2001).The silage microflora plays a key role in the successful outcome of the conservation process. The flora can basically be divided into two groups namely the desirable and the undesirable microorganisms. The desirable microorganisms are the lactic acid bacteria. The undesirable ones are the microorganisms that can cause anaerobic spoilage (e.g. clostridium and enterobacteria) or aerobic spoilage (e.g. yeasts, bacilli, listeria and moulds) (Weinberg and Muck, 1996) (Figure 5).

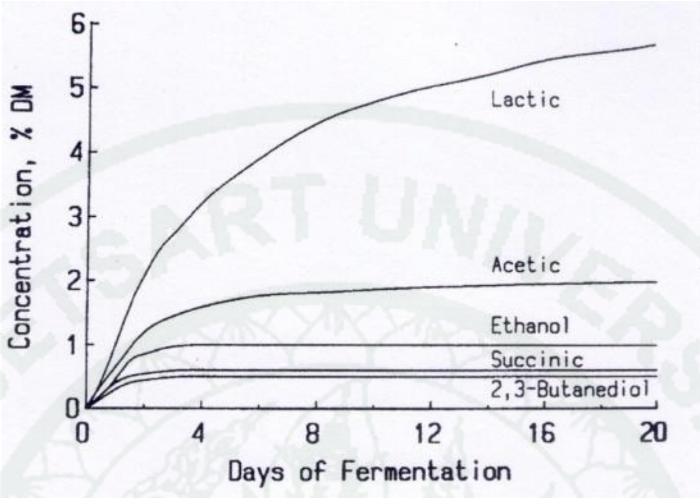

Figure 5 Change of microorganism at fermentation process

Source: Muck (1991)

The chemical standard of fermentation process was presented in table 9.

Table 9 The chemical standard of silage

Chemical composition	Standard
pH	4.20
Lactic acid	3.00-13.00%
Butyric acid	<0.2%
NH_3-N	<11.00 of nitrogen

Source: Catchpoole and Henzell (1971)

7. The effect of silage as roughage source in dairy cow

Corn silage is ideal forages for dairy cow due to its high energy and low fiber content. The fermentation analysis can tell an excellent, average or poor fermentation of corn silage has occurred. The normal ranges for fermentation and product of corn silage and grass silage was showed in Table 10.

Table 10 Typical concentrations of common fermentation end products in corn silage, legume silage and grass silages (DM =30-40%)

End product	Corn silage	Legume silage	Grass silage
pH	3.7-4.2	4.3-4.7	4.3-4.7
Lactic acid (%)	4.0-7.0	7.0-8.0	6.0-10.0
Acetic acid (%)	1.0-3.0	2.0-3.0	1.0-3.0
Propionic (%)	<0.1	<0.5	<0.1
Butyric acid (%)	0	<0.5	0.5-1.0
Ethanol (%)	1.0-3.0	0.2-1.0	0.5-1.0
Ammonia-N (% of CP)	5.0-7.0	10.0-15.0	8-12

Source: Kung and Shaver (2001)

However, cereal silages such as corn silage are susceptible to spoilage because of higher concentrations of lactic acid and WSC which the substrate for fungi development. Homofermentative LAB (such as *Lactobacillus plantarm*) increase lactic acid and decrease VFA, ammonia nitrogen and pH in silage (Kleinschmit and Kung, 2006)

Sruamsiri *et al*. (2007) was carried out the chemical composition of agro-industrial by product that the average CP contents was showed in Table 11. These result showed that all of by products were not a good roughage source and should not be used as the main roughage for ruminants because of their low contents of CP and

DM. However, baby corn husk was the highest in CP content (9.88%) but the lowest in NDF and ADF contents (54.44 and 22.38%). The physical characteristic of ensiled pineapple wastes with or without rice straw were in a good condition even though their DM content was lower than optimal range of ensiling products. These might be due to the high NFE contents in pineapple waste especially fructose which are converted to lactic acid by lactic acid bacteria. Moreover, the supplement of rice straw increased DM content of the silage but decreased in CP content.

Table 11 Chemical composition of agro-industrial by product

Items	**DM (%)**	**% of DM**		
		CP	**NDF**	**ADF**
Baby corn husk	19.35	9.88	54.44	22.38
Pineapple wastes	9.12	7.32	78.98	31.45
Ensiled pineapple waste	8.11	7.42	70.43	34.58
Ensiled pineapple waste with rice straw (90:10)	17.23	5.76	76.51	44.56
Passion fruit peel	16.65	6.34	45.72	36.54
Ensiled passion fruit peel	18.76	7.06	44.68	32.25

Source: Sruamsiri *et al*. (2007)

The chemical composition of ensiled sweet corn cob and husk (ESCH) could be used as roughage sources for ruminants even though their CP contents were lower than 8% and the DM contents were lower than 20%. Furthermore, increasing Ipil-Ipil leaves in the silage tended to increase DM and CP contents, but the average percentages of organic matter (OM), CF, NDF and ADF tented to decrease with increasing Ipil-Ipil leaves in the silage (Table 12).

Table 12 Chemical composition (% of DM) of ensiled sweet corn cob and husk (ESCH) without or with Ipil Ipil leaves (IL)

Item	DM	OM	CP	NFE	NDF	ADF	pH
IPIL-IPIL leaves	33.76	91.62	18.15	50.79	63.47	28.60	-
ESCH	18.73	96.54	9.13	59.21	74.27	31.94	3.92
ESCH+10%IL	18.89	96.38	12.29	58.19	72.92	30.80	4.04
ESCH+20%IL	19.47	95.52	13.57	55.89	69.47	30.62	4.15
ESCH+30%IL	20.69	95.18	14.08	53.98	68.42	30.28	4.32

Source: Adaptation from Sruamsiri *et al*. (2007)

The digestibility of ESCH with or without Ipil-Ipil was showed in Table 13. Cattle fed ESCH+IL consumed slightly higher dry matter content than the ESCH. The supplement of Ipil-Ipil leaves in the silages, which provided more nutrients, especially nitrogen for microbial growth and activities. ESCH had lower apparent digestibility of DM, OM and CP than the other treatments and no significant differences among groups were found on apparent digestibility of CF, EE and ADF

Table 13 Apparent digestibility of ensiled sweet corn cob and husk (ESCH) with or without Ipil-Ipil leaves (IL) in 4 native beef cattle

Apparent digestibility, %	ECSH	ESCH+10%IL	ESCH+20%IL	ESCH+30%IL
DM	52.77±6.12^{c}	66.24±5.33^{ab}	70.32±3.24^{a}	60.28±4.11^{b}
OM	56.90±5.68^{c}	68.09±4.21^{a}	73.34±4.53^{a}	63.68±5.37^{b}
CP	49.27±5.22^{c}	56.08±5.13^{b}	68.59±1.88^{a}	55.49±3.26^{b}
CF	62.41±5.08	64.50±3.17	61.42±1.02	57.44±3.86
EE	75.68±2.45	81.43±3.01	82.40±2.32	76.82±1.87
NFE	53.96±4.13^{b}	69.05±3.76^{a}	73.52±3.17^{a}	67.57±3.34^{a}
NDF	59.34±4.11^{b}	63.34±2.68^{b}	72.27±1.91^{a}	62.54±4.16^{b}
ADF	46.53±4.28	52.00±4.02	53.93±3.24	49.73±1.85

Table 13 (Continued)

[a, b, c]Means in the same row with different superscripts differ (P<0.05)

Source: Sruamsiri *et al*. (2007)

Phipps *et al*. (1995) reported that dairy cows have higher intakes of corn silage based diets than diets based on grass silage as the sole forage. Milk production and milk protein concentration have also been increased by replacing grass silage (GS) with maize silage (MS). Ó Mara *et al*. (1998) studied that the effect of replacing high digestibility grass silage with MS on milk production and forage intake of Friesian cows. Cows were fed 6 kg/d (fresh weight) of concentrates and one of four forage: (1) all GS (2) 67:33 GS:MS (3) 33:67 GS:MS and (4) all MS. Concentrate crude protein (CP) level was varied to equalize total dietary CP. The grass silage and maize silage had different CP contents and these concentrates were formulated to provide similar dietary CP concentrations on all treatment. The chemical composition of grass silage and maize silage was showed in Table 14. Silage DM intakes were 8.8, 9.7, 10.4 and 10.7 kgDM/d for treatment 1 to 4, respectively. The intake on treatment 1 was significantly lower than treatment 3 and 4 (P<0.01 and P<0.001, respectively). Milk yields were 21.4, 23.0, 23.1 and 22.7 kg/d for treatment 1 to 4 respectively. The differences in milk yield between the GS only and the two GS:MS mixtures were significant (P<0.05). Maximum milk protein concentration and yield of fat and protein were achieved on the mixed forage diet containing 67% maize silage (Table 15). The results showed that moderate quality MS can successfully replace a high proportion of high digestibility GS in dairy cow diets.

Table 14 Chemical composition of the grass silage and maize silage (g/kg of DM)

Items	**Grass silage**	**Maize silage**
DM (g/kg)	223	257
Ash	88	64
CP	155	91
Starch	-	219
pH	3.91	3.98
Ammonia N (g/kg of total N)	109	66
Modified acid detergent fiber	306	272
Neutral detergent fiber	525	565
Ethanol	8.7	4.4
Acetic acid	26.9	13.8
Propionic acid	2.8	1.6
Butyric acid	2.1	0.9
Lactic acid	138	46
In vitro DM digestibility (g/kg)	759	694

Source: O´ Mara *et al*. (1998)

Table 15 Mean silage dry matter (DM) intake, milk yield, milk composition and live weight change for cows on the four experimental treatments

	Grass silage : maize silage				
	100:0	**67:33**	**33:67**	**0:100**	**SE**
Silage DM intake (kg/d)	8.8^{b}	9.7^{ab}	10.4^{a}	10.7^{a}	0.35
Milk yield (kg/d)	21.4^{b}	23.0^{a}	23.1^{a}	22.7^{ab}	0.48
Milk composition (g/kg)					
Fat	37.7	36.7	37.6	37.4	0.73
Protein	30.6	31.0	31.6	30.9	0.04
Lactose	46.5	46.5	45.8	46.0	0.02

Table 15 (Continued)

	Grass silage : maize silage				
	100:0	**67:33**	**33:67**	**0:100**	**SE**
Mean liveweight (kg)	505	511	521	500	11.3
Liveweight change (kg/d)	0.10[b]	0.13[ab]	0.39[a]	0.33[a]	0.071

[a,b,c] Within rows, means not sharing a common superscript differ significantly (P<0.05)

Source: Adaptation from Ó Mara *et al.* (1998).

Dönmez *et al.* (2003) studied the corn silage treated with 5% of molasses on concentration and percentages of VFAs. The result showed that Acetic acid was significantly lower (P<0.05) in sheep fed corn silage treated with molasses compared with other treatments (0.05% formic acid and 10 g/t enzyme), but propionic acid and butyric acid concentrations were similar among treatments and ranged from 60-67% for acetic acid, 16-20% for propionic acid and 12-17% for butyric acids. Ruminal ammonia nitrogen concentration ranged from 7.71-15.87 mg/dl.

8. The effect of PMR as roughage source on dairy cow

Suwannasin (2009) studied the use of by products from agro-industry such as bagasse, sweet corn waste and vinasses to produce partial mixed ration (PMR) for dairy cow feed. The PMR was produced in two levels of crude protein that compose of PMR 7%CP and PMR 12%CP (anhydrous ammonia). Fifteen crossbred cows (50% Holstein Friesian 37.5% Brahman and 12.5% native) were 3 treatments feeding: Treatment 1 cows were fed concentrate (16% CP) at 6 kg/head/day and fed *ad libitum* rice straw (control group), Treatment 2 cows were fed concentrate (16% CP) at 4 kg/head/day and 8 kg/head/day PMR 7%CP and fed *ad libitum* rice straw, Treatment 3 cows were fed concentrate (16% CP) at 4 kg/head/day and 8 kg/head/day PMR 12%CP and fed *ad libitum* rice straw. Cows fed rice straw were highest total DM intake (P<0.05). However, cows fed PMR 7%CP and PMR 12%CP were higher body weight change and average daily gain than cows fed rice straw ($P<0.05$). Actual milk yield and 4% FCM in cows fed with PMR were highest (Table 16). It was conclude that PMR 7%CP and PMR 12%CP can be used as feed for dairy cow.

Table 16 Mean of milk production and composition between cows fed different treatments

Items	Control group	PMR 7%CP	PMR 12%CP
Actual milk yield (kg/d)	4.80^{c}	5.82^{b}	6.38^{a}
4% FCM	6.39^{c}	7.18^{b}	7.38^{a}
Milk composition (%)			
-Fat	5.97^{a}	5.24^{b}	4.82^{b}
-Protein	3.22^{a}	3.03^{b}	2.97^{b}
-Solid not Fat (SNF)	8.96^{a}	8.45^{b}	8.31^{b}
-Total Solid (TS)	14.93^{a}	13.70^{b}	13.13^{b}

Source: Suwannasin (2009).

9. Blood metabolite

The change in blood metabolite concentration could be associated with change in diet (Blowey *et al*, 1973). Parker and Blowey (1976) investigated the relationship of blood components to nutrition and fertility of the dairy cow. They found that the most consistent correlations were the regressions of starch intake to non esterified fatty acids and the ratio of starch and protein intake to plasma urea. The blood metabolite concentrations were used as parameters of the nutritive background (Butler, 1998).

9.1 Glucose

Plasma glucose (GLU) is an important source of energy for many cell. GLU in plasma normally maintain by the breakdown of dietary carbohydrate and a rather complex system of endogenous production (Keneko *et al*., 1997). Endogenous glucose product results from glycogenolysis (glycogen broken down to glucose in the liver) and effect from gluconeogenesis. The maintenance of normal plasma glucose requires delicate balance of glucose availability with glucose utilization. Glucose is not the only energy source, which fuels the energy requirement of the body tissue, fatty acids, protein and other substances also provide energy. However, glucose is an obligate fuel for central nervous system (NRC, 1984). Many hormones are involved with glucose regulation (glucagon, epinephrine, cortisol and insulin). Insulin secreted from B cells of the pancreas is the most noteworthy and dominant glucoregulatory factor. Insulin primarily stimulates glucose utilization by a variety of insulin sensitive tissues including muscle, fat and liver. Small changes in insulin result in substantial changes in blood glucose values (Bogin, 1994). An increase in insulin will generally lower plasma glucose levels. Glucagon, epinephrine and cortisol are all glucose raising hormones. Glucagon acts on the liver by stimulating both glycogenolysis and gluconeogenesis (Guyton and Hall, 2006). Epinephrine both limits glucose utilization and stimulates its production. Bulent *et al.* (2006) reported exponent decrease in serum glucose concentration as the parturition approached in dairy cattle and the significant decrease in blood glucose level during late pregnancy signifies rapid utilization of glucose towards the fag end of the pregnancy. Cows generally go ketoic during third trimester (Mandali *et al*., 2002) and insufficient feed intake during the winter months may also result in the lower glucose levels in pregnant cows. Several worker have reported blood glucose level in cattle averaging 2.40±0.03 mmol/l (Prudhvireddy *et al*., 2003), 2.72±0.22 and 2.33±0.13 mmol/l (Nath *et al*., 2004), respectively.

9.2 Blood urea nitrogen

Blood urea nitrogen is a nutritional indicator related to protein intake and is formed in the liver. Moreover, is mainly excreted by the kidneys (Keneko *et al.*, 1997; Coppo, 2004). Consequently, urea is useful in evaluating kidney function in conjunction with creatinine, which originates from the muscle and filtered by the kidney (Jain, 1996). The majority of the blood urea nitrogen is synthesized in the liver from ammonia. Once formed, urea diffuses freely throughout all body fluids. The kidney is the most important route of urea excretion and as a result. Urea has long been used as a barometer of renal function appears in the glomerular filtrate in the same concentration as is found in the blood. This filtration process does not require energy (Keneko *et al*., 1997). Blood urea has been used as an indicator of the balance between the availability of dietary degradable protein (RDP) and fermentable carbohydrates in the rumen (Firkins, 1996) and of protein metabolism and status in dairy cows (Roseler *et al.*, 1993). NH_3 that is synthesized to urea by the liver can originate from an excess of dietary RDP and deamination of absorbed protein to yield energy substrates (Oldham, 1984).

9.3 Triiodothyronine (T3)

Triiodothyronine is amine hormone which produce by thyroid gland. There are 2 types (Triiodothyronine and Thyroxine). The concentration of T3 was lower than Thyroxine (T4) within blood . The effect of T3 was higher than T4. 85% of T3 was produced by T4. Thyroid hormone, ether T4 or T3, are known to be associated with adjustments of ungulates to changed environment (Habeeb *et al.,* 1992). High ambient temperatures seem to have a direct influence in decreasing thyroid activity, and this effect is probably initiated at the hypothalalmic level (Yousef and Johnson, 1985). Thyroid activity appears to respond similarly to feed intake and metabolism (Johnson and Vanjonack, 1976). The decrease in thyroid hormones results in a decrease in basal metabolic rate and muscle activity, both effects which decrease heat production (Kamal and Ibrahim, 1969). Lower feed intake, another typical response to high temperatures, also leads to reduced thyroid activity (Magdub *et al.*, 1982). The process of produce these hormone depend on the amount of iodine and tyrosine amino acid. The level of the concentration of T3 and T4 were different among animals which was shown in Table 17 (Dunlop, 1991)

Table 17 Mean and range of Thyroxine (T4) and Triiodothyronine (T3) hormone in the serum of the animal

Type of animal	**Thyroxine (μg/dl)**	**Triiodothyronine (ng/dl)**
cattle	6.0 (3.6-9.0)	90.0 (40.0-170.0)
goat	3.5 (3.5-4.2)	45.0 (90.0-190.0)
sheep	4.5 (3.0-6.0)	100.0 (60.0-150.0)
horse	1.5 (1.5-2.4)	75.0 (30.0-160.0)
swine	3.5 (1.7-2.4)	90.0 (40.0-14.0)

Source: Dunlop (1991)

Thyroid hormone was affected on growth performance which stimulated metabolism of protein, carbohydrate, fat and vitamin (Dunlop, 1991). Furthermore, thyroid hormone which affect on protein formation and absorption. The optimum level of thyroid hormone could stimulate the metabolism of protein. The low feed intake could affect on decrease thyroid hormone and reduce to change T4 to T3.

9.4 Non esterified fatty acid (NEFA)

The concentration of NEFA is the parameter to indicate in the rate of mobilization of adipose tissue (Åkerlind *et al.*, 1998). Concentrations of NEFA in plasma concur with the lack of mobilization of body fat (LeBlanc *et al.*, 2005). The plasma concentration of non-esterified fatty acid is an index of the magnitude of the mobilization of adipose tissue in dairy cattle (Bauman *et al.*, 1999). NEFA have been shown to negatively correlated with energy balance (Erfle *et al.*, 1974) and in lactating dairy cows are highest immediately post partum. Serum NEFA is an indicator of the mobilization of body fat (Kronfield, 1982).

10. Rumen ecology

Ruminants can better utilize forage compared with mono-gastric animals because they possess microorganism in their rumen, which release enzyme to digest forages (Jounay, 1989). The rumen has an important role and function in preparing fermentation end product for biosynthetic processes of ruminants. It is therefore essential that the rumen is healthy and is able to establish an optimum ecology in order to perform well with regard to rumen microorganisms (bacteria, protozoa and fungi), pH substrates (roughage, energy, effective fiber), fermentation end product (NH_3-N, VFAs) and microbial synthesis VFAs, particularly propionic (C3), acetate (C2) and butyrate (C4) are major sources of energy and allow the synthesis of glucogenic and lipogenic compounds. The concentration of total VFAs highly differs among diets. The total VFAs concentration in the diet range from 70-130 mmol/l (France and Siddons, 1993). While NH_3-N is an essential sources of nitrogen for microbial protein synthesis. The established rumen was affected by types of feed and roughage to concentrate ratios, and these consequently influenced the population of microorganisms and fermentation pattern. There are significant differences in type of feed and quality between temperate and tropical feed resources which would likely influence rumen microorganisms and the fermentation nutrient pool (Wannapat, 2000), Futhermore, different feeding systems prevailing in these regions would affect on rumen ecology. In ruminants fed on temperate feeds, increasing levels of concentrates dramatically lowered rumen pH and resulted in acidosis (Slyter, 1976). VFAs decreased rumen pH but lactic acid accumulating in the rumen had a more pronounced effect (Burin and Britton, 1986). When readily fermentation carbohydrates are fed suddenly to ruminants without prior exposure to such diet, a rapid fermentation will be taken place in the rumen. This may result in a decrease of the pH from about 6.8 to values near 5.5 or even lower. The value of pH 5.5 is of special importance, since at this or at lower pH values there is an increased risk of lactic acidosis (Countotte *et al.*, 1979). The amount of decrease in pH after an increase in the fermentation rate will depend on the buffering capacity of the rumen fluid. Feeding can influence rumen fluid pH and ruminal pH can influence microbial fermentation and its end production (Hungate, 1966). Low ruminal pH, it is known that the fermentation product VFA, which reduce pH when their production is faster than their absorption from the rumen. Thus pH is often decreased due to rapid fermentation of readily fermentable carbohydrates (RFC) following their digestion. The decrease tended to be linearly related to the level of RFC intake (Dixon and Stockdale, 1999). Ruminal NH_3-N has been reported to be an important compound in supporting efficient rumen fermentation and it is the major nitrogen source for microbial protein synthesis and growth (Wanapat and Pimpa, 1999). Erdman *et al.,* (1986) found that a higher level of NH_3-N can increase the rate of fermentation in vivo, depending on the potential fermentation of feed. Perdok and Leng (1990) found that a higher level of ruminal NH_3-N (15-20 mg%) increase dry matter intake and digestibility in cattle fed with low quality roughage. Moreover, the rumen pH may be affected by NH_3-N concentration in the rumen fluid when urea is hydrolyzed by urea utilizing bacteria into NH_3. Slyler *et al.* (1979) and Pan *et al*. (2003) demonstrated that increased rumen NH_3-N (22.5 mg%) might increase ruminal pH, TVFA production and stimulated cellulolytic activity in the rumen. Wanapat and Pimpa (1999) found that higher level of ruminal NH_3-N at 17.6% resulted in the highest total purine derivatives, indicating highest rumen microbial protein synthesis. Chamberlain *et al.* (1985) reported that microbial utilization of ruminal NH_3-N was enhanced when pH was increased up to 6.5. The relative high pH would allow more NH_3 to remain in non-ionized from and, hence, be available for absorption across the rumen epithelium (Visek, 1984).

MATERIALS AND METHODS

There were 6 experiments in this research study. Experiment 1 studied the nutritive values and fermentation characteristics of different types of FBP. Experiment 2 studied the storage period based on nutritive values and fermentation characteristics of FBP for 1, 2 and 3 months. Experiment 3 studied the effect of FBP on mid lactation in dairy Cow and experiment 4 studied the effect of different proportions of FBP and rice straw on in *vitro* gas production and true digestibility. Experiment 5 and 6 studied the effects of different proportion of FBP and rice straw on heifer and dairy cow performances.

1. The effect of FBP corn, FBP Pineapple, and FBP mixed on nutritive values and fermentation characteristics

2. The effect of storage period on nutritive values and characteristics of FBP

3. The effect of FBP as roughage source on mid lactation dairy Cow

4. The effect of the different proportion of FBP and rice straw *on vitro* gas production and true digestibility

5. The effects of different proportion of FBP and rice straw on Heifers performance

6. The effects of optimum proportion of FBP and rice straw on dairy cow performance.

Materials

1. 30 healthy >75% multiparous Holstein Friesian blood of dairy cows in mid-lactation (lactation number 2^{nd} to 5^{th}), Days In Milk (DIM) 60-120, 3-5 years old and with 400-450 kg BW.
2. 16 healthy >75% Holstein Friesian blood of dairy heifers with 200-250 kg BW.
3. Rice straw
4. FBP
5. Vinasses
6. Sweet corn residue ensiled (corn husk and corncob)
7. Commercial concentrate with 14 % crude protein and 20% crude protein
8. Minerals and vitamins
9. Internal and external anti-helminthic.
10. Scale
11. Fecal collected tools
12. Feed sample collected tools
13. Blood sample collected tools
14. Volatile fatty acid analyze tools
15. NH_3-N analyze tools
16. Water soluble carbohydrate analyze tools
17. Milk Yield and milk composition analyze tools
18. Milk urea nitrogen analyze tools
19. Ammonia Nitrogen analyze tools
20. *In viro* gas production tools
21. Acid Insoluble Detergent (AIA) for digestibility analyze tools
22. Chemical substances and chemical composition analyze by proximate analysis
23. Chemical substances and chemical composition analyze by Van Soest method
24. Hot air oven
25. Willey mill
26. Centrifuge

Methods

Experiment 1 The effect of type of fermented by-products on nutritive values and fermentation characteristics.

1.1 Management of fermented by-products

1.1.1 Management of fermented by-products of corn (FBP corn)

The FBP corn was composed of corn husk, corncob, bagasse and vinasses. Corn husk and corn cob were obtained from canning factories. Bagasse was by-product from sugar industry. These by-products was collected and cut into 3-4 cm. Vinasses was obtained from the ethanol plant. The ratio of these by-products and vinasse was 93:7 (on fresh basis). The mixtures of all products were mixed and fermented in 2 layers plastic bags. Each bag was weighed 35 kg and ready of feeding after fermentation for 30 days.

1.1.2 Management of fermented by-products of pineapple (FBP Pineapple)

The FBP pineapple was composed of pineapple peel, bagasse and vinasses. pineapple peel were obtained from canning factories. Bagasse was by-product from sugar industry. These by-products was collected and cut into 3-4 cm. Vinasses was obtained from the ethanol plant. The ratio of these by-products and vinasse was 93:7 (on fresh basis). The mixtures of all products were mixed and fermented in 2 layers plastic bags. Each bag was weighed 35 kg and ready of feeding after fermentation for 30 days.

1.2.3 Management of fermented by-products mixed (FBP Mixed)

The FBP mixed were composed of pineapple peel, corn husk, corn cob, bagasse and vinasses. Pineapple peel, corn husk, corn cob were obtained from canning factories. Bagasse was by-product from sugar industry. These by-products was collected and cut into 3-4 cm. Vinasses was obtained from the ethanol plant. The ratio of these by-products and vinasse was 93:7 (on fresh basis). The mixtures of all products were mixed and fermented in 2 layers plastic bags. Each bag was weighed 35 kg and ready of feeding after fermentation for 30 days.

1.2 Data collection and Chemical analysis

In this study, the proportion of bagasse and vinasses was used the same in all treatments. The 5 bags of each FBP were opened at 30 day of fermentation to evaluate their dry matter (DM), crude protein, ether extract and ash (AOAC, 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were used the methods of Goering and Van Soest (1970). The physical characteristic of silage was described for its color, odor, texture, moisture and existing spoilage (Rohweder *et al.*, 1978). The pH value of silage was measured using calibrated pH meter (Bolsen *et al.*, 1992). Concentration of silage VFA (Lactic acid, Acetic acid and Butyric acid) were measured using steam distillation method of the same supernatant sample that have been used for pH measurement (Cheva-Isarakul and Cheva-Isarakul , 1980).

Treatment 1 fermented by-products of corn (FBP corn)
Treatment 2 fermented by-products of pineapple (FBP Pineapple)
Treatment 3 fermented by-products mixed (FBP Mix)

1.3 Statistical analysis

Data from the chemical analysis and fermentation parameters were analyzed as a Completely Randomized Design (CRD) with five replicates and using the model as follow.

$$Yij = \mu + T\ i + Є\ ij$$

where

Yij = observation of dependent variables from treatment i and replication j

μ = the overall mean,

Ti, = effect of treatment i^{th} (i = 1, 2, 3)

Єi = the residual effect with NID (mean 0 and a common variance)

The treatment means were compared by Duncan' s New Multiple Rang Test. (Steel and Torrie, 1980). All statistical analysis was performed using the SAS (1996) procedure. The results were reported as mean ±standard deviation (SD) and statistical significance were based on P<0.05.

Experiment 2 The effect of storage period on nutritive values and characteristics of FBP

2.1 Management of fermented by-products with difference storage period

The best quality of FBP obtained from the first experiment was used in this study. Three storage times were compared as follow.

Treatment 1 FBP Mix was kept for one month (30 days)

Treatment 2 FBP Mix was kept for two months (60 days)

Treatment 3 FBP Mix was kept for three months (90 days)

2.2 Data collection and Chemical analysis

The 5 bags of FBP in each treatment were opened at 1, 2 and 3 months of fermentation respectively to analyze DM, CP, EE and ash (AOAC, 1990). NDF, ADF and ADL were using the methods of Goering and Van Soest (1970). The cellulose was obtained throughout difference between ADF and lignin (Van Soest, 1968). The physical characteristic of silage was described for its color, odor, texture, moisture and existing spoilage (Rohweder *et al.*, 1978). The pH value of silage was measured using calibrated pH meter (Bolsen *et al.*, 1992). Concentration of silage VFAs (Lactic acid, Acetic acid and Butyric acid) were measured using steam distillation method of the same supernatant sample that have been used for pH measurement (Cheva-Isarakul and Cheva-Isarakul , 1980).

2.3 Statistical analysis

The data from chemical analysis and fermentation parameters were analyzed as a Completely Randomized Design (CRD) with five replicates and using the model as follow.

$$Yij = \mu + T\,i + \epsilon\,ij$$

where

Y ij = observation of dependent variables from treatment i and replication j

μ = the overall mean,

Ti = effect of treatment i^{th} (i = 1, 2, 3)

Єi = the residual effect with NID (mean 0 and a common variance)

The treatment means were compared by Duncan' s New Multiple Rang Test (Steel and Torrie, 1980). All statistical analysis was performed using the SAS (1996) procedure. The results were reported as mean±standard deviation (SD) and statistical significance were based on P<0.05

Experiment 3 Effect of Fermented By-Product (FBP) on mid lactation Dairy Cow Performance

3.1 Animals, diets and management

Fifteen, 75-85.5% multiparous Holstein Freesian blood of dairy cows in mid-lactation (lactation number 2^{nd} to 5^{th}) with DIM 83.31±26.47 and an average 417.88±52.60 kg BW were used in the present study. All dairy cows were randomly allocated to three groups.

Treatment 1 Cows were fed with rice straw and 1 kg of vinasses in separate bowl (RS+V)

Treatment 2 Cows were fed with sweet corn waste silage (SCWS)

Treatment 3 Cows were fed with fermented by-products (FBP)

All cows were housed in individual pens and were fed *ad libitum* of roughage and allowing not more than 10% refusals. The commercial concentrate (19.80 % CP) was vary calculated base on requirement for maintaining and production each treatment and formulation of isoprotein diets was based on the NRC (NRC, 2001) with twice daily feeding at 06.00 a.m. and 15.00 p.m. before milking. Fresh water and minerals were available at all times.

3.1.1 Management of fermented by-products mixed (FBP)

The FBP was composed of pineapple peel, corn husk, corn cob, bagasse and vinasses. Pineapple peel, corn husk, corn cob were obtained from canning factories. Bagasse was by-product from sugar industry. These by-products was collected and cut into 3-4 cm before used it. Vinasses was obtained from the ethanol plant. The ratio of these by-product and vinasse was 93:7 (on fresh basis). The mixtures of all products were mixed and fermented in 2 layers plastic bags. Each bags weighed 35 kg and ready of feeding after fermentation for 30 days. Detail of each period in experiment

Adaptation and data collection period was shown in figure 6.

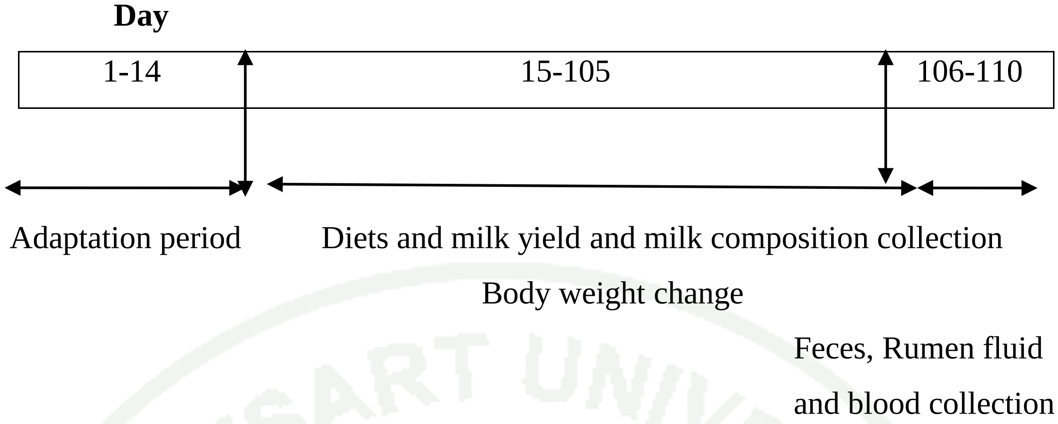

Figure 6 Adaptation and data collection period

3.2 Sample collection and chemical analysis

3.2.1 Feed sample

The roughage were fed *ad-libitum* each treatment. For the concentrate was varied calculate base on requirement for maintaining and lactating each treatment. Feed intake was obtained as the difference between feed offered and refusal collected daily. Sample of feeds (concentrate, vinasses, SCWS and FBP) were obtained and analyzed in all treatments. These feed samples were analyzed for DM, CP, EE, Ash and GE (AOAC, 1990), NDF, ADF and ADL (Goering and Van Soest, 1970). The SCWS and FBP were analyzed for pH value of silage was measured using calibrated pH meter (Bolsen *et al.*, 1992), WSC was determined by the phenol-sulfuric acid method of Dubois *et al*. (1956). Moreover, volatile fatty acid (Lactic acid, Acetic acid Butyric acid and propionic acid) were analyzed by HPLC (Rooke *et al.*, 1990).

3.2.2 Milk yield and Milk composition

Daily milk yield was individually recorded at twice daily in the morning and in the afternoon every day (7.00 a.m. and 15.30 p.m.). Milk samples were analyzed for milk composition (fat, protein, lactose, total solids, fat and solid not fat) by infrared spectroscopy (Milko Scan 133, Foss Electric, Denmark Tester). Milk urea nitrogen (MUN) was determined using the Sigma diagnostics procedure (Valadares *et al.*, 1999). Four percentage fat corrected milk (4%FCM) was calculated by the equation of Walker *et al.* (2001) as follows:

FCM (kg/cow/d) = milk yield (kg/cow/d) x [0.4+0.015 x fat content (g/kg)]

Fecal samples were collected from all cows daily for 5 consecutive days before the end of the experiment by rectal sampling at 10.00 (Goachet *et al.*, 2009). These samples were dried at 60 °C and ground (1 mm screen) and then analyzed for DM, EE, ash and CP content (AOAC, 1990), NDF and ADF (Goering and Van Soest, 1970). Acid-insoluble ash (AIA) was used to estimate digestibility of nutrients. Sample of fecal and feed were analyzed for Acid Insoluble Ash (AIA). Dry matter digestibility coefficient was analyzed from the ratio of AIA in fecal and feed by the method of Hanbanjong and Sinjermsiri (1989) modified from Van Keulen and Young (1977).

% AIA = (A-B)/W x 100

A = Weight of crucible with ash
B = Weight of empty crucible
W = Weight of sample dry matter

Percentage of dry matter digestibility =100 x (1-%AIA in feed/% AIA in feces)

Estimated digestible nutrient intake (kg/d) can be calculated as follows (Khan *et al*., 2003)

$$\text{Nutrient digestibility (\%)} = \frac{\text{Nutrient intake - Nutrient in feces}}{\text{Nutrient intake}} \times 100$$

The ME values of the feeds were calculated using the following equation (AFRC, 1993)

ME (MJ/kgDM) = 0.016DOMD (digestible organic matter in the dry matter)

3.2.3 Body weight change

Cows were weighed every month by cattle scales. The data of body weight was calculated weight change by this equation:

Weight change (kg) = final weight (kg) – initial weight (kg)

3.2.3 Blood metabolites Procedures

A technique to assess the nutritional status of dairy cows in relation to production was applied in dairy cows in the end of experiment. Individual jugular venous blood samples was collected at 7.00 h immediately after morning milking (before feeding, 0h), and before the afternoon milking (after feeding 4h). Heparinized samples was centrifuged and stored at -20° C before was analyzed for plasma urea nitrogen (BUN) (Tiffany *et al*. 1972) and Plasma Glucose (Slein, 1963). Nonesterified fatty acids (NEFA) in serum samples was measured enzymatically (Fawcett and Scott, 1960) and triiodothyronine (T3) by Electrochemiluminescence immunoassay (ECLIA).

3.2.4 Cost and benefit Analysis

Feed cost and income were calculated to evaluation the cost and benefit from using different feed treatments in the experiment. These costs were found to be: 9.67 baht/kg of concentrate (20% CP); 1.80 baht/kg of rice straw and SCWS; 5 baht/kg of vinasse and 2.45 baht/kg of FBP. Milk price was found to be 16.50 baht/kg at the time of the experiment in Saraburi Province.

3.3 Statistical analysis

The data from treatments were analyzed as a Completely Randomized Design (CRD) with five replicates and using the model as follow.

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

where

Y_{ij} = observation of dependent variables from treatment i and replication j

μ = the overall mean,

T_i = effect of treatment i^{th} (i = 1, 2, 3)

ϵ_i = the residual effect with NID (mean 0 and a common variance)

The treatment means were compared by Duncan' s New Multiple Rang Test (Steel and Torrie, 1980). All statistical analyses were performed using the SAS (1996) procedure. The results were reported as mean±standard deviation (SD) and statistical significance were based on $P<0.05$.

Experiment 4 The effect of different proportions of fermented by-products and rice straw on *in vitro* gas production and true digestibility

4.1 Diets and management

This study was conducted using an *in vitro* gas technique at difference levels of FBP with rice straw. The method use for the gas production was described by Menke and Steingass (1988). The ration concentrate (19.80% CP) and roughage had been used 60:40%. The experimental design was employed using completely randomized design (CRD) with three replicates per treatment. The treatments were used ratio FBP with rice straw and concentrate as:

Treatment 1: 60% concentrate + 40% rice straw (on DM basis)
Treatment 2: 60% concentrate + 16% rice straw and 24% FBP (on DM basis)
Treatment 3: 60% concentrate + 20% rice straw and 20% FBP (on DM basis)
Treatment 4: 60% concentrate + 24% rice straw and 16% FBP (on DM basis)

4.1.1 Sample preparation

All feeds were dried at 65 $^{\circ}$C until the constant weight for DM determination. Then, the samples were ground to pass through 1 mm. Feed sample was weigh 200 mg into each serum bottles. After weighed place into incubator at 39 $^{\circ}$C.

4.1.2 Rumen fluid collection and artificial saliva preparation

Ruminal fluid was collected from slaughter cow at abattoir of Prathum thani province according to Chaudhry (2008). The rumen fluid was filtered through four layers of cheesecloth into plastic bottles and pre warm in thermos flasks. Preparation of artificial saliva was done according to Menke and Steingass (1988). Add distilled water, buffer solution, macro mineral solution and resazurin solution into flask, warm to 39 $^{\circ}$C. Then add reducing solution and put magnetic into flask and gently bubble CO_2 into solution until the blue color turn to pink then clear. Rumen fluid was poured into artificial saliva. The ratio of saliva rumen fluid as 2 : 1. The whole process of dispensing the rumen liquor (rumen fluid + artificial saliva) into serum bottles. Add 30 ml solution to each bottle using a dispenser. Then, the bottles place in incubator at 39 $^{\circ}$C.

4.2 Sample collection and chemical analysis

4.2.1 Chemical analysis

The substrate including as roughage source (FBP and rice straw) and concentrate were analyzed to DM, EE, ash and CP content according to method of AOAC (1990). NDF, ADF and ADL were calculated by the method of Goering and Van Soest (1970).

4.2.2 Gas production recording

During the incubator, the gas production was recorded at 0, 2, 4, 6, 8, 10, 12, 18, 24, 36, 48, 60, 66 and 72h. The 12 hours should be recorded every hour. Then, it was recorded every three hours until hour 24. After that, the gas productions were recorded every 6 hours until 72 h. Cumulative gas production data were fitted to the model of Ørskov and McDonald (1979) as follows;

$$Y \quad = \quad a + b\,(1-e^{-ct})$$

Where:

Y = volume of gas production at time, t

a = the gas production from the immediately solution fraction (ml)

b = the gas production from the insoluble fraction (ml)

c = the gas production rate constant for insoluble fraction (ml/h)

t = incubation time

4.2.3 Volatile fatty acid (VFA) and NH_3-N measurement

At 4 hr post inoculation a set of samples were analyzed for VFAs and NH_3-N. The sample was chosen at random amount 20 ml into glass bottle and fill 1 molar sulfuric acid volume 1 ml. Then, it was centrifuged at 16,000xg for 15 minutes. Supernatant was collected amount 15 ml and freeze at -20 $^{\circ}$C. The samples was analyzed NH_3-N (Bremner and Keeney, 1965), total volatile fatty acid, acetic, propionic and butyrate (Samuel *et al.* 1997).

4.2.4 Microorganism counting

The sample was collected 1 ml into glass bottle contain 1 M formalin (10% formalin solution in 0.9% normal saline) 9 ml. The samples were determined number of microorganism (bacteria, protozoa and fungi) by direct count method according to Galyean (1989)

4.2.5 *In vitro* true digestibility determination

At 48h post incubation was determined in vitro true digestibility (IVTD) according to Van Soest and Robertson (1985). The sample from whole treatment had been transferred quantitatively to a spoutless beaker by repeated washing with 100 ml neutral detergent solution. The content was refluxed for 60 min and filtered through pre weighed Gooch crucibles. After that, it was be rinsed with 25 ml. of acetone. Then, sample was dried at 100 $^{\circ}$C for 5 hours and record actual weight. The crucible was placed a furnace at 600°C for 2 hours. The DM of the residue was weighed and IVTD of feed was calculated as follows:

$$\text{True digestibility (TD)} = \frac{\text{(DM of feed taken for incubation-NDF residue)}}{\text{DM of feed taken for incubation}} \times 100$$

The *in vitro* organic matter disappearance (IVOM) was obtained by incinerating the dried residues at 600°C for 2 hours

4.3 Statistical analysis

The data were analyzed in a Completely Randomized Design (CRD) and using the model as follow.

$$Yij = \mu + T\,i + \epsilon\,ij$$

where

Y ij = observation of dependent variables from treatment i and replication j

μ = the overall mean,

Ti = effect of treatment i^{th} (i = 1, 2, 3, 4)

ϵi = the residual effect with NID (mean 0 and a common variance)

All data were analyzed by SAS (SAS, 1996). Duncan' s New Multiple Rang Test was used to test the different among treatment means (Steel and Torrie, 1980). The results were reported as mean±standard deviation (SD) and statistical significance were based on P<0.05.

Experiment 5 The effects of different proportions of fermented by-products (FBP) with rice straw on Heifer Performance

5.1 Animals, diets and management

Sixteen healthy of 75-85.5% Holstein Frisian of dairy heifers with 11 to 14 months of age with average body weight of 246.33±13.03 kg were used in this experiment. Heifers were randomly allocated into four groups.

Treatment 1 consisted of four dairy heifers fed rice straw *ad lib*

Treatment 2 consisted of four dairy heifers fed of FBP and rice straw 40:60 *ad lib* (DM basis)

Treatment 3 contained of four dairy heifers fed FBP and rice straw 50:50 *ad lib* (on dry basis).

Treatment 4 contained of four dairy heifers fed FBP and rice straw 60:40 *ad lib* (on dry basis)

All dairy heifers were housed in individual pens and were fed *ad libitum* of roughage with allowing not more than 10% refusals. The commercial concentrate (14.37% CP) was vary calculated base on requirement for maintaining and growth each treatment and formulation of isoprotein diets was based on the NRC (NRC, 2001) with twice daily feeding at 06.00 a.m. and 15.00 p.m. before milking. In addition, fresh cool water from individually automatic bowl and mineral block were available at all times.

5.1.1 Detail of each period in experiment

Adaptation and data collection period were shown in figure 7.

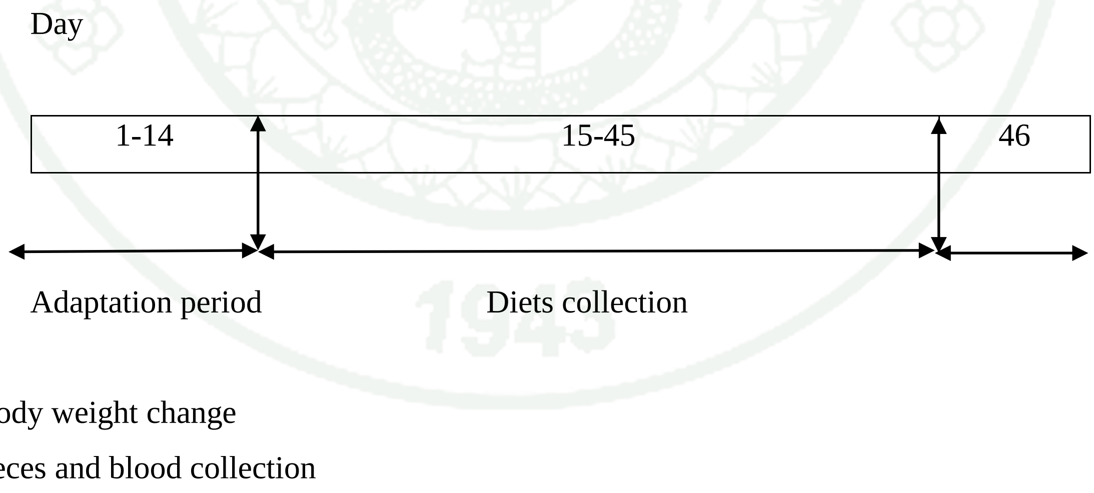

Figure 7 Adaptation and data collection period

Sample collection and chemical analysis

5.2.1 Feed

Feed intake was obtained as the difference between feed offered and refusal collected daily. Sample of feeds (concentrate, FBP and rice straw) were obtained and analyzed in all treatments once a month. These feed samples were analyzed for DM, CP, EE, Ash and GE (AOAC, 1990), NDF and ADF (Goering and Van Soest, 1970). pH value of silage was measured using calibrated pH meter (Bolsen *et al.*, 1992). Moreover, concentration of silage VFAs (lactic acid, acetic acid and butyric acid) were measured using steam distillation method of the same supernatant sample that have been used for pH measurement (Cheva-Isarakul and Cheva-Isarakul , 1980).

5.2.2 Fecal Samples

Fecal samples were collected from all heifers for 5 consecutive days before the end of the experiment by rectal sampling at 10.00 (Goachet *et al.*, 2009). These samples were dried at 60 °C and ground (1 mm screen) and then analyzed for DM, EE, ash and CP content (AOAC, 1990), NDF, ADF and ADL (Goering and Van Soest, 1970). Acid-insoluble ash (AIA) was used to estimate digestibility of nutrients. Sample of fecal and feed were analyzed for AIA. Dry matter digestibility coefficient was analyzed from the ratio of AIA in fecal and feed by the method of Hanbanjong and Sinjermsiri (1989) modified from Van Keulen and Young (1977).

$$\% \text{ AIA} = (A-B)/W \times 100$$

A	=	Weight of crucible with ash
B	=	Weight of empty crucible
W	=	Weight of sample dry matter

Percentage of dry matter digestibility = 100 x (1-%AIA in feed/% AIA in feces)

The ME values of the feeds were calculated using the following equation (AFRC, 1993)

Estimated digestible nutrient intake (kg/d) can be calculated as follows (Khan *et al*., 2003)

$$\text{Nutrient digestibility (\%)} = \frac{\text{Nutrient intake - Nutrient in feces}}{\text{Nutrient intake}} \times 100$$

ME (MJ/kgDM) = 0.016DOMD (digestible organic matter in the dry matter)

5.2.3 Weight gain

Cows were weighed every month by cattle scales. The data of body weight was calculated weight change by this equation:

Weight change (kg) = final weight (kg) – initial weight (kg)

5.2.4 Blood metabolites procedures

A technique to assess the nutritional status of dairy heifers in relation to production was applied in dairy cows in the end of experiment. Individual jugular venous blood samples was collected at 7.00 h immediately after morning milking (before feeding, 0h), and before the afternoon milking (after feeding 4h). Heparinized samples was centrifuged and stored at -20° C before was analyzed for blood urea nitrogen (BUN) (Tiffany *et al*. 1972) and blood Glucose (Slein, 1963) and triiodothyronine (T3) by Electrochemiluminescence immunoassay (ECLIA).

5.3 Statistical analysis

The data were analyzed in a Completely Randomized Design (CRD) and using the model as follow.

$$Yij = \mu + T\,i + \epsilon\,ij$$

where

Y ij = observation of dependent variables from treatment i and replication j

μ = the overall mean,

Ti = effect of treatment i^{th} (i = 1, 2, 3, 4)

Єi = the residual effect with NID (mean 0 and a common variance)

All data were analyzed by SAS (SAS, 1996). Duncan' s New Multiple Rang Test was used to test the different among treatment means (Steel and Torrie, 1980). The results were reported as mean±standard deviation (SD) and statistical significance were based on P<0.05.

Experiment 6 The effects of optimum proportion of FBP with rice straw on dairy cow performance

6.1 Animals, diets and experimental design

Fifteen of 75-87.5% multiparous Holstein Friesian of lactatingdairy cows in the 2nd lactation, days in milk (DIM) 111.25±25.12, 5-6 years old with an average body weight of 407.33±53.48 kg and include the vaccination were used in this experiment.

Treatment 1 consisted of five dairy cows fed *ad lib* with rice straw

Treatment 2 consisted of five dairy cows fed FBP with rice straw as 50:50 (DM basis)

Treatment 3 consisted of five dairy cows fed sweet corn waste silage (SCWS) with rice straw as 50:50 (DM basis)

All cows were housed in individual pens and were fed *ad libitum* with roughage and allowing not more than 10% refusals. The commercial concentrate (19.80 % CP) was calculated base on requirement for maintaining and production each treatment and formulation of isoprotein diets was based on the NRC (NRC, 2001) with twice daily feeding at 06.00 a.m. and 15.00 p.m. before milking. In addition, fresh cool water from individually automatic bowl and mineral block were available at all times.

6.1.1 Fermented By-Product (FBP) and Sweet Corn Waste silage (SCWS) management

The FBP was composed of pineapple peel, corn husk, corn cob, bagasse and vinasses. Pineapple peel, corn husk and corn cob were obtained from canning factories. Bagasse was by-product from sugar industry. These by-products were collected and chopped into 3-4 cm before using. Vinasses were obtained from the ethanol plant. The ratio of these by-products and vinasses was 93:7 (on fresh basis). The mixtures of all products were thoroughly mixed and fermented in 2 layers plastic bags. Each bag was weighed 35 kg for 30 days after fermented.

Sweet Corn Waste silage (SCWS) was composed of corn husk, cobs, discarded kernels and small amount of stalk. They were chopped into 2-3 cm pieces. The mixtures of all products were mixed and fermented in 2 layers plastic bags for 30 days. Each bag was weighed 30 kg for 30 days after fermented, the FBP and SCWS bags were opened and samples were collected and analyzed for chemical composition and fermentation characteristics.

6.2 Sample collection and chemical analysis

6.2.1 Feed

Feed intake was obtained as the difference between feed offered and refusal collected daily. Sample of feeds (concentrate, FBP, SCWS and rice straw) were obtained and analyzed in all treatments once a month. These feed samples were analyzed for dry matter intake (DM), crude protein (CP), ether extract (EE) Ash and Gross energy (GE) (AOAC, 1990), NDF, ADF and ADL (Goering and Van Soest, 1970) pH (Bolsen *et al*., 1992), Moreover, volatile fatty acid (lactic acid, acetic acid, butyric acid and propionic acid) were analyzed by HPLC (Rooke et al., 1990). NH_3-N concentration in silage was observed from the supernatant used by micro diffusion Conway (AOAC, 1990). Free fatty acids in feed were analyzed by method of Kelly *et al*. (1998).

6.2.2 Milk yield and Milk composition

Daily milk yield was individually recorded at twice daily in the morning and in the afternoon every day (7.00 a.m. and 15.30 p.m.). Milk samples were analyzed for milk composition (fat, protein, lactose, total solids, fat and solid not fat) by infrared spectroscopy (Milko Scan 133, Foss Electric, Denmark Tester). MUN was determined using the Sigma diagnostics procedure (Valadares *et al.*, 1999). 4%FCM was calculated by the equation of Walker *et al.* (2001) as follows:

$$\text{FCM (kg/cow/d)} = \text{milk yield (kg/cow/d)} \times [0.4+0.015 \times \text{fat content (g/kg)}]$$

Milk samples were taken for free fatty acids and CLA analyses (Gas chromatography; Hewlett Packard GCD system HP 6890). Fatty acid analysis was carried out as previous described (Hara and Radin, 1978). In brief, milk fat was extracted from milk using hexane and isopropanol (3:2, vol/vol)/g of fat cake, modified from Kelly *et al*. (1998). Heptadecanoic acid (17:0) was added as an internal standard. The fatty acid methyl esters (FAME) were analyzed by GC. The GC conditions were as follows: injected temperature, 240 ºC; detector temperature, 260 ºC; carrier gas, He; split ratio, 1/30; temperature program, 70 ºC for 4 min, followed by an increase of 13 ºC /min to 175 ºC, then 4 ºC /min to 215 ºC. Peaks were identified by comparison of retention times with those of the corresponding standards 1 (SupelcoTM37 component FAME Mix, Sigma-Aldrich Co., USA). Identification of 2 the peak included fatty acids between 14:0 and 22:6 and CLA isomers, i.e. *c*9, *t*11; 3 *t*10, *c*12.

6.2.3 Fecal Samples were collected

Fecal samples were collected from all dairy heifers for 5 consecutive days before the end of the experiment by rectal sampling at 10.00 (Goachet *et al*., 2009). These samples were dried at 60 °C and ground (1 mm screen) and then analyzed for DM, ether extract, ash and CP content (AOAC, 1990), NDF, ADF and ADL (Goering and Van Soest, 1970). Acid-insoluble ash (AIA) was used to estimate digestibility of nutrients. Sample of fecal and feed were analyzed for Acid Insoluble Ash (AIA). Dry matter digestibility coefficient was analyzed from the ratio of AIA in fecal and feed by the method of Hanbanjong and Sinjermsiri (1989) modified from Van Keulen and Young (1977).

$$\% \text{ AIA} = (A-B)/W \times 100$$

A	=	Weight of crucible with ash
B	=	Weight of empty crucible
W	=	Weight of sample dry matter

Percentage of dry matter digestibility =100 x (1-%AIA in feed/% AIA in feces)

Estimated digestible nutrient intake (kg/d) can be calculated as follows (Khan *et al*., 2003)

$$\text{Nutrient digestibility (\%)} = \frac{\text{Nutrient intake - Nutrient in feces}}{\text{Nutrient intake}} \times 100$$

The ME values of the feeds were calculated using the following equation (AFRC, 1993)

ME (MJ/kgDM) = 0.016DOMD (digestible organic matter in the dry matter)

6.2.4 Weight gain

Cows were weighed every month by cattle scales. The data of body weight was calculated weight change by this equation:

Weight change (kg) = final weight (kg) – initial weight (kg)

6.2.5 Blood metabolites Procedures

A technique to assess the nutritional status of dairy cows in relation to production was applied in dairy cows in the end of experiment. Individual jugular venous blood samples was collected at 7.00 h immediately after morning milking (before feeding, 0h), and before the afternoon milking (after feeding 4h). Heparinized samples was centrifuged and stored at -20 ºC before was analyzed for BUN (Tiffany *et al*. 1972) and blood glucose (Slein, 1963). and triiodothyronine (T3) by Electrochemiluminescence immunoassay (ECLIA).

6.2.6 Rumen fluid collection

Rumen fluid samples were collected at 0 and 4h-post feeding at the end of experiment. Approximately 200 ml of rumen fluid was taken from the middle part of the rumen by a stomach tube connected with a vacuum pump. Rumen fluid was immediately measured for pH using portable pH meter and were then filtered through four layers of cheesecloth. Samples were used for NH_3-N analyses where 5 ml of 1 M H_2SO_4 solution was added to 50 ml of rumen fluid. The mixture was centrifuged at 16,000x*g* for 15 minutes and the supernatant was stored at -20 ºC prior to NH_3-N have been analyzed according to Bremner and Keeney (1965) and VFA analyses using a HPLC (Samuel *et al.*, 1997). Another portion was kept in the plastic bottle. Then the samples have been analyzed total volatile fatty acid (TVFA) and acetic acid (C_2), propionic acid (C_3) and butyric acid (C_4). VFA have been analyzed by Gas Chromatography (GC6890, Agilent Technologies) according to Samuel *et al*. (1997).

6.2.7 Cost and benefit Analysis

Feed cost and income were calculated to evaluation the cost and benefit from using different feed treatments in the experiment. These costs were found to be: 9.67 baht/kg of concentrate (20% CP); 1.80 baht/kg of rice straw and SCWS and 2.45 baht/kg of FBP. Milk price was found to be 16.50 baht/kg at the time of the experiment in Saraburi Province.

6.3 Statistical analysis

The data obtained from the experiment were analyzed by ANOVA as a Completely Randomized Design (CRD) using the procedure of the Statistical Analysis System Institute (SAS, 1996) and using the model as follow.

$$Yij = \mu + T\,i + \epsilon\,ij$$

where

Y ij	=	observation of dependent variables from treatment i and replication j
μ	=	the overall mean,
Ti	=	effect of treatment i^{th} (i = 1, 2, 3)
ϵi	=	the residual effect with NID (mean 0 and a common variance)

Differences between treatment means were determined by Duncan´s New Multiple Range Test (DMRT). The results were reported as mean±standard deviation (SD) and statistical significance were based on P<0.05.

Places

1. FBP and Sweet corn waste silage making at Rich and Green company Kanchanaburi province

2. Experimental study in dairy cow at Dairy farming promotion organization of Thailand (DPO) Muaklek district Saraburi province

3. Laboratory of Nakhonratchasima Animal Nutrition Research and Development Centre.

4. Laboratory of Department of Animal Science, Faculty of Agriculture, Kasetsart University.

5. Laboratory of Professional Laboratory Management Corp Co., Ltd. Bangkok.

6. Laboratory of Faculty of Veterinarian Kasetsart University *Kampangsan* Campus.

7. Phytochemistry Research and Analysis Unit, Central Laboratory and greenhouse complex Kasetsart University *Kampangsan* Campus.

8. Bureau of Animal Nutrition Development, Department of Livestock Development sub-distric Bangkadi Pathumthani province

Duration of experiment

The experiment was started in February 2010 and ended in March 2012.

RESULTS AND DISCUSSION

Experiment 1 The effect of type of FBP (FBP mixed, FBP corn and FBP Pineapple on nutritive values and fermentation characteristics

1. Physical characteristics

The physical characteristics factors such as color, odor and general appearance provide a good indication of the expected overall nutritive value. All group of FBPs had the color depend on raw material by-products to make silage and acceptable smell, while FBP corn and FBP pineapple were detected butyric acid odor. The odor of butyric acid or ammonia which occur when poor quality of forage fermentation, possibly resulting in clostridial silage which is characterized by high levels of butyric acid (McDonald *et al.*, 1991). It is know that silage produced with high resulting in larger losses and increase in the production of acetic acid and butyric acids (Erdman, 1993) and consequently the intake is reduced. FBP mixed and FBP corn were firm in texture while FBP pineapple were slightly wet when touched. Church (1991) stated that a good quality of silage should be green-yellow, firm texture and not slimy. FBP mixed showed a good preservation process.

Table 18 The characteristics of FBP mixed, FBP corn and FBP pineapple at 30 days of ensiling

characteristics	FBP mixed	FBP corn	FBP pineapple
color	dark-yellow	yellow	dark-yellow
odor	lactic-acid[1]	butyric acid[2]	butyric acid[2]
texture	firm	firm	soft-tissue

[1]Lactic acid odor is similar to that the sour milk

[2]Butyric acid odor is similar to that of rancid butter or fat

2. Chemical composition and fermentation characteristics

At 30 days of ensiling, The chemical composition of FBP mixed and FBP corn were significant higher DM, EE and NFE than FBP pineapple (P<0.05), Furthermore, The ash in FBP mixed was significant the highest (P<0.05). The NDF and hemicellulose in FBP corn was higher than FBP pineapple, But did not different with FBP mixed. CP in FBP mixed tended to be higher than the other groups. Low DM of silages were susceptible to saccharolytic and proteolytic clostridial fermentation (Leibensperger and Pitt, 1987). The FBP pineapple tended to reduce CP which similar to those reported by Jetana *et al.* (2009) who found that pineapple waste is a by-product from agro industry waste as an energy source which contain low nitrogen content (0.09%). The NDF and hemicellulose of FBP corn were significant higher than FBP pineapple. Ribeiro *et al.* (1993) who found that pineapple by product when provided as sole food does not cover animal requirements because its low protein and NDF content. Tawila *et al.* (2008) reported that ensiling can be considered as an efficient way to preserving high moisture by-products. A material must have high concentration of WSC, low buffering capacity, DM content of 25.0-40.0% and adequate lactic acid bacteria (LAB) prior to ensiling (Wikinson, 2005).

Table 19 Chemical composition and fermentation characteristics of FBP Mixed, FBP corn and FBP pineapple at 30 days of ensiling

Chemical composition	**Treatments**			**SEM**
	FBP mixed	**FBP corn**	**FBP pineapple**	
DM	22.89±0.21[a]	24.29±1.12[a]	15.60±0.56[b]	0.24
CP	7.72±0.68	6.37±0.29	6.16±0.14	0.14
EE	1.19±0.05[a]	1.28±0.02[a]	0.43±0.12[b]	0.02
Ash	9.32±1.25[a]	6.52±1.62[b]	7.13±0.71[ab]	0.41
NFE	51.57±2.43[a]	50.99±0.74[a]	46.27±3.41[b]	0.82
NDF	72.61±1.28[ab]	74.71±1.50[a]	70.13±2.79[b]	0.66
ADF	44.41±3.22	43.85±2.48	46.78±2.22	0.89
ADL	8.69±1.39	7.97±0.84	9.20±0.44	0.32

Table 19 (Continued)

Chemical composition	Treatments			SEM
	FBP mixed	FBP corn	FBP pineapple	
Cellulose[1]	35.71±2.15	35.88±1.66	37.58±1.80	0.63
Hemicellulose[2]	28.20±4.47[ab]	30.86±1.74[a]	23.35±0.59[b]	0.93
pH	3.87±0.03[b]	3.92±0.00[a]	3.41±0.02[c]	0.01
Lactic acid	4.98±0.54[a]	2.20±0.10[b]	1.69±0.45[b]	0.14
Acetic acid	5.37±0.16[b]	2.32±0.18[c]	8.75±0.14[a]	0.27
Butyric acid	0.99±0.87	1.00±0.55	0.99±0.86	0.56

[a,b,c] Means within the same row with different superscripts differ (P<0.05)

SEM = standard error of the mean

The fermentation characteristic of pH in FBP pineapple was significant the lowest (P<0.05). The low pH in this group possibly due to the presence of citric and other organic acids in the fruit (Cervera *et al.*, 1985). The concentration of lactic acid in FBP mixed was significant the highest (P<0.05). Johnson *et al.* (2001) reported that high quality silage depend on lactic acid which acid is the predominant acid produced, as it is most efficient fermentation acid and will drop the pH of the silage the fastest. The fastest of the fermentation is completed, the more nutrients will be retained in the silage (Johnson *et al.*, 2001). Zobell *et al*. (2004) reported that a good quality of silage is characterized by a lactic acid concentration of 3-14%. In this study, FBP mixed was higher value of lactic acid and optimum in level of lactic acid concentration. The additive of vinasses are used to improve silage preservation by ensuring that lactic acid bacteria dominate the fermentation phase in the ensiling process (Titterton and Bareeba, 1999). Animah *et al.* (2004) reported that four percent molasses added to the ensiled material generally improved silage quality derived from grasses in terms of increased lactic acid content. Bolsen *et al.* (1996) also reported that the fermentation process was highly influenced by the availability of fermentable carbohydrate and predominant bacteria during ensiling process. The concentration of acetic acid in FBP pineapple was significant the highest (P<0.05). The high level of acetic acid in this group described the positive aspect of the formation of acetic acid by heterofermentative lactic acid bacteria, which inhibits spoilage organisms (Cook, 1995). In this study, the butyric acid concentration were higher all groups which reduced energy content. Fermentation products in silage, which contain high numbers of lactic acid bacteria, usually have high levels of lactic acid and low level of acetic acid and ethanol. The production of VFA in silage is reflection of an inefficient fermentation or of secondary fermentation of lactic acid to butyric acid and degradation of amino acids to ammonia with the production of amino acid from skeleton of the amino acid (Chamberlain and Wilkinson, 1996). In our experiment 1, the physical characteristics and chemical composition of FBP mixed showed the good quality of silage

Experiment 2 The effect of storage period on nutritive values and characteristics of Fermented By-Products (FBP)

1. Qualities of ingredients of by-products to make Fermented by-product

The chemical composition of ingredients of FBP were presented in Table 18. The result showed that corn cob and vinasses had higher crude protein content than the other ingredients. Wanapat *et al.* (2009) reported that corn cob can be used as energy source with urea in Swamp buffalo. However, the level of fibers (NDF and ADF) were higher when use of corn cob as energy source compare with cassava chip. Vinasses could be used as a source of protein and minerals for animal feed. Vinasse was found to be higher calcium, phosphorus and potassium than molasses (Tumwasorn, 2007). The pineapple peel, corn husk and corn cob were low in DM (13.67, 20.34 and 17.89%, respectively) but higher in ADF content (30.12, 48.13 and 28.20, respectively). The low DM contents of these by-products were not a good silage source which are susceptibility to saccharolytic and proteolytic clostridial fermentation (Leibensperger and Pitt, 1987). The corn cob had higer protein content because some left over corn seeds were found on the cob. The clostridium was normally found not only from butyric acid but also responsible for the degradation of proteins in corn cob to ammonia (Weinberg and Muck, 1996). The Bagasse is an alter by-product source for FBP which has high DM, NDF and ADF (90.8, 88.6 and 49.63%, respectively). Thus, the supplement bagasse in FBP could increase DM content. Vinasses was added in FBP which decrease the pH and NDF content which similar to reported by Siang-Chong (2010).

Table 20 The ingredients and chemical composition (% of dry matter) of FBP

Item	Vinasses	Bagasse	Pineapple peel	Corn husk	Corn cob
DM	32.28	90.82	13.67	20.34	17.89
CP	10.28	3.81	7.54	6.10	10.45
EE	1.83	1.06	0.88	1.08	3.97
NDF	0.10	88.60	70.23	68.19	69.30
ADF	0.01	49.63	30.12	48.13	28.20
Ash	20.63	7.66	6.74	3.98	4.64

2. Visual Evaluation of different fermentation period of FBP

FBP mixed when fermented for 30 and 60 days showed a good preservation process (Table 22). For 90 days after fermented detected butyric odor and firm texture. However, Cevera *et al.* (1985) who founded that the fermentation fresh orange pulp with or without urea for 90 days after fermented had a good preservation of residue. The FBP mixed all groups were a good preservation process because no ethanol odor was detected which ethanol odor is the parameter for determine the quality of silage (McCullough, 1975).

Table 21 The characteristics of FBP-Mixed, FBP corn and FBP pineapple with different fermented period

characteristics	**FBP[1] Mixed 30 days**	**FBP[1] Mixed 60 days**	**FBP[1] Mixed 90 days**
color	dark-yellow	dark-yellow	dark-yellow
odor	lactic-acid[2]	lactic-acid	butyric acid[3]
texture	firm	firm	firm

[1] Fermented By-Product

[2]Lactic acid odor is similar to that the sour milk

[3]Butyric acid odor is similar to that of rancid butter or fat

3. Chemical composition and fermentation characteristics

The chemical composition and fermentation characteristics of FBP at 30, 60 and 90 days after fermented are presented in Table 23. The chemical composition of DM, CP, CF, Ash, NFE, ADF, NDF, ADL, cellulose and hemicelluloses were not different among 30, 60 and 90 days after fermentation. However, the EE of FBP at 60 and 90 days after fermented were significant higher than 30 days after fermented. Silage can be kept for months or years (Wong, 1999) and can be used at any time as when required, especially during periods of drought (Koon, 1993). However, the fresh wet crop residues of agro-industry by-products which are useful feed resources, but theses cannot be stored for a long time (Cowan, 1999).

The fermentation characteristic of pH was not different among treatments (3.40-3.58). Leibensperger and pitt (1988) point out that a rapid decrease in pH inhibits clostridial fermentation and hydrolysis of plant proteins by plant enzymes. The concentration of lactic acid in FBP at 30 days after fermented was significant the highest ($P<0.05$). This study was similar to those reported by Bilal (2009) who studied in mot grass additive with molasses or corn showed minimum pH and maximum lactic acid contents were found in silage ensiled for 35 days, probably because of increased population of lactic acid which increased the accumulation of lactic acid with increasing fermentation time and subsequently reduced pH value. According to McDonald *et al.* (1999) and Yang *et al.* (2004) who stated that attainment of low pH is one of important determinants for final silage fermentation quality. The FBP after fermented for 30 and 60 days showed a good quality of silage with supported by Zobell *et al*. (2004) who found that the good quality of silage is characterized by a lactic acid concentration of 3-14 %. The odor of butyric acid in 90 days after fermented (Table 22) with related to the concentration of acetic and butyric acid were significant the highest ($P<0.05$) in these group associated by McCullough (1975) who found that the present of clostridial species which produce ammonia, butyric and carbon dioxide (CO_2) maintaining an elevated pH level. Those condition reduced lactate production and relate to develop of fungi species (*Candida* sp., *Endomicopsis* sp., *Hansenula* sp., *Pichia* sp., *Torulosis* sp.) (Woolford, 1984) Furthermore, The concentration of acetic acid and butyric acid at 90 days after fermented was significant the higher than 30 days after fermented ($P<0.05$). Thus, can be kept FBP for 60 days which no affect on physical characteristics and chemical composition.

Table 22 Chemical composition and fermentation characteristics of FBP with different fermentation periods

Chemical composition	**FBP mixed**			**SEM**
	30 days	**60 days**	**90 days**	
DM	22.91±0.20	22.15±0.67	21.01±1.47	0.31
CP	7.47±1.08	6.79±0.09	6.35±0.55	0.23
EE	1.19±0.05[b]	1.51±0.20[a]	1.50±0.08[a]	0.04
Ash	6.77±0.25	6.83±0.11	6.67±0.58	0.12
NFE	51.82±2.03	51.44±2.21	49.11±7.78	1.61
NDF	72.61±1.28	72.96±0.92	72.35±0.62	0.32
ADF	44.41±3.22	44.65±0.82	45.03±1.67	0.72
ADL	8.70±1.39	8.25±1.19	10.44±0.41	0.36
Cellulose[1]	35.71±2.15	36.40±1.19	34.63±1.25	0.49

Table 22 (Continued)

Chemical composition	FBP mixed			SEM
	30 days	60 days	90 days	
Hemicellulose[2]	28.20±4.47	28.31±1.43	26.74±2.05	0.99
pH	3.42±0.02	3.58±0.16	3.40±0.08	0.04
Lactic acid	4.99±0.54[a]	3.16±1.41[b]	2.62±0.23[b]	0.29
Acetic acid	4.80±0.16[b]	5.38±0.82[ab]	7.41±1.59[a]	0.35
Butyric acid	0.99±0.87[b]	2.82±1.66[ab]	3.65±0.64[a]	0.38

[a,b] Means in the same row with different superscripts differ ($P<0.05$)

Cellulose[1] =NDF-ADF

Hemicellulose[2] = ADF-ADL

SEM = standard error of the mean

Experiment 3 Effect of Fermented By-Product (FBP) on milk yield and composition of mid lactation Dairy Cow

1. Chemical composition and fermentation characteristics

The chemical composition of concentrate, rice straw, vinasse, SCWS and FBP were presented in Table 24. The chemical composition of rice straw in our study was found to be similar to those values reported by Nguyen *et al*. (2012). Sruamsiri *et al*. (2007) reported that the dry matter of SCWS was lower than 20% which can used as roughage source for cattle. The dry matter of FBP were found similarly to those reported by Mustafa *et al*. (2004) who founded that dry matter of sweet corn residue ensilaged was 22.62%. Furthermore, Jaster *et al*. (1983) reported that sweet corn residue contains 22.0 % DM, 9.8 % CP, 59.4% NDF, 37.4% ADF and 9.8 MJ/kg ME. Moreover, Dönmez *et al*. (2003) reported that the corn silage treated with 5% molasses significantly increased DM, CP and lactic acid content and decreased the concentration of NDF and ADF. Our FBP in this study had higher WSC than those of SCWS. WSC or non-soluble carbohydrate (NC) (sugar and starch) is used as energy source for microbes in rumen to produce volatile fatty acid (VFA) such as acetic, propionic and butyric acids. Moreover, WSC are regarded as essential substrates for the growth of lactic acid bacteria for produce lactic acid which to improve conservation of silage (Rotz and Muck, 1994). Haigh and Parker (1985) suggested that a concentration of more than 30g/kg DM of WSC in herbage is critical for useful fermentation.

The WSC found in FBP was higher than the critical useful (55 g/kg DM) which showed sufficient amount of WSC for efficient fermentation. The optimum level of WSC was 6-12% (Aminah *et al*. 2004). The value of pH and lactic acid was similar to optimum level (Catchpoole and Henzell, 1971) which ensiling of FBP requires substantial amounts of fermentable sugars to produce sufficient lactic acid and reduced the pH for stabilize the product (McDonald, 1981; Wilkinson, 2005). Good quality silage is characterized by a lactic acid concentration (Zobell *et al.,* 2004) which lactic acid is desired in silage making, thus have been developed to improve conservation of silage (Rotz and Muck, 1994). Lactic acid affect on the microorganism was inhibited (Weinberg and Muck, 1996). The concentration of butyric acid in FBP were lower than 0.1 g/kg DM which is indicative of well preserved silages (Kung and Shaver, 2001). According to reported by Siang-Chong (2010) who found that leucaena silage was added 4, 6 and 8% of vinasse was not detected butyric acid, thus can be used vinasse for additive to improved the silage quality. Ammonia nitrogen production of FBP and SCWS were similar. Ammonia nitrogen in silage reflects the degree of protein degradation (Wilkinson, 2005) and well preserved silages contain less than 100 g ammonia nitrogen/kg true protein (TN). The increase of CP during ensiling which affect on proteolytic activity during fermentation produces NH_3 but due to efficient fermentation and early stability of silage, this proteolysis activity is inhibited and produced NH_3 helps in getting the aerobic stability because of its fungicidal properties (Kung *et al*., 2000). The other possible reason of increase in CP contents due to additive may be protein sparing activity, as by day 7, pH has been reduced sufficiently to inactivate the plant proteolytic enzymes. These enzymes are acid labile with optimum pH ranges from 5 to 6 and their activity is decreased as pH approaches 5 but completely stopped at pH 4.5 to 3.8 (Sharp *et al.* 1994).

Table 23 Chemical composition (% of dry matter) of dietary treatments used in the experiment

Item	Concentrate	Rice straw	Vinasses	FBP[1]	SCWS[2]	RS+V[3]
DM	91.62	86.70	32.30	24.29	17.68	85.65
OM	95.17	84.04	79.37	93.50	93.70	83.76
CP	19.80	4.05	10.28	8.35	9.58	4.41
EE	4.26	0.82	1.83	1.24	2.01	0.88
NDF	38.90	73.50	0.01	71.00	75.01	63.23
ADF	34.50	43.85	0.10	46.61	37.79	41.33
WSC	-	-	-	5.50	3.90	-
pH	-	-	-	3.42	3.44	-
Lactic	-	-	-	6.10	4.00	-
Acetic	-	-	-	8.71	12.00	-
Butyric	-	-	-	0.00	2.81	-
Propionic	-	-	-	1.60	2.10	-

[1] Fermented By-Product [2] Sweet corn waste silage [3]Rice straw + Vinasses 1 kg

2. Feed intakes and nutrient digestibilities

The DM intake is presented in Table 25. The DM of roughage intake of cow fed RS+V was significant highest ($P<0.05$) in term of kg/d than cow fed FBP and SCWS, respectively. However, There were no differences in roughage DMI and total DMI in term of percent body weight among cows fed rice straw with vinasses and FBP. The lowest DM intake of SCWS was not to be related to the water content in the silage (Erdman, 1993) but also depend on the final fermentation product (lactic, acetic and butyric acids) are present in SCWS. Huhtanen *et al.* (2003) reported that the fermentation quality of silages has a major effect on feed intake, nutrient utilization and milk production in ruminants. It is known that silage with high moisture content result in increased of acetic and butyric acid which is reduced feed intake. The DM intake of FBP in our study was found to be the same when compare with fed RS+V. The FBP which used in this study did not present odor of butyric acid (0 % of DM) which no effect on feed intake. Erdman (1993) reported that final fermentation products (lactic, acetic and butyric acids) are present in high concentrations in high moisture forages seem to be on affect negatively the intake of silage. Especially, silage had odor of butyric acid which affect on palatability. FBP had high concentration of starch may become a significant factor at high intake levels for dairy cow (Van Soest, 1994).

Table 24 Effect of difference fiber source on DM intake and live weight change in lactating dairy cows

Items	**FBP[1]**	**SCWS[2]**	**RS+V[3]**	**SEM**
Roughage intake				
kg/d	4.64±0.42[b]	2.68±0.28[c]	5.55±0.29[a]	0.07
%BW	1.20±0.19[a]	0.64±0.06[b]	1.26±0.14[a]	0.04
Concentrate intake				
kg/d	7.34±0.02[c]	8.18±0.40[b]	8.93±0.05[a]	0.06
%BW	1.90±0.25	1.94±0.11	2.03±0.29	0.06
Total intake				
kg/d	11.99±0.06[b]	10.68±0.45[c]	14.47±0.03[a]	0.07
%BW	3.10±0.42[a]	2.57±0.14[b]	3.29±0.41[a]	0.09

[a,b,c] Means in the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Sweet corn waste silage [3]Rice straw + Vinasses 1 kg

SEM = standard error of the mean

Digestibility coefficients, estimated nutrients and energy intake were presented in Table 26. Digestibility of DM, OM, CP, NDF and ADF were significantly higher (P<0.05) in cows fed FBP and SCWS than cows fed rice straw with vinasse. Nguyen *et al*. (2012) reported that rice straw had low nutritive value and digestibility of DM. Digestible nutrient intake of DM, OM, NDF and ADF in this study were significantly the highest (P<0.05) in cows fed FBP.

Digestible nutrient intake of CP was in the same range among cows fed FBP and SCWS. Cows fed FBP had higher digestibility coefficient of nutrient which agreed well with reported of Oldham (1984) who found that dry matter intake and nutrient digestibility of the diet increased with increasing crude protein contents. For estimated energy intake, intake of ME in term of Mcal/d was significantly highest (P<0.05) in cows fed FBP. Furthermore, intake of ME Mcal/kg/DM was significantly higher (P<0.05) in cows fed FBP and SCWS than RS+V. This result showed the higher nutritive values of feed intake which could be related to the high apparent digestibility of DM and OM intake and eventually resulted in higher intake of ME Mcal/d and Mcal/kg/DM.

Table 25 Effect of difference fiber source on nutrient digestibility and digestibility nutrient intake in lactating dairy cows

Items	**FBP[1]**	**SCWS[2]**	**RS+V[3]**	**SEM**
Apparent digestibility, %				
DM	71.20±7.58^{a}	69.56±6.04^{a}	50.02±0.11^{b}	1.49
OM	75.50±6.59^{a}	73.35±5.01^{a}	55.93±1.93^{b}	1.27
CP	73.74±4.61^{a}	72.55±4.16^{a}	55.42±2.40^{b}	0.99
NDF	64.42±10.51^{a}	59.79±8.11^{a}	40.55±3.22^{b}	2.04
ADF	64.25±9.20^{a}	59.81±7.56^{a}	33.86±3.05^{b}	1.83

Table 25 (Continued)

Items	**FBP[1]**	**SCWS[2]**	**RS+V[3]**	**SEM**
Estimated digestible nutrient intake, kg/d				
DM	8.50±0.86[a]	7.46±0.65[b]	7.22±0.28[b]	0.17
OM	8.54±0.68[a]	7.42±0.56[b]	7.52±0.22[b]	0.14
CP	1.36±0.05[a]	1.36±0.05[a]	1.12±0.08[b]	0.02
NDF	3.96±0.61[a]	3.08±0.40[b]	3.08±0.20[b]	0.11
ADF	3.00±0.38[a]	2.28±0.31[b]	1.86±0.17[c]	0.00
Estimated energy intake				
ME, Mcal/d[3]	32.46±2.66[a]	28.30±3.04[b]	28.52±0.82[b]	0.51
ME, Mcal/kg DM	2.71±0.24[a]	2.64±0.18[a]	1.97±0.07[b]	0.05

[a,b] Means in the same row with different superscripts differ ($P<0.05$)

[1]Fermented By-Products [2] Sweet corn waste silage [3]Rice straw + Vinasses 1 kg

[3]1 kg of digestible organic matter (DOM) = 3.8 Mcal ME (Kearl, 1982)

SEM = standard error of the mean

3. Blood metabolite

Blood urea nitrogen (BUN) also was affected by dietary protein. The BUN in this study was similar among treatments (12.40-19.60 mg/dl) were similar to those reported by Robinson *et al*. (1991) who found that lactating Holstein cows receiving alfalfa silage had BUN 15.0-20.4 mg/dl. Hammond *et al*. (1983) found that BUN was related to both protein amount and solubility. Blood Glucose (BG) at 0 hr post feeding in group of dairy cow fed FBP and SCWS were significant higher than fed RS+V ($P<0.05$). However, at 4 and mean of BG were not significant among treatments ($P<0.05$). Moreover, Triiodothyronine (T3) were not different among treatment ($P>0.05$). The concentration of NEFA at 4 hr and mean in group of RS+V was significant the highest ($P<0.05$). The NEFA is related to weight loss in this group indicate that there was significant difference in the rate of mobilization of adipose tissue (Akerlind *et al*., 1998). Furthermore, the plasma concentration of NEFA is an index of the mobilization of adipose tissue (Bauman *et al*., 1999). The high level of NEFA in group of cow fed RS+V was associated with the body weight loss (-6.25 kg) (Table 29). NEFA changes reflect body fat mobilization. Dairy cow fed RS+V had highest NEFA which indicated that cause of energy deficiency in the diet of the cow (Bartley, 1989). The negative relationship of NEFA to TDN was observed in dry cows. It was confirmed that an increase in NEFA directly indicated a negative energy balance in group of fed RS+V (NRC, 2001).

Table 26 Blood urea nitrogen, blood glucose, triiodothyronine and non-esterified fatty acid of lactating dairy cows receiving different fiber sources

Items	FBP[1]	SCWS[2]	RS+V[3]	SEM
BUN, mg/dl				
0 h-post feeding	15.80±2.39	13.80±3.56	12.40±0.55	0.14
4 h-post feeding	19.60±4.22	16.80±4.66	18.40±1.14	0.50
Mean	17.70±3.29	15.25±3.54	15.50±0.91	0.38
BG				
0 h-post feeding	55.00±0.71[a]	55.00±1.87[a]	52.60±0.55[b]	0.31
4 h-post feeding	59.00±2.45	57.40±4.67	59.60±1.14	0.53
Mean	57.00±1.54	56.20±2.68	56.10±0.74	0.47
T3, mg/dl				
0 h-post feeding	158.20±71.92	176.20±56.64	123.40±8.26	13.71
4 h-post feeding	203.00±87.37	220.20±57.20	140.80±17.41	15.79
Mean	180.60±79.32	198.20±56.38	132.10±11.72	14.60
NEFA, mg/dl				
0 h-post feeding	10.64±2.89	11.35±2.13	11.87±1.61	0.59
4 h-post feeding	6.41±1.02[b]	7.20±0.73[b]	9.46±1.45[a]	0.29
Mean	8.53±1.26[b]	9.28±1.42 [ab]	10.66±1.51[a]	0.38

[a,b] Means in the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Sweet corn waste silage [3]Rice straw + Vinasses 1 kg

SEM = standard error of the mean

4. Milk production and composition

Milk production and milk composition were presented in Table 28. Milk yield in cow fed FBP and SCWS tended to be higher than RS+V. Cows fed RS+V was reduced milk production because its low starch of the diets according to reported by Ireland-Perry and Stallings (1993). In addition, Phipps et al. (1995) reported that diets based on maize silage (MS) increase the milk yield and milk protein content. Furthermore, Wanapat (2009) who found that cows fed untreated rice straw had 10.8 kg/d of milk yield. The supplement of vinasses in rice straw group could enhance milk yield and milk composition. Milk protein in cows fed SCWS was significant the highest ($P<0.05$). But did not different in group of cows fed FBP. High starch diets are more likely to give a high propionic and rumen fermentation (Sutton et al. 1987) which has been associated with increases in milk protein concentration (Rook and Balch, 1961) that similar reported by Phipps et al. (1995) who found that increase amount of replacing grass silage (GS) with MS in the diet significantly increased the DM intake, milk yield and milk protein. An increase in milk protein concentration in cow fed FBP and SCWS may also be attributed to microbial protein synthesis being energetically more efficient on MS than on GS based diets (Givens and Rulquin, 2004).

Furthermore, the increase milk protein concentration with increasing concentration feed level is probably due to increased metabolizable energy intake of the cows (Ferris et al., 1999). Tamminga (1992) reported that energy intake and milk protein content were positively correlated. Milk fat and lactose were unaffected by all dietary treatments in our study. But tended to increase in cows fed SCWS and FBP, respectively. The high fat content of milk in group of cow fed FBP and SCWS was probably due to the optimum silage particle (Grant and Weidner, 1992). and type of the forage. Corn silage should be chopped at ⅜- to ¾-inch and forages with small particle sizes have been reported to depressing fat. Finely chopped forages can cause metabolic disorders such as ruminal acidosis and displaced abomasums (Mueller et al, 1987). Similar to those reported by Ó Mara et al. (1998) who found that cows fed MS had milk fat, protein and lactose as 3.74, 3.09 and 4.6%, respectively. Furthermore, Lock and Shingfield (2004) found that cows fed MS had no effect on milk fat content. Solid-not fat and total solid were significantly higher in cow fed SCWS and FBP than RS+V ($P<0.05$).

Our study were in agreement with report of Swamiphak (1996) who stated that SNF percentage of raw milk in Thailand had the range between 8.13 and 8.67. Similary, reported by Rahman *et al.* (2003) who found that cows fed maize stover silage was not effect on milk fat, protein, TS and SNF (4.7, 3.0,12.2 and 7.6%, respectively). Kaewkamcharn *et al*. (2000) and Swamiphak (1996) reported that SNF in raw milk from collecting centers under the Dairy Farming Promotion Organization of Thailand (DPO) was decline from 1993 to 1999. Since SNF is one of the parameter in the milk price. Cows fed FBP seemed to be higher milk yield with effect on milk protein, SNF and TS which Gibson (1987) stated that the high positive correlation between milk yield and total solids, fat and protein yields. The fat and protein ratio in milk yield was not significant ($P>0.05$) and was in the optimum range for positive energy balance. Heur et al. (2000) reported that a high milk fat to protein ratio indicated a negative energy balance while the optimum milk fat and protein ratio between 1 to 1.25 indicated the positive energy balance (Flatt et al., 1969).

Milk urea nitrogen (MUN) in this study was found in range from 17.20-18.10 mg/dl. However, cows fed FBP tended to be increased BUN and MUN than the other groups which indicated that FBP was balanced in protein and energy for dairy cows. MUN concentration in this study was not found to be significant difference among treatments ($P>0.05$) and were in the normal range as reported by Schroeder (2002) who stated that cows with MUN less than 10 to12 mg/dl and higher than 16 to 18 mg/dl would result in high feed costs, reduced health, lower production performance and low milk production. Also, BUN and MUN in this study were closer to the normal level as reported by Roseler *et al.* (1993) who found that balanced diets for lactating dairy cows were associated with average BUN concentration of 15 mg/dl and average MUN concentration of 5-16 mg/dl (Jonker *et al*., 1999).

Table 27 Effect of difference fiber source on milk yield and milk composition in lactating dairy cows

Items	FBP[1]	SCWS [2]	RS+V [3]	SEM
Milk yield, kg/d	14.24±0.98	13.13±1.07	12.96±3.07	0.44
4% FCM, kg/d	13.21±1.63	13.04±1.35	12.19±2.25	0.40
Milk composition, %				
Fat	3.88±4.39	3.95±0.38	3.25±0.99	0.17
Protein	3.05±0.26[ab]	3.10±0.14[a]	2.78±0.14[b]	0.04
Lactose	4.63±0.23	4.64±0.20	4.36±0.28	0.05
Solid-not fat	8.36±0.24[a]	8.41±0.21[a]	7.76±0.27[b]	0.07
Total solids	12.08±1.02[ab]	12.37±0.58[a]	11.02±1.02[b]	0.21
Fat/Protein ratio	1.27±0.24	1.28±0.10	1.16±0.31	0.05

[a,b] Means in the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Sweet corn waste silage [3]Rice straw + Vinasses 1 kg

SEM = standard error of the mean

5. Body weight gain and live weight change

The body weight change during study period was presented in Table 30. In this study, dietary treatment had significant effect on body weight (BW) changes. Cow fed FBP had higher weigh gain increase (11.16 kg) (P<0.05), By contrast, the group fed RS+V and SCWS weigh loss (-6.25 and -8.50 kg) such as weigh loss because of the low quality of forage (rice straw and SCWS silage).

Table 28 Body weight Change and average daily gain of lactating cows receiving different fiber sources

Items	**FBP**[1]	**SCWS**[2]	**RS+V**[3]	**SEM**
Live weight				
Initial, kg	391.90±59.07	416.20±26.86	445.20±63.60	0.22
Final, kg	403.60±72.00	407.60±29.33	437.20±54.83	12.38
Body weight change, kg	11.16±17.24[a]	-8.50±7.55[b]	-6.25±17.34[b]	7.38

[a,b] Means in the same row with different superscripts differ (P<0.05)

1 Fermented By-Product 2 Sweet corn waste silage 3Rice straw + Vinasses 1 kg

SEM = standard error of the mean

6. Income over feed cost

Feed cost is a major part of the total costs of milk production and cost of feed are rising in dairy cattle that is importance to optimize the level of nutrient intake and to optimize the sources of nutrient intake. Variable costs, income and income over feed costs were presented in Table 30. Total variable costs were significance higher in group of cow fed FBP (P<0.05). However, cows fed with FBP could reduce the concentrate cost (77.48±0.25 baht/kg) due to lower intake (7.34±0.03 baht/kg). The income over fed cost in group of fed with FBP tended to be the highest. Cows fed with FBP returned the highest income and gained more profit to farmer.

Table 29 Effect of difference fiber source on the variable costs, income and economic return during the experimental period

Items	FBP[1]	SCWS[2]	RS+V[3]	SEM
Variable cost[4] (baht)				
Roughage	46.08±4.17[a]	26.57±0.85[b]	15.84±0.61[c]	0.68
Concentrate	77.48±0.25[c]	84.39±0.00[b]	94.29±0.65[a]	0.09
Total	123.56±4.28[a]	110.96±2.85[b]	110.13±0.38[b]	0.66
Income				
Milk yield (kg/h/d)	14.24±0.98	13.13±1.07	12.95±3.07	0.44
Value	234.90±16.13	216.64±17.65	213.74±50.74	7.24
Income over feed cost (baht/h/d)	116.94±18.38	105.67±16.90	103.62±50.72	7.30

[a,b,c] Means in the same row with different superscripts differ (P<0.05)

[1] Fermented By-Products [2] Sweet corn waste silage [3]Rice straw + Vinasses 1 kg

[4]Variable costs in this study include concentrate (20% CP) 9.67 baht/kg, rice straw 1.80 baht/kg, vinasses 5 baht/kg, sweet corn waste silage 1.80 baht/kg and FBP 2.45 baht/kg, Milk price 16.50 baht/kg.

SEM = standard error of the mean

Experiment 4 The effect of different proportion of Fermented By-Products (FBP) with rice straw using in *vitro* gas production

1. Chemical composition and fermentation characteristics

The chemical composition of feed use in this experiment was presented in Table 31. FBP contained DM 23.0%, CP 6.27%, NDF 71.74% and ADF 10.29%. The chemical composition of FBP was similar to maize silage which had DM 25.25% and CP 7.86% (Kamalak *et al.*, 2005). Rice straw contained CP 4.05%, NDF 73.46 % and ADF 43.85%. The chemical composition of rice straw was similar to those reported by Foiklang *et al.* (2012) who found that rice straw contained CP 3%, NDF 85.6% and ADF 53.2%.

Table 30 Chemical composition of feed used in this study (on dry matter basis)

Items	Concentrate	FBP[1]	RS[2]	FBP:RS (DM basis)		
				40:60	**50:50**	**60:40**
DM	90.11	23.05	86.74	61.26	74.00	48.53
CP	14.37	6.27	4.05	4.94	4.49	5.38
EE	2.62	1.14	0.82	0.95	0.88	1.01
CF	14.73	35.94	34.91	35.32	35.12	35.53
Ash	8.28	7.00	15.96	12.38	14.17	10.58
NFE	60.00	49.65	44.26	46.42	45.34	47.49
NDF	36.02	71.74	73.46	72.77	73.12	72.43
ADF	24.60	47.29	43.85	45.23	44.54	45.91
ADL	2.36	10.29	9.00	9.52	9.26	9.77
Cellulose[3]	22.24	37.00	34.85	35.71	35.28	36.14
Hemicellulose[4]	11.42	24.45	29.61	27.55	28.58	26.51

[1]Fermented By-Product [2]Rice straw

Cellulose[3] =NDF-ADF

Hemicellulose[4] = ADF-ADL

2. Gas production characteristics

The *in vitro* gas production technique has proved to be a potentially useful technique for feed evaluation (Menke *et al.*, 1998) as it can be used to measure the rate and extent of nutrient degradation (Cone *et al.*, 1997). In addition, the *in vitro* gas production technique is less expensive (Getachew *et al.*, 2004). This method provides easy determination (Khazaal *et al.*, 1993) and is suitable for use in developing countries (Blummel *et al.*, 1997). Gas production from the fermentation of the ratio of FBP and rice straw were measured at 2, 4, 6, 12, 24, 48 and 72 h *in vitro*. Gas production characteristics were presented in Table 32 and Figure 8. The resulted show that gas volume at 72h after incubation was significantly different ($P<0.05$) among treatments. Cumulative gas production at 72 h after incubation as the ratio of FBP and rice straw as 50:50 on DM basis (60.64 ml/200 mgDM) was significant different the higher (P<0.05) than group of FBP and rice straw as 40:60 on DM basis and rice straw only (53.12 and 52.96 ml/200 mgDM). The reason might be due to the high content of lignified cell wall in rice straw. The FBP and rice straw as 40:60 and rice straw only which led to attachment difficulties by microorganisms. However, the gas production at 2 to 48 h were not significant different among treatment, in which the ratio of FBP and rice straw as 50:50 as DM basis had the highest maximum volume of gas production. However, the microbe rumen fluid in group of FBP and rice straw as 40:60 and 60:40 might be used the substrate rapidly which affect on low cumulative gas production (Figure 8). Furthermore, the differences in fermentation characteristics of different proportion of FBP and rice straw may be related to the variations in CP, NDF and ADF contents observed in this study.

Table 31 The gas volume and values of kinetic parameter from fermentation of the ratio roughage source

Incubation time (hr)	**The ratio of roughage source FBP[1]: RS[2] (DM basis)**				**SEM**
	60:40	**50:50**	**40:60**	**0: 100**	
Gas volume, ml/200 mg DM					
2	4.09±1.71	5.11±0.23	4.01±2.98	6.29±2.05	1.00
4	11.04±1.33	12.16±0.33	10.80±3.05	13.13±0.28	1.03
6	17.45±0.98	18.11±2.04	16.51±3.16	19.06±0.30	0.98
8	22.39±1.45	22.45±1.83	20.85±3.26	23.18±0.65	1.01
10	26.48±1.91	25.50±1.92	23.91±3.47	26.22±0.86	1.12
12	29.27±2.14	28.85±1.71	26.29±3.57	28.61±1.17	1.16
24	39.84±2.26	39.83±1.44	35.05±4.61	37.40±2.66	1.46
48	53.66±2.29	53.17±1.24	47.14±4.51	48.76±3.99	1.64
72	58.76±2.53[ab]	60.64±1.47[a]	53.12±4.92[b]	52.96±4.97[b]	1.89

Table 31 (Continued)

Incubation time (hr)	**The ratio of roughage source FBP[1]: RS[2] (DM basis)**				**SEM**
	60:40	**50:50**	**40:60**	**0: 100**	
Gas production parameter					
a (ml)	0.25±0.60	1.87±1.24	1.25±1.33	1.90 ±0.24	0.48
b (ml)	57.65±1.96[a]	58.08±2.71[a]	50.54±3.90[b]	49.41±5.03[b]	1.80
a+b (ml)	57.90±2.28[ab]	59.94±5.22[a]	51.79±4.88[b]	51.34±2.08[b]	1.95
c (h^{-1})	0.06 ±0.00	0.05±0.01	0.06 ±0.01	0.06 ±0.00	0.50

[a,b]Means in the same row with different superscripts differ (P<0.05)

[1] Fermented by products [2] Rice straw

SEM = standard error of the mean

The gas production is directly proportional to the rate at which substrate being degraded (Dhanoa *et al.*, 1995). Additionally, kinetics of gas production is dependent on the relative proportions of soluble, insoluble but degradable and undegradable particles of the feed (Getachew *et al.*, 1998). Menke *et al.* (1979) suggested that the gas volume after 24 h of incubation has a relationship with metabolizable energy in feedstuffs. Sommart *et al.* (2000) reported that gas volume is a good parameter to predict digestibility, fermentation, end-product and microbial protein synthesis of the substrate by rumen microbes in the *in vitro* system. The value for absolute *a* ($|a|$), can be used to describe that ideal fermentation of the soluble fraction. In this study, the absolute gas production were not different among treatments. The intercept value *a* for the different treatment gas production from soluble fractions range from 0.25-1.90. The soluble fraction makes it easily attachable by ruminal microorganisms and leads to greater gas production. The gas volumes at asymptote (*b*) describe the fermentation of the insoluble fraction. The gas production from the insoluble fraction in this study in group of FBP and rice straw 50:50 and 60:40 as DM basis were significant higher than group of FBP and rice straw 40:60 as DM basis and rice straw only (P<0.05).

Rate of gas production (*c*) expressed in this study were not significant different (P>0.05). High rates of gas production influenced by the soluble carbohydrate fractions readily available to ruminal microbes. Deaville and Givens (2000) also reported that the carbohydrate fraction could affect the kinetics of gas production. Potential extent of gas production (*a+b*) expressed in ml as group of FBP and rice straw 50:50 was significant the highest (P<0.05). Generally, the potential of gas production in group of supplement FBP could improve the parameter of potential extent of gas production because of the high carbohydrate fraction (particularly NDF). The parameter of gas production characteristics in this studied was similar to those reported by Kamalak *et al.* (2005) who was to determine the effect of inclusion of polyethylene glycol (PEG 8000) during *in vitro* incubation on gas production kinetics, organic matter digestibility (OMD) and the metabolisable energy (ME) content of foliage from the tannin containing tree species, *Pistica lentiscus, Arbutus andrachne* and *Juniperus communis*.

The resulted in our study showed that the value for absolute *a*, the gas volumes at asymptote (*b*), Rate of gas production (*c*) and potential extent of gas production (*a+b*) were 4.19, 68.80, 0.095 and 73.00 ml per 0.200 g of dry matter. The cell wall content (NDF and ADF) in group of rice straw and FBP with rice straw 40:60 were negatively correlated with low gas production at 72 hr. The negative correlation between gas production and cell wall content may be result of the reduction of microbial activity (Ndlovo and Nherera, 1997). The low value of the estimated parameters can also be attributed the high fiber content prevalent in the rice straw which used in this study. However, gas production can be estimated feed degradation that it is a good parameter to predict digestibility, fermentation end products and microbial protein synthesis of microbes in *in vitro* (Bergman, 1990).

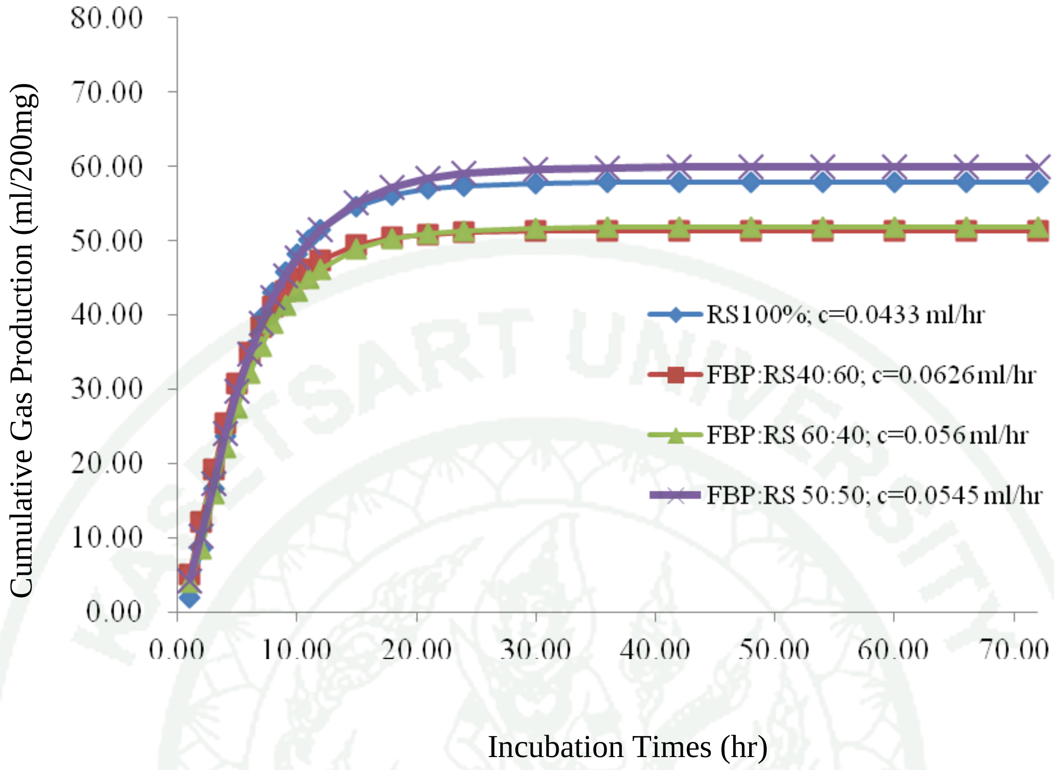

Figure 8 The gas volume estimated by y = a+b [1-exp $^{(-ct)}$]

The effect of proportion of FBP and rice straw on true digestibility (IVDM), *In vitro* organic matter digestibility (IVOM), Volatile fatty acids (VFAs) and ammonia nitrogen (NH_3-N) were present in Table 33. The IVDM was not different among treatments. However, The IVOM in group of proportion of FBP and rice straw as 50:50 and 40:60 on dry matter basis (83.55 and 81.71%) were significant (P<0.05) higher than group of proportion of FBP and rice straw 60:40 and rice straw only (72.88 and 64.92%). The result of this study was higher than Tang *et al*. (2008) who found IVDM and IVOM in Rice straw mixed with alfalfa as the ratio 50:50 were 56.90% and 53.60%. Rice straw had relatively lower gas production when compared with FBP. High IVDM and IVOM in group of supplement FBP may be due to its high crude protein content (Cone *et al.*, 1999). IVDM and IVOM were shown to have high correlation with gas volume (Sommart *et al.*, 2000). Gas volumes also have a close relationship with feed intake (Blummel and Becker, 1997) and growth rate in cattle (Blummel and Ørskov, 1993).

Total VFA, C_2 and C_3 concentration were similar among treatments. while, C_4 in group of proportion of FBP and rice straw 40:60 was significant the highest ($P<0.05$). C_4 concentration was lowest in group of FBP and rice straw 60:40 as DM basis that group was lower fiber content. The proportion of C_2:C_3 was not different among treatments (4.00-4.91). Cressman *et al*. (1980) reported that no change in molar proportion of VFA with increasing dietary CP. Furthermore, Holter *et al*. (1980) reported that a trend for the percentage of propionate to increase with increasing protein intake. Feeding of tropical forages to animal results in imbalance in digestive and products (high acetate and low propionate) which causes inefficient utilization of metabolizable energy (MacRae and Lobley, 1982). The NH_3-N in group of the ratio of FBP and rice straw 60:40 was significant the highest ($P<0.05$) However, the value was in the optimum level of NH_3-N (Wanapat, 1990) (15-30 mg/dl) which was reported to be suitable for microbial protein synthesis, feed digestibility and voluntary feed intake in ruminants fed on low quality roughage. NH_3-N concentration is related to protein content in feed because of many rumen microorganism required ammonia for growth and synthesis of microbial protein. The extent of this conversion depends on a variety of factors including solubility of the protein, their resistance to breakdown, rate of passage of feed through the rumen (Eschenlauer *et al.*, 2002). This resulted was high levels of NH_3 in the rumen. A large part of it will leave the rumen by absorption through the rumen wall mainly as a consequence of ruminal imbalance between degraded protein and energy supply for optimal microbial capture of the NH_3-N (Beever and Siddons, 1986). Excess ammonia is metabolized in the liver to urea and excreted in the urine which has a negative effect on the cow energy balance (Twigge and Van Gils, 1988).

The concentration of NH_3-N in fermentation maintain between 20-50 mg/100 ml can guarantee the rapid growth of microbes (Satter and Slyter, 1974). Wanapat *et al.* (2008) reported that ruminal NH_3-N concentration increased linearly with increasing supplemental rumen degradable protein (RDP) level. The ruminal microbes using total direct count was presented in the Table 34. The bacteria, protozoa and fungi zoospore population were not different among treatment ($P<0.05$). The population of bacteria in treatment of rice straw tended to be reduced bacteria.

Furthermore, The treatment of rice straw only tended to be increased protozoa count. The three treatments with supplement FBP could reduce protozoa because FBP compose of yeast in the process of vinasse. Robinson and Erasmus (2009) found that yeast exhibited on protozoa count, a trend for population to decrease in the presence of *Saccharomyces cerevisiae* was observed (Piva *et al.,* 1993). Guedes *et al.* (2008) found that yeast could stimulate the activity of cellulolytic bacteria and increase lactate utilization in the rumen, hence increased fiber digestion and flow of microbial protein synthesis in dairy cows and significantly altered the amino acid profile of duodenal digesta (Newbold *et al.*, 1995).

Table 32 *In vitro* true digestibility (IVDM), *In vitro* organic matter digestibility (IVOD), Volatile fatty acids (VFAs) and ammonia nitrogen (NH_3-N) in different levels roughage source

Parameter	The ratio of roughage source (as dry basis)				SEM
	FBP[1]: RS[2] (percent)				
	60:40	50:50	40:60	0:100	
In vitro true digestibility (%)	76.09±0.17	76.18±2.19	76.99±0.30	75.41±0.35	0.56
In vitro OM digestibility (%)	72.88±4.12 ^{b}	83.55±1.77 ^{a}	81.71±4.26 ^{a}	64.92±3.33^{c}	1.76
Total VFAs (mM)	14.78±2.36^{ab}	12.52±1.16^{bc}	11.48±2.29^{bc}	14.16±2.75^{bc}	1.08
VFA (mol/100 mol)					
Acetate (C_2)	73.92±2.16	73.03±1.49	71.79±0.94	73.63±0.72	0.72
Propionate (C_3)	15.12±1.07	15.22±1.06	15.45±0.42	14.75±0.56	0.41
Butyrate (C_4)	10.96±1.08^{b}	11.75±0.61^{ab}	12.76±1.26^{a}	11.62±0.14^{ab}	0.44
C_2:C_3	4.91±0.51	4.81±0.44	4.64±0.10	4.00±0.24	0.18
NH_3-N (mg/dl)	25.72±0.00 ^{a}	24.29±1.43 ^{ab}	23.81±1.65 ^{ab}	22.86±1.43^{b}	0.65
Bacteria, x10^9 cells/ml	4.66±0.92	5.33±2.72	6.13±1.51	3.20±1.44	0.44

Table 32 (Continued)

Parameter	The ratio of roughage source (as dry basis) FBP[1]: RS[2] (percent)				SEM
	60:40	50:50	40:60	0:100	
Protozoa, x10[6] cells/ml	0.16±0.11	0.15±0.05	0.16±0.05	0.46±0.15	0.03
Fungi zoospore, x10[6] cells/ml	0.40±0.28	0.42±0.14	0.40±0.14	0.40±0.38	0.07

[a,b,c] Means within the same row with different superscripts differ ($P<0.05$)

[1] Fermented By-Products [2] Rice straw

SEM = standard error of the mean

Experiment 5 The effects of different proportion of Fermented By-Products (FBP) and rice straw on Heifers Performance

1. Chemical composition and fermentation characteristics

The chemical composition of concentrate, rice straw and FBP on dry matter basis were presented in Table 35. The CP, NDF and ADL of rice straw in this study were higher quality than the values reported by Wanapat *et al*. (2009) (2.5, 84.9 and 61.3%, respectively). The chemical composition of FBP were found to be similar to those of the Mustafa *et al*. (2004) who reported that DM and CP of sweet corn residue ensiled was 23.9 and 9.6 %. Jaster *et al*. (1983) reported that sweet corn residue had 21.0% DM, 10.8% CP, 37.4% ADF and 59.40% NDF. Furthermore, the fermentation characteristic of lactic acid, acetic acid and butyric acid were 8.2, 1.0 and 0.02%, respectively. The value of pH and lactic acid of FBP was in the optimum level and agreed to the report by Catchpoole and Henzell (1971) (4.2 and 3-13% on DM basis). Silage should contain 7.2-8.9% of CP (McDonald, 1981) and 9.6-12.2 MJ ME/kgDM and would require supplementation to increase a daily gain (Marley *et al.*, 2007).

Table 33 The chemical composition of diets used in the experiment

Items	Concentrate	FBP[1]	RS[2]	FBP:RS (DM basis)		
				40:60	50:50	60:40
Chemical composition (% of dry matter)						
DM	90.11	24.00	89.80	63.24	76.64	50.32
CP	14.37	7.24	3.15	4.79	3.96	5.60
EE	2.62	1.25	0.30	0.68	0.49	0.87
Ash	7.80	6.30	10.40	8.76	9.58	7.94
ADF	24.60	46.6	53.30	50.62	51.96	49.28
NDF	36.02	77.00	79.50	78.50	79.00	78.00
ADL	2.36	8.00	25.80	18.68	22.24	15.12
pH	-	4.00	-	-	-	-
Lactic	-	4.40	-	-	-	-
Acetic	-	2.58	-	-	-	-
Butyric	-	1.01	-	-	-	-

2. Feed intakes and nutrient digestibilities

The effects of FBP and rice straw on feed intake were presented in Table 35. It was found in this study that all heifers fed with FBP and rice straw had higher DM intake than those fed with rice straw alone. Total DM intake in term of percent body weight was found no different in DM intake among heifers fed with FBP and rice straw as 60:40, 50:50 and 40:60 (on dry basis) ($p>0.05$). The FBP intake as DM basis in this study was similar to those reported by Suksombat and Mernkrathoke (2005) who found that the total DM intake in group of cows fed corn silage as 4.66 kg/d. In this studied heifers fed rice straw had the lowest feed intake which agreed well to those reported by Wanapat *et al*. (1985) who reported that rice straw is low voluntary feed intake (1.5-2%). The supplementation FBP and rice straw was increased DM intake with similar to those reported by Phipps *et al*. (1992) who found that higher intake upon used maize silage as part of forage. Kirchgessner and Schwarz (1984) also found that the intake of DM increased by feeding maize silage and grass silage in the mixture. Bruins (1989) reported that it was only necessary for different feed stuffs to be offered together if they were markedly different in nutritive value or palatability. Phipps *et al.* (1984) mentioned a positive effect on intake of mixing the forages when one of the offered forages was of low quality. Furthermore, the increase of feed intake in heifer fed FBP and rice straw with similar to reported by Pate (1981) who found that steer fed corn silage which increase DM intake. Thomas and Thomas (1988) reviewed several factors affecting silage intake. Lactic acid, digestibility and nitrogen content of silage had positive correlations with silage intake, whereas acetic acid and ammonia nitrogen were negatively correlated with silage intake. Intake of tropical forages by heifer is low due to their pool ruminal digestion and prolonged retention time (Dominguez Bello and Escbar, 1997).

Table 34 Effect of difference fiber source on feed intake in dairy heifers

Items	**FBP[1] : RS[2] (on DM basis)**			**RS[2]**	**SEM**
	60:40	**50:50**	**40:60**		
Roughage DM intake					
kg/day	3.51±0.39[b]	4.80±0.34[a]	3.85±0.34[ab]	3.30±0.16[b]	0.18
%BW	1.42±0.18[b]	1.95±0.16[a]	1.54±0.16[ab]	1.32±0.16[b]	0.05
Concentrate DM intake					
%BW	1.27±0.04	1.28±0.03	1.25±0.03	1.26±0.03	0.02
Total DM intake					
kg/day	6.66±0.41[b]	7.93±0.36[a]	6.92±0.36[ab]	6.45±0.36[b]	0.19
%BW	2.70±0.21[ab]	3.20±0.18[a]	2.81±0.18[ab]	2.59±0.18[b]	0.09

[a,b] Means in the same row with different superscripts differ ($P<0.05$)

[1] Fermented By-Product [2] Rice straw

SEM = standard error of the mean

Digestibility coefficients of all treatments were shown in Table 36. Heifers fed FBP and rice straw at the ratios 60:40, 50:50 and 40:60 (on dry basis) had higher digestibility of DM (67.53, 59.00 and 54.12%, respectively), OM (71.13, 64.33 and 60.11%, respectively.), CP (62.60, 58.87 and 54.70%, respectively), NDF (67.53, 59 and 54.12%, respectively), ADF (55.15, 48.79 and 40.20%, respectively) than heifers fed rice straw only (36.50, 47.87, 36.84, 33.81 and 18.38%, respectively). In this study, the supplementation of FBP and rice straw could increase the digestibility of nutrient. Heifer fed rice straw only tended to be decrease digestion because depression of digestibility is a function of competition between digestion and passage rates, the influence being greater on the slower digesting fractions in the plant cell wall (Van Soest, 1965). Heifers fed high level of FBP had higher digestibility coefficient of nutrient which greed well with reported of Oldham (1984) who found that DM intake and nutrient digestibility of the diet increased with increasing CP contents. Jaster *et al*. (1983) reported that dairy heifer fed 50% of sweet corn waste with 50% of corn silage had digestibility of DM 68.10%, CP 55.9%, NDF 66.2%, and ADF 61.1%, respectively.

Digestible nutrient intake of DM, OM, CP, NDF and ADF in this study were significantly higher ($P<0.05$) in heifers fed FBP and rice straw at the ratios 60:40, 50:50 and 40:60 (on dry basis) than fed rice straw only. For estimated energy intake, intake of ME in term of Mcal/d was significantly highest ($P<0.05$) in heifers fed FBP with rice straw at the ratios 50:50 (on dry basis). Furthermore, intake of ME in term of Mcal/kg/DM in heifers fed FBP and rice straw at the ratios 60:40 (on dry basis) were significant the highest ($P<0.05$). This result showed that the higher nutritive values of feed intake which could be related to the high apparent digestibility of DM and OM intake and eventually resulted in higher intake of ME Mcal/d and Mcal/kg/DM. Rice straw is deficient of essential nutrients because they contain lower amount of energy and protein which supplement FBP in fed could increase digestible nutrient intake, energy intake and intake of ME.

Table 35 Effect of difference fiber source on nutrient digestibility and digestibility nutrient intake in dairy heifers

Items	FBP[1] : RS[2] (on DM basis)			RS[2]	SEM
	60:40	50:50	40:60		
Apparent digestibility, %					
DM	67.53±1.30[a]	59.00±1.12[b]	54.12±1.12[c]	36.50±1.12[d]	0.56
OM	71.13±1.10[a]	64.33±0.95[b]	60.11±0.95[c]	47.87±0.95[d]	0.49
CP	62.60±2.33[a]	58.87±2.02[b]	54.70±2.02[b]	36.84±2.02[d]	0.53
NDF	63.53±1.23[a]	59.00±1.06[b]	54.12±1.06[c]	33.81±1.06[d]	1.92
ADF	55.15±0.10[a]	48.79±0.79[b]	40.20±0.79[c]	18.38±0.79[d]	0.40
Estimated digestible nutrient intake, kg/d					
DM	4.50±0.33[a]	4.67±0.26[a]	3.76±0.47[b]	2.37±0.13[c]	0.08
OM	4.37±0.28[b]	4.67±0.26[a]	3.83±0.52[b]	2.70±0.08[c]	0.08
CP	0.40±0.01[a]	0.39±0.02[ab]	0.36±0.04[b]	0.20±0.00[c]	0.01
NDF	2.39±0.24[a]	2.66±0.19[a]	1.96±0.40[b]	1.25±0.10[c]	0.06
ADF	1.49±0.16[a]	1.56±0.12[a]	1.09±0.22[b]	0.37±0.05[c]	0.04
Estimated energy intake					
ME, Mcal/d[3]	16.66±1.14[c]	17.82±0.95[a]	14.62±1.88[b]	10.37±0.36[c]	0.30
ME, Mcal/kg DM	2.28±0.07[a]	1.97±0.05[b]	1.82±0.05[c]	1.04±0.12[c]	0.45

[a,b,c,d] Means in the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Rice straw

[3] 1 kg of digestible organic matter (DOM) = 3.8 Mcal ME (Kearl, 1982)

SEM = standard error of the mean

3. Blood metabolite

The effects of FBP and rice straw on blood glucose (BG), blood urea nitrogen (BUN), hormone triiodothyronine (T3) and non-esterified fatty acid were reported in Table 38. The BG of heifers fed FBP and rice straw 50:50 (on dry basis) at 0, 4h and mean post feeding were found to be the highest ($P<0.05$). However, the optimum range of BG concentration in dairy cows were 50-71 mg/dl (Robert and Prasse, 1998). BG is an important source of energy for many cells. BG in plasma normally maintains by the breakdown of dietary carbohydrates and a rather complex system of endogenous production (Keneko *et al*., 1997). BUN of dairy heifers at 0 and means post feeding fed FBP and rice straw were higher than those heifers fed rice straw only. The BUN has been used as a parameter of ruminant protein metabolism (Blowey *et al.,* 1973). However, BUN was in the normal ranges (6.30-25.5 mg%) as reported by Wanapat (1990). In addition, Preston *et al*. (1965) and Lewis (1975) reported that the concentration of BUN is correlated to the ammonia production in the rumen. Furthermore, Preston (1995) suggested that the quality of ammonia absorbed from the rumen reflected in circulating BUN. Diets which are balanced in protein and energy have BUN concentrations of 12.7 mg%, while BUN levels lower than this could be due to an insufficiency in crude protein per unit of digestible energy (Hwang *et al*., 2001). In this study, the value of BUN in dairy heifer fed FBP and rice straw were similar 12.7 mg%. It was indicated that heifer fed FBP and rice straw could balance protein and energy. Triiodothyronine (T3) on heifer fed FBP with rice straw 60:40 % (on DM basis) found to be the highest ($P<0.05$). In this study, T3 had close to the optimum level (40-170 n/dl). Squires (2003) reported that the sufficiency nutrient will decrease thyroid hormone and decreased thyroid hormone (T4) to T3. Carbohydrate and protein had significant effect on T3 and T4 levels which carbohydrate was stimulating T4 and protein was stimulating to change T4 to T3.

Table 36 Effect of difference fiber source on blood glucose, blood urea nitrogen, Triiodothyronine and NEFA of dairy heifers

Items	FBP[1] : RS[2] (on DM basis)			RS[2]	SEM
	60:40	50:50	40:60		
BG (ml/dl)					
0 post feeding	75.67±0.78[ab]	78.33±0.67[a]	76.00±0.67[ab]	74.00±0.67[b]	0.31
4	77.67±0.49[b]	80.00±0.42[a]	76.33±0.42[b]	76.67±0.42[b]	3.71
Mean	76.67±0.46[b]	79.16±0.43[a]	76.16±0.43[b]	75.33±0.43[b]	0.14
BUN (ml/dl)					
0 post feeding	9.66±0.58[a]	10.00±0.51[a]	8.33±0.51[ab]	7.00±0.51[b]	0.34
4	11.33±0.74	12.00±0.64	12.33±0.64	10.67±0.64	0.20
Mean	10.50±0.23[a]	11.00±0.20[a]	10.33±0.20[a]	8.83±0.20[b]	0.22
T3 (ml/dl)					
0 post feeding	186.00±4.10[a]	160.00±3.55[b]	162.00±3.55[b]	166.00±3.55[b]	2.32
4	212.00±4.10[a]	188.00±3.55[b]	181.00±3.55[b]	188.50±3.55[b]	1.43
Mean	200.00±3.54[a]	175.00±3.06[b]	170.50±3.06[b]	178.30±3.06[b]	1.66

[a,b] Means in the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Rice straw

SEM = standard error of the mean

4. Body weight change

The body weight change during study period was presented in Table 38. Dairy heifers fed FBP and rice straw at the ratios 50:50, 60:40 and 40:60% on dry basis were significant higher body weight change (58.00, 43.00 and 34.33 kg, respectively) than those fed with rice straw only (20.67 kg) (P<0.05). The supplement of high level concentrate (3.15 kg/d as DM basis) might have a positive effect on body weight change. Furthermore, the feed cost per gain in group of heifers fed FBP with rice straw at the ratios 50:50 tended to be the highest.

Table 37 Effect of difference fiber source on live weight change and average daily gain of heifer cows

Items	FBP[1] : RS[2] (on DM basis)			RS[2]	SEM
	60:40	50:50	40:60		
Live weight, kg					
Initial, kg	247.00±7.08	246.25±6.13	249.00±6.13	249.25±6.13	2.95
Final, kg	290.00±5.00^{b}	304.25±4.33^{a}	289.50±4.33^{b}	273.25±4.33^{c}	2.24
BWchange, kg					
	43.00±7.13^{ab}	58.00±6.17^{a}	34.33±6.17^{ab}	20.67±6.17^{b}	3.46
Feed cost/gain (FCG)					
(bath/kg)	1.53±0.96	2.01±1.20	1.30±0.2	1.61±0.44	0.20

^{a,b} Means in the same row with different superscripts differ ($P<0.05$)

[1] Fermented By-Product [2] Rice straw

SEM = standard error of the mean

Experiment 6 The effects of optimum proportion of Fermented By-Product (FBP) with rice straw on dairy cow performance

1. The chemical composition of feed

The chemical composition of concentrate, rice straw, FBP and SCWS on dry matter basis were presented in Table 39. The DM of SCWS and FBP were found to be similar to those reported by Mustafa *et al*. (2004) who stated that dry matter of sweet corn residue ensilaged was 22.62%. The NDF of roughages (FBP, SCWS and RS) was provided sufficient effective fiber for production of fat corrected milk. Furthermore, the chemical composition of FBP and SCWS were similar to those report by AKsu *et al*. (2006) who found that corn silage contained DM, Ash, OM, NDF, ADF, CP, pH, lactic acid, acetic acid and butyric acid were 26.90, 8.90, 91.10, 61.89, 36.21, 7.37, 3.77, 1.08, 1.26 and 0 %, respectively. Grant (1997) reported that NDF of roughage 60% still provided sufficient effective fiber for production of fat in milk. The value of pH and lactic acid of FBP was at the optimum level (4.2 and 3-

13% on DM basis) (Catchpoole and Henzell, 1971). The FBP had higher WSC than SCWS. WSC or NC (sugar and starch) is used as energy source for microbes in the rumen to produce volatile fatty acid (VFAs) such as lactic, acetic, propionic and butyric acids. The optimum level of WSC was 6-12% (Aminah *et al*. 2004). A relative high content of WSC in FBP which improve the ensiling process (Khorasani *et al.* 1997). WSC is one energy source supplied for ruminal VFAs. The product degraded from WSC is also propionic acids (Abramson *et al.*, 2005).

Good quality silage is characterized by lactic acid concentration (Zobell *et al*., 2004) which is desired in silage making, and thus has been developed to improve conservation of silage (Rotz and Muck, 1994). Furthermore, Parakassi (1999) reported that WSC content in the plant material more than enough (>10%) to provide material for lactic acid bacteria (LAB) to produce acid and lower the pH value of during ensiling (Parakassi, 1999). Lactic acid effect on the microorganism was inhibition on growth (Weinberg and Muck, 1996). The concentration of butyric acid from FBP was lower 0.1 g/kg DM which is indicative of well preserved silages (Kung and Shaver, 2001). Ammonia production of FBP and SCWS were similar to those reported by Auilera *et al.* (1997) who found that ammonia production of silage made from mango fruit 80% and corn stover 20% was 1.35%. The propionic acid of FBP and SCWS were similar to those reported by Nkosi and Meeske (2010) who found that the propionic acid in maize silage had 0.1 g/kgDM. The level of acetic acid in FBP and SCWS were high level which agree with those reported by Bruins (1990) who found that addition molasses into silage caused hetero fermentative fermentation or conversion of lactic acid to acetic acid resulted in increased acetic acid concentration in silage. The SCWS had higher linoleic acid (C18:2) than FBP and rice straw (Table 40). However, SCWS contained the lowest concentration of linolenic acid (C18:3). Both linoleic acid and linolenic acid are converted to CLA in the rumen (Kelly *et al*., 1998).

Table 38 The chemical composition (% of dry matter) of diets used in the experiment

Items	Concentrate	FBP[1]	SCWS[2]	RS[3]	FBP:RS 50:50	SCWS:RS 50:50
DM	87.90	24.01	22.62	88.27	56.14	55.45
CP	18.29	7.80	7.11	3.60	5.70	5.36
EE	3.30	1.25	1.87	0.56	0.91	1.22
Ash	8.20	6.40	3.81	13.18	9.79	8.55
NDF	38.90	75.54	83.47	76.48	76.01	79.98
ADF	34.50	43.77	41.34	48.58	46.18	44.96
ADL	9.40	7.85	4.05	17.40	12.63	10.73
WSC	-	5.19	2.48	-	-	-
pH	-	3.58	3.51	-	-	-
Lactic	-	6.07	0.68	-	-	-
Acetic	-	8.69	10.60	-	-	-
Butyric	-	0.00	2.71	-	-	-
Propionic	-	1.59	0.00	-	-	-

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw

Table 39 Fatty acid composition of concentrate and different fiber sources

Items	Concentrate	FBP[1]	SCWS[2]	RS[3]
	-----------------------g/100g of total fatty acid------------------------			
$C_{8:0}$	0.67	0.08	0.07	0.04
$C_{12:0}$	11.93	1.15	0.09	0.87
$C_{14:0}$	4.06	0.58	0.38	1.42
$C_{16:0}$	17.83	19.50	27.43	35.23
$C_{18:0}$	3.11	3.33	3.98	4.82
$C_{18:1n9c}$	26.98	16.82	24.11	10.11
$C_{18:2n6c}$	30.36	25.90	34.32	23.66
$C_{18:3n6}$	0.00	0.21	0.07	0.26
$C_{20:0}$	0.48	0.89	0.98	2.88
$C_{20:1}$	0.21	0.12	0.38	0.05
$C_{22:0}$	0.27	0.59	0.97	2.06

[1]Fermented By-Product [2]Sweet corn waste silage [3]Rice straw

2. Feed intakes

The DM intake was presented in Table 41. There were no significant differences in roughage (kg/d and %BW) and concentrate DM intake (%BW). The concentrate DM intake in terms of kg/d was highest in cow fed only rice straw ($P<0.05$). Cows fed solely on rice straw in terms of kg/d had higher ($P<0.05$) total DM intake than cows fed FBP with rice straw. However, total DM intake in term of %BW was not different among cow fed different fiber sources. Huhtanen *et al.* (2003) reported that the fermentation quality of silages had a major effect on feed intake, nutrient utilization and milk production in ruminants. The FBP used in this study was not present odor of butyric acid (0 % of DM) thus, had no effect on feed intake. Erdman (1993) reported that final fermentation products (lactic, acetic and butyric acids) were present in high concentrations in high moisture forages which were likely to have a negative effect on the intake of silage. DM intake can be regulated by many factors such as rumen pH, rate of passage of digesta from the rumen and extent of feed digestion in the rumen. (Allen, 2000)

Table 40 Dry matter intake of lactating dairy cows receiving different fiber sources

Items	FBP[1]+RS[3]	SCWS[2]+RS[3]	RS[3]	SEM
Roughage DM intake				
kg/day	5.18±0.28	5.38±0.29	4.94±0.35	0.11
percent body weight	1.25±0.21	1.37 ±0.34	1.23±0.21	0.03
Concentrate DM intake				
kg/day	6.41±0.00[b]	6.41±0.00[b]	7.33±0.00[a]	0.00
percent body weight	1.57±0.23	1.66±0.26	1.83±0.20	0.06
Total DM intake				
kg/day	11.59±0.28[b]	11.79±0.29[ab]	12.26±0.35[a]	0.50
percent body weight	2.80±0.43	3.03±0.61	3.06±0.42	0.71

[a,b] Means within the same row with different superscripts differ ($P<0.05$)

[1] Fermented By-Product [2] Sweet corn waste silage [3]Rice straw

SEM = standard error of the mean

3. Blood metabolites

The effect of roughage source on blood metabolite concentrations were presented in Table 42. The BUN in group of dairy cow fed SCWS and rice straw and rice straw only were significant higher than dairy cow fed FBP and rice straw. Preston *et al.* (1965) reported that concentrations of BUN are highly correlated to protein intake and reflect the level of NH_3-N production in the rumen (Lewis, 1975). Furthermore, the concentration of BUN is correlated to the level of ammonia production in the rumen. Preston (1995) suggested that the quantity of ammonia absorbed from the rumen reflected in circulating BUN. Diets which are balanced in P/E have BUN concentration of 12.7%, While BUN levels lower than this could be due to an insufficiency in CP per unit of digestible energy (Hwang *et al.*, 2001). The blood glucose was not significant among treatments. Although BG is one of the important indicators of the energy status (Payne and Payne, 1987). Triiodothyronine (T3) was not different among treatments. T3 is the hormone which effect on feed intake, growth performance and utilization of nutrient (Dunlop, 1991). However, T3 in this study was closed in the optimum range of cattle (40-170 ng/dl). This resulted was evaluated that the roughage all treatments were not affect on feed intake, growth performance and utilization of nutrient. The concentration of NEFA at 0 h in group of rice straw was significant the highest (P<0.05). The NEFA is related to weight loss in this group (Table 46). However, the concentration of NEFA at 4 hr and mean were not different among treatments, indicate that there was no significant difference in the rate of mobilization of adipose tissue (Åkerlind *et al.*, 1998).

The concentration of non esterified fatty acid (NEFA) is an index of the magnitude of the mobilization of adipose tissue in dairy cattle (Bauman *et al.*, 1999). NEFA have been shown to negatively correlated with energy balance (Erfle *et al.*, 1974) and in lactating dairy cows are highest immediately post partum. Serum NEFA is an indicator of the mobilization of body fat (Kronfield, 1982).

Table 41 Blood urea nitrogen, blood glucose, T3 and non esterified fatty acid of lactating dairy cows receiving different fiber sources

Items	**FBP[1]+RS[3]**	**SCWS[2]+RS[3]**	**RS[3]**	**SEM**
BUN, mg/dl				
0 h-post feeding	10.40±1.82[b]	15.60±0.89[a]	15.20±0.44[a]	0.31
4 h-post feeding	14.60±1.52[b]	21.00±1.87[a]	22.00±1.41[a]	0.42
Mean	12.50±1.66[b]	18.30±0.57[a]	18.60±0.74[a]	0.38
BG				
0 h-post feeding	59.40±3.13	61.40±0.54	61.60±1.14	0.50
4 h-post feeding	55.40±0.54	62.20±0.84	56.40±1.14	0.22
Mean	57.40±1.71	61.80±0.45	59.00±1.12	8.06

Table 41 (Continued)

Items	FBP[1]+RS[3]	SCWS[2]+RS[3]	RS[3]	SEM
T3, ng/dl				
0 h-post feeding	167.20±42.49	153.40±28.62	135.60±30.27	8.88
4 h-post feeding	170.80±32.61	154.40±17.98	147.40±35.11	7.64
Mean	169.00±37.48	153.90±17.88	137.40±34.60	0.31
NEFA, mg/dl				
0 h-post feeding	8.92±0.33[ab]	7.78±2.03[b]	11.06±1.93[a]	0.42
4 h-post feeding	8.87±2.46	9.76±1.89	6.75±2.97	0.62
Mean	8.90±1.26	8.76±1.23	8.91±1.88	0.39

[a,b] Means within the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw

SEM = standard error of the mean

4. Rumen ecology

Rumen ecology was measured by rumen pH, ammonia nitrogen (NH_3-N) and blood urea nitrogen (BUN) concentration. Rumen ecology parameters are presented in Table 43. Ruminal pH in group of dairy cow fed SCWS and rice straw was the lowest significantly different (P<0.05) at 0 h post feeding. However, the pH at 4 h post feeding and means were not significant among treatment. The optimum of pH in the normal range is 6.7-6.9 which has been reported as optimal for microbial digestion of fiber (Firkins, 1996) and also digestion of protein in the rumen (range 6-7) (Wanapat, 1999). Mould and Orskov (1984) demonstrated that cellulose digestion was limited when ruminal pH was below 6.0. In this study, the pH was much higher than this threshold value. Furthermore, Beauchemin *et al.* (2003) reported that ruminal pH values were higher than 5.8 which indicated a positive effect on reducing the risk of acidosis. Ammonia nitrogen (NH_3-N) regarded as the most import nitrogen source for microbial protein synthesis in the rumen (Bryant, 1974) and the level in the rumen is generally high when the feeds are more digestible. High NH_3-N levels indicates that the soluble fraction of protein is also high. The ammonia nitrogen in group of dairy cow fed rice straw only at 0 h after feeding was significantly the highest ($P<0.05$). However, the concentration of NH_3-N were not different among treatments at 4 h and mean after feeding. The NH_3-N in this study were closer to optimal ruminal ammonia nitrogen (15-30 mg%) (Wanapat and Pimpa, 1999) for increasing microbial protein synthesis, feed digestibility and voluntary feed intake. The increases in rumen NH_3-N levels also resulted in increasing levels of BUN (Table 42).

A reduction of NH_3-N in group of dairy cow fed FBP and rice straw has been noted in which sugars have been added to the diet (Hristov *et al.*, 2005). Furthermore, increased microbial protein synthesis was reported when grass silage was supplemented with ether sugar (Khalili and Hahtanen, 1991) or molasses (Broderick and Radloff, 2004) which yielded higher OM and NDF digestibility than starch (Heldt *et al.*, 1999). In this study, the ingredient of FBP was supplemented with vinasses which reduced ammonia nitrogen. The sugar from vinasses improved microbial growth and fiber digestibility. Ruminants mainly depends on fermentation produced in the rumen for energy, namely, VFAs consist of acetic, propionic and butyric acids. These are the product from rumen fermentation process. These different products are degraded from various energy sources (Abramson *et al.*, 2005). Total VFA production at 0, 4h and means post feeding in group of dairy cow fed FBP and rice straw was significant the highest ($P<0.05$). These increase VFA concentrations suggest a greater microbial fermentation rate, favouring to fiber digestion and acetate production (Kwak and Herbein, 1990), However, total VFA production at 4 h post feeding was not different among treatment (48.75-59.22 mmol/l).

The concentration of total VFAs highly differs among diets. It generally ranges from 60 to 120 mmol/l. Total VFAs in this study, which are closed with reported. The acetate production at 4 hr and means post feeding in group of cow fed SCWS and rice straw was significant the highest ($P<0.05$), while acetate has an important role in meeting animal metabolic energy requirement and milk fat synthesis. The propionate production at 4 h and mean post feeding in group of dairy cow fed FBP and rice straw and group of dairy cow fed rice straw only were significant the highest ($P<0.05$). The butyrate production at 4 hr and means post feeding in group of dairy cow fed rice straw was significant the highest ($P<0.05$). Butyric acid supplies energy to ruminal epithelial cells. Approximately 60% of animal glucose requirement is provided by propionic acid. Thus, the percentages of VFAs have a very important role on animal production. The percentage of VFAs is mainly associated with the composition of diet. As sugar and starch content increase in diet, percentage of acetic acid decrease (Houtert, 1993). In this study, VFA in ruminal fermentation fluctuate from 65:25:10 to 70:20:10 (acetate :propionate :butyrate, in molar percentage) ratio which could be all treatments received high fiber diets (Qrskov *et al.*, 1999). Tropical forage in comparison to temperate forages produces less amount of VFA and microbial biomass (microbial protein) after ruminal fermentation (Dominguez Bello and Escbar, 1997).

The proportion of acetate and propionate (C2:C3) in group of dairy cow fed SCWS and rice straw and FBP and rice straw (6.08 and 5.35) were significant higher than fed rice straw only (5.17) ($P<0.05$). These resulted due to an increase of acetate production and reduction of propionate which is an increased ruminal acetate production in group of dairy cows fed FBP and SCWS. The molar ratio of acetate:propionate has been used to evaluate the substrates. Rapidly fermentable carbohydrates yield relatively higher propionate compared to acetate, and the reverse takes place when slowly fermentable carbohydrates are incubated (Makkar *et al.* 1995). Steve (2001) reported that under optimal rumen fermentation conditions, the acetate to propionate (C2:C3) ratio should be greater than 2.2 and high levels of acetate can indicate a high fiber, low fermentable carbohydrate ration. High levels of proportion acid can indicate reduced fiber digestion and acidosis in cattle. The average values of acetate to propionate ratio in this study were higher ratio was influenced by high level of acetate from roughage source. The CH_4 concentration in the rumen in group of dairy cows fed rice straw and SCWS with rice straw were higher than fed FBP and rice straw. Reduction of acetate to propionate ratio when feeding FBP could reduce methane and improves the efficiency of feed utilization, since relative higher propionate production is associated with less methane production and so less of energy in from of gas (Machmueller et al., 1998).

Table 42 Volatile fatty acids (VFAs) and methane (CH_4) production of lactating cows receiving different fiber sources

Items	**FBP[1]+RS[3]**	**SCWS[2]+RS[3]**	**RS[3]**	**SEM**
pH				
0 h-post feeding	7.25 ± 0.07^{ab}	7.13 ± 0.18^{b}	7.33 ± 0.14^{a}	0.03
4	6.97±0.13	7.06±0.12	6.94±0.15	0.04
Mean	7.14±0.11	7.10±0.12	7.14±0.11	0.04
NH_3-N, mg/dl				
0 h-post feeding	10.02 ± 2.47^{b}	12.28 ± 3.44^{ab}	15.72 ± 2.86^{a}	0.72
4	15.60±2.22	13.72±5.21	14.86±2.96	0.95
Mean	12.80±1.71	13.00±4.05	15.29±2.23	0.73
Total VFA, mmol/l				
0 h-post feeding	57.67 ± 8.08^{a}	48.37 ± 1.15^{b}	45.21 ± 2.11^{b}	1.26
4	59.22 ± 3.49^{a}	53.03 ± 1.26^{ab}	48.75 ± 8.29^{b}	1.36
Mean	58.45 ± 2.29^{a}	50.70 ± 1.13^{b}	46.98 ± 4.05^{b}	0.71
Acetate, mmol/100mol				
0 h-post feeding	77.92±0.20	79.66±0.77	77.69±1.03	0.38
4	76.23 ± 0.82^{b}	78.58 ± 0.40^{a}	74.88 ± 1.61^{b}	0.28
Mean	77.08 ± 1.22^{b}	79.12 ± 0.52^{a}	76.28 ± 1.04^{b}	0.26
Propionate, mmol/100mol				
0 h-post feeding	13.95±1.01	13.03±0.72	13.91±0.53	0.20
4	14.88 ± 0.61^{a}	13.01 ± 0.58^{b}	15.62 ± 1.23^{a}	0.22
Mean	14.42 ± 0.62^{a}	13.02 ± 0.37^{b}	14.77 ± 0.44^{a}	0.12
Butyrate, mmol/100mol				
0 h-post feeding	8.13±1.20	7.31±0.64	8.40±1.010.55	0.22
4	8.88 ± 0.43^{b}	8.41 ± 0.20^{l}	9.49 ± 0.54^{a}	0.11
Mean	8.50 ± 0.79^{ab}	7.86 ± 0.23^{l}	8.94 ± 0.52^{a}	0.14
C2:C3 ratio, mmol/100mol	5.35 ± 0.24^{a}	6.08 ± 0.20^{a}	5.17 ± 0.29^{b}	0.06
CH_4, mol/100 mol[4]	14.60 ± 1.52^{b}	21.00 ± 1.87^{a}	22.00 ± 1.41^{a}	0.11

[a,b] Means within the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw

[4]Calculated according to Moss *et al*. (2000) CH_4 production = 0.45(acetate) – 0.275(propionate)+0.4(butyrate)

SEM = standard error of the mean

Table 44 presented rumen microorganism populations. Total of bacteria counts were similar among treatments. Furthermore, the population of protozoa and fungi zoospores were not different among treatments. Diet contain a large proportion of silage have been thought to have a low efficiency of microbial protein synthesis in the rumen compared with grass or hay based diet (Thomas and Thomas, 1988). Protozoa in group of dairy cow fed rice straw tended to be increased. The population of protozoa in the rumen can also affect on rumen fermentation of starch. Jouaney and Ushida (1999) reported that the number of protozoa per ml of rumen fluid depends on the rate of soluble sugars and starches in the ration and also pH. The population of bacteria and fungi zoospore in this study was higher than Chanthakhoun *et al.* (2012) who found that cattle fed rice straw as roughage source had mean of bacteria and fungi zoospore as 2.2 x 10^8 and 3.8 x 10^5 cells/ml.

Table 43 Ruminal microorganism population of lactating cows receiving different fiber sources

Items	**FBP[1]+RS[3]**	**SCWS[2]+RS[3]**	**RS[3]**	**SEM**
Bacteria, x10^9 cells/ml				
0 h-post feeding	2.40±1.00	2.00±0.75	1.64±0.98	0.24
4	2.80±2.31	4.28±2.11	3.42±1.06	0.49
Mean	2.60±1.22	3.14±1.18	2.53±0.65	0.27
Protozoa, x10^6 cells/ml				
0 h-post feeding	0.44±0.28	0.66±0.25	0.63±0.15	0.06
4	0.44±0.39	0.58±0.37	0.68±0.15	0.08
Mean	0.44±0.28	0.62±0.08	0.66±0.08	0.04
Fungi zoospore x10^6 cells/ml				
0 h-post feeding	1.70±1.30	2.00±2.30	2.55±0.82	0.38
4	6.30±6.65	6.03±1.99	7.01±3.30	1.15
Mean	4.00±3.22	4.01±0.94	4.78±1.61	0.59

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw

SEM = standard error of the mean

5. Milk production and fatty acid composition

Milk yield and 4% fat corrected milk (4% FCM) were significantly different (P<0.05) among treatments. Cows fed FBP with rice straw had higher milk yield and 4% FCM yields (P<0.05) than cow fed SCWS with rice straw and rice straw only (Table 45). This is similar to the report by Phipps *et al*. (1995) who found that diets based on maize silage (MS) increased milk yield and milk protein content. Wanapat *et al*. (2009) reported that feeding rice straw only in dairy cows could decrease milk yield as low as 10.80 kg/d. A low milk production was mainly because of the poor quality forage situation, especially the poor quality of rice straw and SCWS. Milk protein, milk fat, solid not fat (SNF) and total solid (TS) contents were not significantly different (P>0.05) among treatments. Lock and Shingfield (2004) found that cows fed MS had no effect on milk fat content. Milk lactose in cows fed FBP with rice straw and rice straw only was significant (P<0.05) higher than those cows fed SCWS with rice straw (P<0.05). Milk yield is related to milk lactose because of the water phase of milk, and there by the total milk volume is passively regulated by osmotic forces. Lactose is the main osmotic component in milk (Linzell and Peaker, 1971). Mansson (2001) reported that bovine milk contains approximately 4.60% lactose, 3.4% protein, 4.2% fat which was in our finding ranges. Cows fed FBP significantly produced the highest milk yield (P<0.05) in association with milk protein, SNF and TS. Scarcity of green fodder, high temperature and under feeding reduced the SNF content of milk (Islam, 1990). Gibson (1987) stated that the high positive correlation between milk yield, total solids, fat and protein indicates that adequate feeding of dairy cows will correspondingly lead to increased milk yield constituents. Such a high milk production and 4%FCM was the highest in group of cows fed FBP because FBP is high quality of forage. FBP is the highest crude protein and low fiber content when feeding the dairy cow could improve milk yield and milk composition. The chemical composition of milk fat, milk protein, lactose, SNF and total solid in this studied was similar to report by Suksombat and Mernkrathoke (2005) who found that cows fed corn silage produced 3.53% milk fat, 2.89 % milk protein, 4.47 % lactose, 8.06% SNF and 11.59% total solid. Sandovol-Castro *et al.* (2000) reported that the availability and quality of roughage feed under the tropical dairy system could influence the level of milk output as well as its components. Sutton (1987) stated that in general, an increase in the amounts of fat, protein and lactose results from an increase in milk volume. It is likely that the feeding of slowly degradable starch, which is digested in the rumen and small intestine can stimulate the production of glycogenic, precursors which may in yield of lactose (Nocek and Tamminga, 1991).

The milk fat to protein ratio was not significant among treatments. A high milk fat to protein ratio indicates a negative energy balance (Heur *et al.*, 2000). MUN in group of fed rice straw was significant highest (P<0.05). Schroeder (2002) reported that cows with MUN levels less than 10 to 12 mg% and higher level 16 to 18 mg/dl could result in higher feed costs, lower productive performance and lower milk production. Also, BUN and MUN in this study were closer to the normal level as reported by Roseler *et al.* (1993) who found that balanced diets for lactating dairy cows were associated with average BUN concentration of 15 mg/dl and average MUN concentration of 5-16 mg/dl (Jonker *et al.*, 1999) according to this experiment which found that concentration of BUN and MUN were 12.50-18.60 mg/dl and 13.60-18.60 mg/dl respectively.

Table 44 Milk yield and milk composition in lactating dairy cows receiving different fiber sources

Items	FBP[1]+RS[3]	SCWS[2]+RS[3]	RS[3]	SEM
Milk yield, kg/day	14.90±1.73[a]	11.91±0.21[b]	10.71±0.87[b]	0.29
4% FCM, kg/day	15.69±2.24[a]	12.50±1.09[b]	11.22±0.43[b]	0.38
Milk composition				
Fat, %	4.37±0.62	4.32±0.56	4.35±0.50	0.15
Protein, %	2.99±0.65	2.95±0.65	3.09±0.20	0.04
Lactose, %	4.60±0.29[a]	4.91±0.06[b]	4.84±0.08[a]	0.05
Solids-not-fat, %	8.52±0.60	8.55±0.19	8.89±0.61	0.13
Total solids, %	12.90±0.73	12.88±0.67	13.24±0.14	0.21

Table 44 (Continued)

Items	FBP[1]+RS[3]	SCWS[2]+RS[3]	RS[3]	SEM
Fat/Protein ratio Milk	1.63±0.23	1.56±0.26	1.50+0.14	0.00
Milk Urea N, mg/dl	17.00±4.06 [ab]	13.60±1.81[b]	18.60±2.30[a]	0.75

[a,b] Means within the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw

SEM = standard error of the mean

The fatty acid composition in the milk fat are presented in Table 46, which shows that caproic acid (C6:0) and palmitoleic (C16:1) acid from cows fed FBP with rice straw had the highest ($P < 0.05$) values. Furthermore, cows fed FBP with rice straw and rice straw only had higher lauric acid (C12:0), tridecylic acid (C13:0) and myristoleic acid (C14:1) than cows fed SCWS with rice straw. Moreover, the short chain fatty acid (SCFA) levels of cows fed FBP with rice straw were found to be the highest ($P < 0.05$). The isomer *trans*-10, *cis*-12 C18:2 CLA was significant higher ($P < 0.05$) in cows fed FBP with rice straw and rice straw only. Cows fed FBP with rice straw had a higher level of *cis*-9, *trans*-11 C18:2 CLA than cows fed SCWS with rice straw and rice straw only, as this isomer of CLA was the major isomer in ruminant milk fat representing 80–90% of the total CLA in the milk fat. The milk fat content of CLA is affected by the intake of unsaturated fatty acid (Griinari *et al*., 1998). Viviani (1970) presented a schematic diagram showing that CLA was formed as an intermediate product in the biohydrogenation pathway of linolenic acid.

However, the linolenic pathway did not involve CLA as an intermediate. The isomer *cis*-9, *trans*-11 may be produced endogenously from *trans*-11-octadenoic acid by Δ-9-desaturase in the body tissue (Griinari *et al*., 1997). Other factors may affect CLA production in the rumen. The type and source of dietary carbohydrate may influence the rates of microbial fermentation in a way that alters the rate of CLA production or utilization by rumen microbes and ultimately the concentration of CLA in the milk fat. The total CLA of cows fed FBP with rice straw was higher than for cows fed SCWS with rice straw. Lock and Garnsworthy (2003) reported that CLA in dairy cows ranged between 0.8 and 1.9 g per 100 g fat (8–19 mg/100g fat). Long chain fatty acids (LCFAs) such as γ-linolenic (C18:3n6c), α-linolenic (C18:3n3c), eicosatrienoic acid (C20:3n6) and arachidonic acid (C20:4n6) were at their highest levels in cows fed FBP with rice straw ($P < 0.05$). The PUFA level in cows fed FBP with rice straw was the highest (4.78%) which was higher than reported by Walstra *et al*. (1999) who found that Polyunsaturated FA (PUFA) was 2.3% of the total fatty acids with linoleic and α-linolenic being the main PUFA constituents. Linoleic and α-linolenic are referred to as essential FAs which cannot be synthesized by humans and need to be supplied in the diet (Walstra *et al*, 1999).

Table 45 Fatty acid of milk fat in lactating dairy cows receiving different fiber sources

Item	RS	FBP +RS	SCW S+RS	SEM
	--------------------------mg/g fat	----------------------------		
C6:0	5.22±0.64^{b}	6.12±0.64^{a}	5.95±0.54^{ab}	0.16
C8:0	5.62±1.34	6.99±0.91	5.79±0.71	0.26
C10:0	13.74±3.16	17.41±3.41	14.62±1.86	0.74
C12:0	39.66±3.38^{a}	39.23±5.18^{a}	29.26±2.09^{b}	0.97
C13:0	0.81±0.05^{a}	0.92±0.16^{a}	0.57±0.08^{b}	0.03
C14:0	109.43±5.45	106.03±13.50	103.81±1.83	2.19
C14:1	9.33±1.18^{ab}	10.85±1.13^{a}	7.81±1.54^{b}	0.34
C15:0	10.46±0.75^{a}	9.51±0.60^{b}	9.57±0.65^{b}	0.17
C16:0	351.13±25.07	344.35±22.14	383.64±46.73	8.57
C16:1	14.53±2.11^{b}	22.32±0.40^{a}	15.22±4.17^{b}	0.70
C18:0	132.69±6.35^{a}	106.75±2.68^{b}	118.68±14.48^{b}	2.39
C18:1n9t	5.04±0.33	5.66±1.21	5.36±0.91	0.22
C18:1n9c	2.15±0.33	2.27±0.19	2.09±0.45	0.17
C18:2n6c	16.48±3.99	19.92±0.24	15.16±3.91	0.83
C18:3n3	1.55±0.08^{b}	1.82±0.15^{a}	1.29±0.32^{b}	0.05
C18:3n6c	0.51±0.10^{ab}	1.49±1.20^{a}	0.00±0.00^{b}	0.18
C20:0	2.52±0.17^{a}	2.02±0.08b	2.16±0.14^{b}	0.03
c9t11CLA (C18:2)	10.41±1.73	12.68±0.93	10.49±0.63	0.49
t10c12CLA(C18:2)	0.59±0.04^{a}	0.84±0.22^{a}	0.15±0.21^{b}	0.05

Table 45 (Continued)

Item	RS	FBP +RS	SCW S+RS	SEM
	--------------------------mg/g fat ----------------------------			
c9c11CLA (C18:2)	0.48±0.27	0.40±0.37	0.15±0.21	0.07
Total CLA	11.81±1.74[ab]	14.20±0.85[a]	11.22±2.58[b]	0.48
C20:2	1.96±1.13[a]	0.70±0.12[a]	0.58±0.11[b]	0.15
C22:0	1.03±0.11[a]	0.69±0.10[b]	0.77±0.50[b]	0.02
C20:3n6	0.58±0.05[b]	0.79±0.15[a]	0.00±0.00[b]	0.03
C20:4n6	1.21±0.09[b]	1.55±0.04[a]	1.26±0.24[b]	0.04
C23:0	0.46±0.05[a]	0.23±0.15[b]	0.37±0.05[a]	0.03
C20:5n3	1.26±0.34[a]	0.74±0.30[b]	0.84±0.03[b]	0.07
C20:1	1.74±0.34	1.66±0.20	1.52±0.26	0.07
Short chain FA (C4:0-C13:0)	66.85±8.78[b]	72.93±10.22[a]	57.66±3.50[b]	2.07
Medium chain FA (C14:0-C17:0)	492.10±25.88	495.65±34.72	520.02±47.98	9.64
Long chain FA (≥C18:0)	430.46±31.01	431.31±44.77	423.03±47.85	10.81
Saturated FA	585.15±187.73	572.60±159.84	676.65±38.29	37.22
Monounsaturated FA	269.73±21.41	311.99±45.02	297.57±31.94	8.99
Polyunsaturated FA	37.98±3.88[b]	44.43±2.41[a]	32.50±6.34[b]	1.17

[a,b] Means within the same row with different superscripts differ ($P<0.05$)

[1] Fermented By-Products [2] Sweet corn waste silage [3] Rice straw

SEM = standard error of the me

5. Digestibilities of nutrients

Digestion coefficients, estimated nutrients and energy intake are shown in Table 47. Digestibility of DM and OM in group of dairy cow fed SCWS and rice straw was significant the highest ($P<0.05$). The lower rate of DM degradation in rumen may also have contributed to the lower digestibility of dairy cow fed rice straw only (Kokkonen *et al.*, 2000). Digestibility of CP, NDF and ADF in dairy cow fed SCWS and rice straw and FBP and rice straw were significant the highest ($P<0.05$).

Digestible nutrient intake of DM in group of dairy cow fed FBP and rice straw was significant the highest ($P<0.05$). Van Soest (1987) stated that the cell wall is the most important factor causing depression of digestibility. NDF of FBP and SCWS were higher degradable than rice straw which affect on high digestibility of NDF and ADF.

Digestible nutrient intake of OM in group of dairy cow fed rice straw was significant the highest ($P<0.05$). Digestible nutrient intake of CP, NDF and ADF in group of dairy cow fed FBP and rice straw and SCWS and rice straw were significant the highest ($P<0.05$). Tropical forages have some important limitation for dairy cow feeding. For example, tropical forage have low energy value because their cell walls contain higher amount of lignin, silica and cutin, resulting in lower fermentation of structural carbohydrate (Domingues Bello and Escobar, 1997) which effect on low digestibility of nutrient. Van Soest (1994) reported that the cellular wall as the main constituent affecting digestibility who stated that starch in high concentrations may become a significant factor at high intake levels for dietary fiber derived from grains. Valadares and Filho (1985) attributed the increase of digestibility in diets with higher concentrate levels to a higher concentration of non-structural carbohydrates which are more digestible than structural ones. The energy intake ME and TDN in group of dairy cow fed FBP was significant the highest ($P<0.05$).

Table 46 Effect of difference fiber source on nutrient digestibility and digestibility nutrient intake in lactating dairy cows

Items	**FBP[1]+RS[3]**	**SCW[2]+RS[3]**	**RS[3]**	**SEM**
Apparent digestibility, %				
DM	63.84±2.15[b]	68.94±2.67[a]	52.80±2.16[c]	3.87
OM	63.97±2.75[b]	69.66±2.66[a]	61.39±1.73[b]	0.64
CP	72.55±2.37[a]	73.74±1.58[a]	55.42±2.56[b]	0.99
NDF	70.30±8.18[a]	73.11±8.20[a]	45.89±2.17[b]	1.76
ADF	70.18±11.23[a]	72.36±8.34[a]	43.16±2.48[b]	2.12

Table 46 (Continued)

Items	FBP[1]+RS[3]	SCW[2]+RS[3]	RS[3]	SEM
Estimated digestible nutrient intake, kg/d				
DM	9.17±0.36[a]	8.02±0.38[b]	6.69±0.24[c]	0.09
OM	8.64±0.26[a]	7.78±0.44[b]	6.74±0.44[c]	0.10
CP	1.36±0.03[a]	1.36±0.01[a]	1.12±0.04[b]	0.02
NDF	5.04±0.61[a]	5.85±0.81[a]	3.18±0.16[b]	0.15
ADF	3.54±0.52[a]	3.78±0.36[a]	2.15±0.11[b]	0.10
Estimated energy intake				
ME, Mcal/d[4]	32.86±1.67[a]	29.57±1.69[b]	25.61±0.98[c]	0.87
ME, Mcal/kg DM[5]	2.60±2.22[a]	2.22±0.11[b]	2.04±0.07[c]	0.03

[a,b,c] Means in the same row with different superscripts differ (P<0.05)

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw

[4]1 kg of digestible organic matter (DOM) = 3.8 Mcal ME (Kearl, 1982)

SEM = standard error of the mean

6. Body weight change

The body weight change during the study period is presented in Table 48. Cows fed rice straw lost weight (-14.40 kg) while cow fed FBP and SCWS and rice straw gained weight (11.40 and 0.80 kg). We found that FBP and rice straw feeding to dairy cows in our study yielded better result than the normal feeding one. FBP containing high concentration of starch may become a significant factor at high intake levels for dairy cow (Van Soest, 1994). The effect of live weight gain in fat deposition depend on the quality and quantity of the forage (Juan *et al.*, 1998).

Table 47 Body weight Change and average daily gain of lactating cows receiving different fiber sources

Items	FBP[1]+RS[3]	SCWS[2]+RS[3]	RS[3]	SEM
Live weight, kg				
Initial, kg	401.00±65.55	414.60±62.41	406.40±41.26	14.18
Final, kg	412.40±59.67	415.40±38.38	392.00±26.19	10.72
Body weight change, kg	11.40±29.15	0.80±15.16	-14.40±19.10	5.70

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw
SEM = standard error of the mean

7. Income over feed cost

Variable costs, income and income over feed costs were presented in Table 49. Feed cost is a major part of the total costs of milk production and cost of feed are rising in dairy cattle that is importance to optimize the level of nutrient intake and to optimize the sources of nutrient intake. Roughage cost in dairy cows fed FBP and rice straw were significant the highest ($P<0.05$). Furthermore, the cost of concentrate in group of dairy cows fed rice straw were significant the highest ($P<0.05$). These cost of roughage and concentrate tended to be increased total feed cost in group of dairy cows fed FBP and SCWS and rice straw. However, the milk yield in dairy cows fed FBP was significant the highest. These resulted that received income over feed costs in that groups fed FBP and rice straw (146.53 baht).

Table 48 Variable costs, income and economic return of lactating cow receiving different fiber source

Items	FBP[1]+RS[3]	SCWS[2]+RS[3]	RS[3]	SEM
Variable cost[4] (baht)				
Roughage	31.60±3.17[a]	29.15±2.43[a]	9.90±0.35[b]	0.60
Concentrate	67.69±0.00[b]	67.69±0.00[b]	77.36±0.00[a]	0.00
Total	99.29±3.17[a]	96.84±2.43[a]	87.26±0.35[b]	0.60
Income				
Milk yield (kg/h/d)	14.90±1.73[a]	11.91±0.21[b]	10.71±0.87[b]	0.29
Value	245.82±28.62[a]	196.45±3.52[b]	176.72.14.41[b]	4.80
Income over feed cost				
(baht/h/d)	146.53 ±25.79[a]	99.61±3.17[b]	89.45±14.46[b]	4.43

[a,b] Means in the same row with different superscripts differ ($P<0.05$)

[1] Fermented By-Product [2] Sweet corn waste silage [3] Rice straw

[4]Variable costs in this study include concentrate (20% CP) 9.67 baht/kg, rice straw and sweet corn waste silage 1.80 baht/kg and FBP 2.45 baht/kg, Milk price was found to be 16.50 baht/kg at the time of the experiment in Saraburi Province.

SEM = standard error of the mean

CONCLUSION AND RECOMMENDATIONS

Conclusion

It could be concluded in these study that FBP had a good silage quality and can be kept for 2 months with the same chemical composition and fermentation characteristics. The digestibility and digestible nutrient intake of DM, OM, CP, NDF and ADF were significant higher in cows fed with FBP. The blood metabolites in dairy cows fed FBP were found to be in normal ranges. Dairy cows fed with FBP tended to have higher milk yield and had no effect on milk composition. Our study found that FBP could be used as roughage source for lactating dairy cow and could improve milk yield and milk composition if fed properly with other feed sources. The *in vitro* study found that cumulative gas production at 72 h after incubation in cows fed with FBP and RS at 50:50 on DM basis was higher ($P<0.05$) than those fed with FBP and RS at 40:60 on DM basis and RS only. Furthermore, the *In vitro* organic digestibility (IVOM) in cows fed with FBP and RS as the ratio 50:50 and 40:60 on DM basis were higher ($P<0.05$) than group of cows fed with FBP and RS at 60:40. The optimum level of FBP and rice straw were at 50:50 on DM basis on *in vitro* gas production. Heifers fed FBP and rice straw at the ratio of 50:50 percent on DM basis increased feed intake. The optimum ratio of feeding FBP and rice straw of 50:50 on dry matter basis was found to give the highest body weight change with no effect on blood metabolites in dairy heifer. Furthermore, Dairy cow fed FBP and rice straw at the ratio of 50:50 percent on dry matter basis increased milk yield and 4% FCM. The levels of SFA and LCFA including C18:3n6c, C18:3n3c, C20:3n6 and C20:4n6 and PUFA were found to be significantly highest in cows fed FBP and rice straw. The body weight change in dairy cow fed FBP and rice straw were found to be the highest while those fed with only rice straw loss weight. It was significantly concluded that feeding FBP with rice straw as roughage source for lactating dairy cow could improve milk yield and body weight gain including milk fat composition with no affect on blood metabolite and rumen ecology. Income over feed cost of cows fed FBP was

32.02 % higher than cows fed SCWS and RS. Again, income over feed cost of cows fed FBP was 38.95 % higher than those cows fed only rice straw.

Recommendations

1. The FBP developed in this study was found to be a bit low in dry matter content, even though the dry matter is higher than sweet corn silage. The feeding of FBP with rice straw and put them together in one feed bag would enable cows to have enough dry matter intake.

2. Since biomass is local in each area, farmers can use the mixture of many agricultural and agro industry by products in their area to produce FBP and feed their cows with higher profit. Single by-product will have less value than two or more by-products.

LITRATURE CITED

Abramson, S., I. Bruckental , I. Lipshitz, L. Moalem, U. Zamwel and A. Arieli. 2005. Starch digestion site: influence of ruminal and abomasal starch infusion on starch digestion and utilization in dairy cows. **British Society of Animal Science.** 80: 201-207.

AFRC. 1992. **Nutrient Requirements of Ruminant Animals: Protein.** Technical Committee on Responses to Nutrients, Report No. 10 Nutrition Abstracts and Review, Series B. 62: 787-835.

Aguilera, A., F. Perez-Gil, D. Grande, I. de la Cruz, and J. Juarez. 1997. Digestibility and corn stover fermentative characteristics of mango, lemon silages with or without addition of molasses and urea. **Small Rumin. Res.** 26: 87-91.

Akerlind, M., M. Emanuelson, K. Dahlborn and K. Holtenius. 1999. Glucose challenge in early lactating dairy cows selected for high or low milk fat concentration. **Anim. Sci.** 68: 717-722.

Aksu, T., E. Baytok and D. Bolat. 2004. Effects of a bacterial inoculants on corn silage fermentation and nutrient digestibility. **Small Rum. Res.** 55: 249-252.

Allen, M.S. 2000. Effects of diet on short-term regulation of feed intake by lactating dairy cows. **J. Dairy Sci.** 83: 1598-1624.

Aminah, A., C. Abu Baker and A. Izham. 2004. **Silage from Tropical Forages: Nutritional Quality and Milk Production.** Available source: http/www.Fao.org/DORCEP/005/x8486E/x8486beod.htm. September 8, 2012.

AOAC. 1990. **Official Methods of Analysis**. 15th ed. Association of Official Analytical Chemists, Washington DC, pp.

Appuhamy, J., B. G., Cassell, C. D. Dechow and J. B. Cole. 2007. Phenotypic relationships of common health disorders in dairy cows to lactation persistency estimated from daily milk weights. **J. Dairy Sci**. 90: 4424–4434.

Bauman, D.E. and J.M. Griinari. 2003. Nutritional regulation of milk fat synthesis. **Annu. Rev. Nutr.** 23: 203-227.

______, C.J. Peel, W.D. Steinhour, P.J. Reynolds, H.F. Tyrrell, A.C.G. Brown and G.L. Haaland. 1999. Effect of bovine somatotropin on metabolism of lactating dairy cows: influence on rates of irreversible loss and oxidation of glucose and nonesterified fatty acids . **J. Nutr.** 118: 1031-1040.

Bauman, D.E. and A.L. Lock. 2006. Conjugated linoleic acid: Biosynthesis and nutritional significant. In: Fox PF. Sweeney PLH (eds.). **Advanced Dairy Chemistry.** NY. USA. 2: 93-136.

Bartley, J.C. 1989. Lipid metabolism and diseases. **Clinical Biochemistry of Domestic Animals.** 108-142.

Beauchemin, K.A., W.Z. Yang and L.M. Rode. 2003 . Effects of particle size of alfalfa-based dairy cow diets on chewing activity, ruminal fermentation and milk production. **J. Dairy Sci.** 86: 630-643.

Beever, D.E. and R.C. Siddons. 1986. Digestion and metabolism in the grazing ruminant. In: L.P. Milligan, W.L. Grovum and A. Dobson (Editors). Control of digestion and metabolism in ruminants. Proc. VIth Int. Symp. Rum. Physiol. Cliffs, New Jersey.

Bergman, E.N. 1990. Energy contributions of volatile fatty acids from the gastrointestinal tract in various species. **Physiol. Rev.** 70: 567-590.

Bilal, M.Q. 2009. Effect of molasses and corn as silage additives on the characteristics of mott dwarf eleplant grass silage at different fermentation periods. **Pakistan Vet. J.** 29(1): 19-23.

Blowey, R. W., D. W. Wood and J. R. Davies. 1973. A national monitoring system for dairy herds based on blood glucose, urea and albumin levels. **Vet. Rec.** 92: 691-696.

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

Blummel, M. and E.R. Ørskov, 1993. Comparison of in vitro gas production and nylon bag degradability of roughages in predicting feed intake in cattle. **Anim Feed Sci Tech.** 40: 109-128.

Bogin, E. 1994**. Handbook for Veterinary Clinical Chemistry.** Kodak Publishing Rochester, New York, NY.

Bolsen, K., C. Lin, B. E. Brent, A. M. Feryerherm, J. E. Urban and W. R. Aimutis. 1992. Effect of silage additives on the microbial succession and fermentation process of alfalfa and corn silages. **J. Dairy Sci**. 75: 3066-3083.

Bolsen, K.K., G. Ashbell and Z. Weinberg. 1996. Silage fermentation and silage additives: Review. **Asian Austral. J. Anim. Sci.** 9: 483-494.

Boucqué Ch, V. and L.O. Fiems. 1988. Vegetable by-products of agro industrial origin. **Livestock Production Science.** 19: 97-135.

Bremner, J. M. and D. R. Keeney. 1965. Steam distillation methods for determination of ammonium, nitrate and nitrit. **Anal Chim Acta.** 32: 485.

Broderick, G.A. and W.J. Radloff. 2004. Effect of molasses supplementation on the production of lactating dairy cows fed diets based on alfalfa and corn silage. **J. Dairy Sci.** 87: 2997-3009.

Bruins, W.J. 1990. **Effect of adding formic acid and molasses to low degree wilted silage.** Regionale Ondenoek centra (Roe'c) Koppet, Lenystai,

Bryant, M. P. 1974. Nutritional features and ecology of predominant anaerobic bacteria of the intestinal tract. **Am. J. Clin. Nutr.** 27: 1313-1319.

Bulent, E., M. Kabu and O.M. Elitok. 2006. Evaluation of liver function tests in cows during periparturient period. **F.U. Salk Bil. Dergisi,** 20: 205-209.

Burin, D.G. and R.A. Britton. 1986. Response to monensin in cattle during subacute acidosis. **J. Anim. Sci.** 63:888.

Butler, W.R. 1998. Effect of protein nutrition on ovarian and uterine physiology in dairy cattle. **J. Dairy Sci.** 81: 2533-2539.

Catchpoole, V. R. and E. F. Henzell. 1971. Silage and silage making from tropical herbage species. **Herb. Abst.** 41: 213-221.

Cawley, G.D. and D.F. Collings. 1977. Nitrate poisoning. **Vet. Rec.** 101: 305-306.

Cervera, C., J. Fernández-Carmona and J. Marti. 1985. Effect of urea on the ensiling process of orange pulp. **Anim. Feed Sci. Technol.** 12: 233-238.

Chamberlain, A.T. and J.M. Wikinson. 1996. Feeding the dairy Cow Chalcombe Publications. Lincoln, UK.

Chamberlain,D.G., P.C. Thomas, W. Wilson and C.J. McDonald. 1985. The effects of carbohydrate supplements on ruminal concentrations of ammonia in animals given diets of grass silage. **J. Agric. Sci.** 104: 331-340.

Chanthakhoun, V., M. Wanapat, P. Kongmun and A. Cherdthong. 2012. Comparison of ruminal fermentation characteristics and microbial population in swamp buffalo and cattle. **Livestock Science.** 143: 172-176.

Chaudhry, A.S. 2008. Slaughtered cattle as a source of ruminant fluid to evaluate supplements for In vitro degradation of grass nuts and barley straw. **Vet. Sci. J.** 2: 16-22.

Cheva-Isarakul, B. and B. Cheva-Isarakul. 1980. ***Handbook of feed analysis***. Faculty of Agriculture Chiangmai University**.**

Choopheng, P., S. Sruamsiri, P. K. Jitramano and T. Rangabhet. 2005. **The use of pineapple waste as cattle feed: physical characteristic and nutritive value of silage from pineapple waste.** The 6 th Annual Conference Maejo University. Changmai.

Church, D.C. 1991. **Livestock Feeds and Feeding.** Prentice Hall international, inc. U.S.A.

Coa, Z., M. Ma, P. Ji and S. Li. 2010. Effect of Maize Silage Particle Size and Feeding Method on Ruminal Fermentation Chewing Activity and Passage Rate of Lactation Cows. **J. Anim. and Vet. Advances**. 9: 374-353.

Cone, J.W., A.H. Van Gelder and F. Driehuis. 1997. Description of gas production profiles with a three-phasic model. **Anim Feed. Sci. Tech.** 66: 31-45.

Cone, J.W. and A.H. Van Gelder. 1999. Influence of protein fermentation on gas production profiles. **Anim. Feed. Sci. Technol.** 76: 251-264.

Corl, B.A., L. Baumgard, H. Dwyer, D.A. Briinari. J.M. Phillps and E. Bauman. 2001. The role of delta (9) desaturase in the production of cis9, trans11. **J. Nutri. BioChem.** 12: 622-630.

Correia, A., P. Sampaio, J. Almeida and C. Pais. 2004. Study of molecular epidemiology of candidiasis in Portugal by PCR fingerprinting of *Candida* clinical isolates. **J. Clin. Microbiol.** 42: 5899-5903.

Counotte, G.H.M., A.T. Klooster, J. Van der Kuilen and R.A. Prins. 1979. An analysis of the buffer system in the rumen of dairy cattle. **J. Anim. Sci.** 49: 1539-1544.

Cressman, S.G., D.G. Grieve, G.D. Macleod, E.E. Wheeler and L.G. Young. 1980. Influence of dietary protein concentration on milk production by dietary cattle in early lactation. **J. Dairy Sci.** 63: 1839.

Dairy Handbook, 1996. Alfa-Laval. Food Engineering AB. Lund. Sweden.

Davison, T., M. McGowan, D. Mayer, B. Young, N. Johnson, A. Hall, A. Matschoss, P. Goodwin, J. Goughan and M. Lake. 1996. **Managing Hot Cows in Australia.** Department of Primary Industries Queenland.

Deaville, E.R. and D.I. Givens. 2001. Use of the automated gas production technique to determine the fermentation kinetics of carbohydrate fractions in maize silage. **Anim Feed Sci Tech.** 93: 205-220.

Decloux, M. and A. Bories. 2002. Stillage treatment in the French alcohol fermentation industry. **Int. Sugar J**. 104: 509–517.

Department of Livestock Development. 2011. **The use of waste residues of corn and sweet corn for animal feed**. Available Source: http://www.dld.go.th /inform /article/artileg .html, February 18, 2011.

Dhanoa, M.S., J. France, R. Siddons and J.G. Buchanan-Smith. 1995. A non-linear compartmental model to describe forage degradation kinetics during incubation in polyester bags in the rumen. **Br. J. Nutr.** 73: 3-15.

Dixon, R.M. and C.R. Stockdale. 1999. Associative effects between forages and grains: consequences for feed utilization. **The Australian Journal Agricultural Research.** 50: 757-773.

Dominguez Bello, M. G. and A. Escobar. 1997. Rumenmanipulation for the improved utilization of tropical forages. **Anim. Feed Sci. Technol.** 69: 91-102.

Donmez, N., M. A. Karsli, A. Cinar, T. Aksu and E. Baytok. 2003. The effect of different silage additives on rumen protozoan number and volatile fatty acid concentration in sheep fed corn silage. **Small Ruminant Research.** 48: 227-231.

Dowd, M. K., S. L. Johansen, L. Cantarella and P. J. Reilly. 1994. Low molecular weightorganic composition of ethanol stillage from sugarcane molasses, citrus waste, and sweet whey. **J. Agr. Food Chem**. 42: 283–288.

Dubois, M., K. A. Gilles, J. K, Hamilton, P. A. Rebers and F. Smith. 1956. Colorimetric Method for Determination of Sugars and Related Substances. **Anal. Chem**. 28: 350-356.

Dunlop, R.P. 1991. Thyroid metabolic hormone. *In*: R. P. Dunlop (ed). **Physiology of Small and Large Animals**. National Academic Press, Washington, D. C. 513-520.

Ensminger, M. E. 1993. **Dairy cattle Science.** 3th ed. Interstate Publishers, Inc.

Erdman, R. 1993. **Silage fermentation: Characteristics affecting feed intake.** In: National silage production conference, Syracuse, WY. Proceeding, 67.

Erdman, R.A., G.H. Proctor and J.H. Vandersall. 1986. Effect of rumen ammonia concentration on in situ rate and extent of digestion of feedstuffs. **J. Dairy Sci**. 69: 2312-2320.

Erfle, J.D., L.J. Fisher and F.D. Sauer. 1974. Interrelationships between blood metabolites and evaluation of their use as criteria of energy status of cows in early lactation. **J. Anim. Sci.** 54: 293.

Eschenlauer, S.C.P., N.M. McKain, N.D. Walker, N.R. McEwan, C.J. Newbold and R.J. Wallace. 2002. Ammonia Production by Ruminal Microorganisms and Enumeration Isolation and Characterization of Bacteria Capable of Growth on Peptides and Amino Acids from the Sheep Rumen. **APPL. ENVITRON. Microbial.,** 68(10): 4925-4931.

FAO, 2002. The Livestock industries of Thailand. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific. 47 p.

Fawcett, J. K. and J. E. Scott. 1960. A rapid and precise method for determination of urea. **J. Clin. Pathol.** 13: 156.

Fernández, B., Ó. López-Campos, S. Andrés, A. R. Mantećo and F. J. Giráldez. 2009. Vinasse added to dried sugar beet pulp: Performance rate, voluntary intake and digestive utilization in sheep. **J. Anim. Sci.** 87: 2055-2063.

Fernández, B., G. Hervás, F.J. Giráldez, P. Frutos and A. R. Mantecón. 2003. Ingestión voluntaria y fermentación ruminal de paja tratada con diferentes niveles de extracto vegetal orgánico de remolacha (vinaza). **ITEA** 24(Suppl.):753–755.

Ferris, T. A., I. L. Mao and C. R. Anderson. 1985. Selecting for lactation curve and milk yield in dairy cattle **J. Dairy Sci**. 68: 1438-1448.

Firkins, J. L. 1996. Maximizing microbial protein-synthesis in the rumen. **J. Nutr.** 126: 1347-1354.

Flatt, W. P., P. W. Moe, A. W. Munson and T. Cooper. 1969. **Energy utilisation by high producingdairy cows. II. Summary of energy balance experiments with lactating Holstein cows**, pp. 235-251 *In* K.L. Blaxter, J. Kielanowski and G. Thorbeck (Ed), Energy Metabolism of Farm Animals. Oriel Press, Newcastle-upon-Tyne.

Foiklang, S., M. Wanapat and T. Norrapoke. 2012. **Effect of Grape Pomace Powder and Roughage sources on Rumen Fermentation by using *In Vitro* Gas Fermentation Technique.** Proceeding of the 15th AAAP Animal Science Congress. Thammasart University Thailand, November 26-30, 2012.

France, J. and R.C. Siddons. 1993. **Volatile fatty acid production,** pp. 107-122 *In* Quatilitive Aspects Ruminant Digestion and Metabolism (Ed. J.M. Forbes and J. France). International, Willing ford, UK.

Fritz, V.A., G.W. Randall and C.J. Rosen, 2001. Characterization and utilization of nitrogen contained in sweet corn silage waste. **Agron. J.** 93: 627-633.

Galyean, M. 1989. **Laboratory Procedures in Animal Nutrition Research**. New Mexico State University.

GEA Wiegand GmbH. 2011. **Evaporators for Stillage Concentration**. Available Source: http://www.geawiegand.com/geawiegand/cmsdoc. nsf/webdoc/ndkw 76yc6y, February 18, 2011.

Getachew, G., M. Blummel, H.P.S. Makkar and K. Becker. 1998. In vitro gas measuring techniques for assessment of nutritional quality of feeds. A Review. **Anim Feed Sci Tech.** 72: 261-281.

Getachew, G., P.H. Robinson, E.J. DePeters and S.J. Taylor. 2004. Relationships between chemical compositions, dry matter degradation and in vitro gas production of several ruminant feeds. **Anim Feed Sci Tech.** 111: 57-71.

Gibson, J. P. 1987. The options and prospects for genetically altering milk composition in dairy cattle. **Anim. Breeding Abstracts.** 55: 232-242.

Givens, D. I. and H. Rulquin. 2004. Utilisation by ruminants of nitrogen compounds in silage.

Grant, R.J. 1997. Interactions among forages and nonforage fiber sources. **J. Dairy Sci.** 80: 1438-1446.

Grant, R. J. and S. J. Weidner. 1992. Effect of fat from whole soybeans on performance of dairy cows fed rations differing in fiber level and particle size. **J. Dairy Sci.** 75: 2742–2751.

Griinari, J. M., D.A. Dwyer, M.A. McGuire, D.E. Bauman, D.L. Palmquist and K. V.V. Nurmela. 1998. *Trans*-octadecenoic acids and milk fat depression in lactating dairy cows. **J. Dairy Sci**. 81: 1251-1261.

Griinari, J.M., P.Y. Chouinard and D.E. Bauman. 1997. **Trans fatty acid hypothesis of milk fat depression revised**, pp. 208-216. *In* Proc. Cornell Nutr. Conf. Feed Manuf. Dept. Anim. Sci., Cornell University, Ithaca.

Goachet, A.G., C. Philippeau, M. Varloud and V. Julliand. 2009. Adaptations to standard approaches for measuring total tract apparent digestibility and gastro-intestinal retention time in horses in training. **Anim. Feed Sci. Technol.** 152: 141–151.

Goering, H. K. and P. J. Van Soest. 1970. **Forage Fiber Analyses (apparatus, reagents, Procedures and some applications**). Agric. Handbook No. 379. Washington, D.C. ARS, USDA.

Guedes, C.M., D. Goncalves, M.A.M. Rodrigues and A. Dias-da-Silva. 2008. Effects of a *Saccharomyces cerevisiae* yeast on ruminal fermentation and fibre degradation of maize silages in cows. **Anim. Feed Sci. Technol.** 145: 27-40.

Guyton, A.C. and J.E. Hall. 2002. Text Book of Medical Physiology. Elsevier, Pvt. Ltd. New Delhi, India.

Habeeb, A.A.M., I.F.M. Marai and T.H. Kamal. 1992. Heat stress, pp. 27-47. *In* C.J.C. Phillips and D. Piggins (eds.). **Farm Animals and the Environment.** CAB International, Wallingford.

Hadalgo, K. 2009. Vinasse in feed: Good for animal and environment. **Feed Tech**. 18-20.

Hanbanjong, U. and D. Sinjermsiri. 1989. **Determination of Ash.** Department of Animal Sciences, Faculty of Agriculture, Kasetsart University.

Haigh, P.M. and J.V.G. Parker. 1985. Effect of silage additives and wilting on silage fermentation, digestibility and intake, and on live weight change of young cattle. **Grass Forage Sci.** 40: 429-436.

Hammond, A.C. 1983. The use of blood urea nitrogen concentration as an indicator of protein status in cattle. **Bov. Pract.** 18: 114.

Hara, A. and N. S. Radin. 1978. Lipid extraction of tissues with a low-toxicity solvent. **Anal. Biochem.** 90: 420-426.

Heinrich, J., C. Johes and K. Bailey. 2011. **Milk components: understanding the causes and importance of milk fat and protein variation in your dairy herd.** Available source: http:// www. Das.psu.edu. September 8, 2012.

Heldt, J.S., R.C. Cochran, G.L. Stokka, C.G. Farmer, C.P. Mathis, E.C. Titgemeyer and T.G. Nagaraja. 1999. Effects of different supplemental sugars and starch fed in combination with degradable intake protein on low quality forage use by beef steers. **J. Anim. Sci.** 77: 2793-2802.

Heur, C., S. Van, W.M. Schukken, Y. Dirkzwager, H.A. Noordhuizen, and J.P.T.M. 2000. Prediction of energy balance in a high yielding dairy herd in early lactation. **Livest. Production Science.** 65: 91-105.

Holter, J.B., J.A. Byrne and C.G. Schwab. 1982. Crude protein for high milk production. **J. Dairy Sci.** 65: 1175.

Honig, H. and M. K. Woolford. 1980. **Changes in silage on exposure to air.** Forage Conservation in the 80s. Occasional Symposium No. 11. British Grassland Society, Hurley Berkshire UK. pp. 76-87.

Houtert, M. F. J. 1993. The production and metabolism of volatile fatty acids by ruminants fed roughages: a review. **Anim. Feed Sci. Technol.** 43: 189-225.

Hristov, A.N., J.K. Ropp, K.L. Grandeen, S. Abedi, R.P. Etter, A. Melgar and A.E. Foley. 2005. Effect of carbohydrate source on ammonia utilization in lactating dairy cows. **J Anim Sci.** 83(2): 408-21.

Huhtanen, P., J.I. Nousiainen, H. Khalili, S. Jaakkola and T. Heikkila. 2003. Relationship between silage fermentation characteristics and milk production parameters: analyses of literature data. **Livestock Production Science,** 81, 57–73.

Hungate, R.E. 1966. **The rumen and its microbes.** Academic Press, New York.

Hwang, S. H., M. J. Lee and H.C. Peh. 2001. Diunal variations in milk and blood urea-nitrogen and whole blood ammonia nitrogen in dairy cow. **Asian-Aust. J. Anim. Sci.** 14: 1683-1689.

Ibeawuchi, J. A. and A. Dangut. 1996. Influence of stage of lactation on milk constituents of Bunaji (Zebu) cattle in a hot humid tropical environment. **Discovery and Innovation.** 8: 249-256.

Ireland-Perry, R. L. and C. C. Stallings. 1993. Fecal consistency as related to dietary composition in lactating Holstein cows. **J. Dairy Sci.** 76: 1074-1082.

Islam, M.N., S.M.I. Hossain and M.A. Mannan. 1984. Studies on the physical parameters and chemical qualities of market milk in Mymensingh town. Bangla. **J. Anim. Sci. 13: 52.**

Jaster, E. H., D. F. Bell and G. C. McCoy. 1983. Evaluation of sweet corn residues as roughage for dairy heifers. **J. Dairy Sci.** 66: 2349-2355.

Jetana, T., W. Suthikrai, S. Usawang, C. Vongpipatana, S. Sophon and J.B. Liang. 2009. The effects of concentrate added to pineapple (*Ananas Comosus linn. Mer.*) waste silage in differing ratios to form complete diets on digestibility, excretion of urinary purine derivatives and blood metabolites in growing male Thai swamp buffaloes. **Trop Anim Health Prod.** 41: 449-459.

Jitramano, P., S. Sruamsiri, P. Choopheng and K. T. Rangabhet. 2005. **The use of pineapple waste as cattle feed: physical characteristic and nutritive value of ensiled pineapple waste with rice straw.** The 31st Annual Conference Kasetsart University. Bankok. pp. 210-217.

Johnson, H.D. and W.J. Vanjonack. 1976. Effects of environmental and other stressors on blood hormone patterns in lactating animals. **J. Dairy Sci**. 59: 1603-1617.

Johnson, L., J. H. Harrison, M. Robutti, B. Swift Mahanna and K. Shinners. 2002. Corn silage management I. Effect of hybrid, maturity, mechanical processing on chemical and physical characteristic. **J. Dairy Sci**. 85: 833-853.

Jonker, J. S., R. A. Kohn and R. A. Erdman. 1999. Milk urea nitrogen target concentrations for lactating dairy cows fed according to national research council recommendations. **J. Dairy Sci.** 82: 1261-1273.

Jouaney, J.P. and K. Ushida. 1999. The role of protozoa in feed digestion Asian-Aust**. J. Anim. Sci.** 12: 113-126.

Jounay, J.P. 1989. Effects of diet on populations of rumen protozoa in relation to fibre digestion. In: Nolan, J.V., Leng. R.A., Demeyer, D.I. (Eds.). The roles of Protozoa and Fungi in ruminant Digestion. Penamul Books. Armidale. Australia. pp. 59-74.

Kaewkamchan, S., P. Vijchulata, P. Chirattanayuth, V. Santisopasri and S. Panichying. 2000. **Raw milk quality from milk collecting centers of Dairy Farming Promotion Organization of Thailand during 1996-1999**, pp. 217-223 *In* The 38th Kasetsart University Annual Conference. 2000. Subject: Animals and Veterinary Medicine. Physic Center Pub., Bangkok.

Kamal, T.H. and I.I. Ibrahim. 1969. The effect of the natural climate of the Sahara and controlled climate on thyroid gland activity in Friesian cattle and water buffaloes. **Int. J. Biometeorol.** 13: 275–285.

Kamalak, A., O. Canbolat, M. Sahin, Y. Gurbuzy, E. Ozkose and C.O. Ozkan. 2005. The effect of polyethylene glycol (PEG 8000) supplementation on in vitro gas production kinetics of leaves from tannin containing trees. **South African Journal of Animal Science.** 35(4): 229-236.

Kawashima, T.W., W. Sumamal, P. Pholsen, R. Chaithiang and W. Boonpakdee. 2002. The use of sugar cane stalk for feeding lactating cows. **Asian-Aust. J. Anim. Sci.** 15(2): 205-208.

Kearl, L. C. 1982. **Nutrient requirement of ruminants in developing countries. Longan: International Feedstuffs Institute.** Utah State University, Utah.

Kelly, M. L., E. S. Bauman, D. E. Van, M. E. Amburgh and D. E. Muller. 1998. Effect of intake of pasture on concentrations of conjugated linoleic acid in milk of lactating cows. **J. Dairy Sci**. 83: 1630-1636.

Keneko, J.J. 1989. **Clinical Biochemistry of Domestic Animal**. 4th ed., Academic Press Inc., San Diego, California.

Khalili, H. and P. Huhtanen. 1991. Sucrose supplements in cattle given grass silage based diet. Digestion of organic matter and nitrogen. **Anim. Feed Sci. Technol.** 33: 247-261.

Khan, Ajmal. M., Mahr-Un- Nisa and M. Sarwar. 2003. Techniques Measuring Digestibility for the Nutritional Evaluation of Feeds. **Int. J. Agri. Biol.** 5(1).

Khazaal, K., M.T. Dentinho, J.M. Riberiro and E.R. Ørskov. 1993. A comparison of gas production during incubation with rumen contents *in vitro* and nylon bag degradability as predictors of the apparent digestibility *in vivo* and the voluntary intake of hays. **Anim Prod.** 57: 105-117.

Khoransani, G., R. Janzen, W. McGill, and J. Kenelly. 1997. Site and extent of mineral absorption in lactating cows fed whole crop cereal grain silage or alfalfa silage. **J. Anim. Sci.** 75:239-248.

Kirchgessner, M. and F.J. Schwarz. 1984. Einflussfaktoren auf die grundfutteraufnahme bei milchkühen. **Ubers. Tierenahr**., 12: 187-214.

Kleinschmit, D.H. and L. Kung Jr. 2006. A meta-analysis of the effects of Lactobacillus buchneri on the fermentation and aerobic stability of corn and grass and small grain silages. **J. Dairy Sci.** 89: 4005-4013.

Kokkonen, T., M. Tuori and L. Syrjala-Quist. 2000. Effect of silage dry matter content and repeseed meal supplementation on dairy cows. 2. Rumen fermentation and digesta passage rate. **Anim, Feed Sci. Tech.** 84: 229-242.

Kongngoen, N., B. L.Cheva-Isarakul and P. Chairatanayuth. 1993. The utilization of urea-molasses liquid supplement to rice straw as ruminant feed. *In* **The Proceeding of 31st Kasetsart University Annual Conference.** Kasetsart University Bangkok. pp. 210-217.

Koon, L.L. 1993. **Production of silawrap silage from fodder grass species for dry season feeding. In: Strategies for suitable forage-based livestock production in S.E.Asia.** Proc. 3 rd Meet. Region. Working Grp. On grazing and Feed Resources for S.E. Asia. 31 Jan.-6 Feb. 1993. Khon Khen, Thailand, pp. 99-101.

Kritchevsky, D. 2000. Antimutagenic and some other effects of Conjugated Linoleic Acid. **Br. J. Nutr.** 83: 459-465.

Kronfield, D.S. 1982. Major metabolic determinants of milk volume, mammary efficiency and spontaneous ketosis in dairy cows. **J. Dairy Sci.** 65: 2204

Kukhuan, C. 2000. **Chemical Treatment of Bagasse to Compensate Roughage Shortage During Dry Season for Dairy Cattle in Thailand**. M.S. Thesis, Suranaree University of Technology.

Kung, Jr. L. and N.K. Ranjit. 2001. The effect of Lactobacillus buchneri and other additives on the fermentation and aerobic stability of barley silage. **J. Dairy Sci.** 84: 1149-1155.

Kung, Jr. L., J.R. Robinson, N.K. Ranjit, J.H. Chen, C.M. Golt and J.D. Pesek. 2000. Microbial population, fermentation end products and aerobic stability of corn silage treated with ammonia or propionic acid based preservative. **J. Dairy Sci.** 83: 1479-1486.

Kung, L. and R. Shaver. 2001. Interpretation and Use of silage Fermentation Analysis Reports. **Focus on Forage.** 3: 1-5.

Kwak, W.S. and J.H. Herbein. 1990. Lactational, metabolic, and physiological effects of dietary fats and isoacids on early lactating first-calf Holstein heifers. **Korean Journal of Dairy Science.** 12(2): 116-124

LeBlanc S.J., K.E. Leslie and T.F. Duffield. 2005. Metabolic Predictors of Displaced Abomasum in Dairy Cattle. **J Dairy Sci**. 88: 159-170.

Leibensperger, R.Y. and R. E. Pitt. 1987. Model of clostridia dominance in ensilage. Grass Forage Sci. 42: 297-317.Lewis, D. 1975. Blood urea concentration in relation to protein utilization in the ruminant. **J. Agric. Sci**. 48: 438-446.

Linzell, J.L. and M. Peaker. 1971. Intracellular concentrations of sodium, potassium and chloride in the lactating mammary gland and their relation to the secretory mechanism. **J. Physiol.** 216: 683-700.

Lock, A.L. and J.K. Shingfield. 2004. **Optimising milk composition. In Dairying using science to meet consumers´needs.** British Dociety of Animal Science, publication no. 29 (ed. E. Kebreab, J. Mills and D.E. Beever), pp. 107-188. Nottingham University Press, Nottingham, UK.

______. and P.C. Garsworthy. 2003. Seasonal variation in milk conjugated linoleic acid and D9-desaturase activity in dairy cows. **Livest. Prod. Sci.** 9: 47-59.

López-Campos., Ó. R. Bodas, N. Prieto, P. Frutos, S. Andrés and F. J. Giráldez. 2011. **J. Anim. Sci.** 89: 1153-1162.

MacRae, J.C. and G.E. Lobley. 1982. Some factors which influence thermal energy losses during the metabolism of ruminants. **Livest. Prod. Sci.** 9: 447.

Machmueller, A., D. A. Ossowski, M. Wanner and M. Kreuzer. 1998. Potential of various fatty feeds to reduce methane release from rumen fermentation in vitro (Rusitec). **Anim. Feed Sci. Technol**. 71: 117-130.

Magdub A., H.D. Johnson and R.L. Belyea. 1982. Effect of environmental heat and dietary fibers on thyroid physiology of lactating cows. **J. Dairy. Sci.** 65: 2323-2331.

Makkar, H.P.S., M. Blümmel and K. Becker. 1995. In vitro effects and interactions of tannins and saponins and fate of tannins in the rumen. **J. Sci. Food Agric.** 69: 481-493.

Mandali, G.C., P.R. Patel, A.J. Dhami, S.K. Rawal and K.S. Christi. 2002. Biochemical profile in buffaloes with periparturient reproductive and metabolic disorders. **Indian J. Anim. Reprod.** 23(2): 130-134.

Manson, H. L. 2001. **Composition of Swedish Dairy Milk.** Report Nr. 7025-P (In Swedish), Swedish Dairy Association 2003.

Marley, C.L., R. Fychan, M.D. Fraser, R. Sanderson and R. Jones. 2007. Effects of feeding different ensiled forages on the productivity and nutrient use efficiency of finishing lambs. **Grass Forage Sci.** 62: 1-12.

McCullough, M.E. 1975. **Silage fermentation. Department of Animal Science.** University of Georgia, College of Agriculture Experiment Station. pp. 1-27.

McDonald, P. 1981. **The Biochemistry of Silage.** John Wiley & Sons. Chichester, New York, N.Y., USA.

McDonald, P., A.R. Henderson and S.J.E. Heron. 1991. The biochemistry of silage. Second Edition. Chalcombe Publications, Marlow, UK.

Menke, K. and H. Steingass. 1988. Estimation of the energetic feed value obtained form chemical analysis and *in vitro* gas production using rumen fluid. **Anim. Res. Devel**. 28: 7-55.

Menke, W., M. West, B. Brandsdottir and D. Sparks. 1998. Compressional and shear velocity structure of the lithosphere in northern Iceland, Bull. **Seism.Soc.Am.** 88: 1561-1571.

Menke, K.H., L. Raab, A. Salewski, H. Steingrass, H. 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 inocubated with rumen liquor. **J. Agri Sci.** 93: 217-222.

Ministry of energy. 2009. **Report of waste from ethanol product.** Available Source: http://www.region2.m-energy.go.th/index.php?option=com, April 2, 2012

Mohd Najib, M. A., A. Aminah and A.B. Idris. 1993. **Forage conservation for livestock smallholders in Malaysia.** pp. 103-109.

Moss, A.R., J.P. Jouany and J. Newbold. 2000. Methane production by ruminants: its contribution to global warming. **Annales de Zootechnie** 49: 231-253.

Mould, F.L. and E.R. Ørskov. 1984. Manipulation of rumen fluid pH and its influence on cellulolytic in sacco dry matter degradation and the rumen microflora of sheep offered either hay or concentrate. **Animal Feed Science and Technology.** 10; 1-14.

Muck, R. E. 1991. Silage fermentation. *In* J. G. Zeikus and E. A. Johnson, eds. **Mixed Cultures in Biotechnology.** McGrawHill, Inc., New York.

Mueller, J.P. and J.T. Green. 2013. **Corn Silage Harvest Techniques. Cooperative Extension Service Purdue University West Lafayette.** Available source: http://www.extension.purdue.edu/extmedia/NCH/NCH-49.html, April 30, 2013.

Mustafa, A. F., F. Hassanat and R. R. Berthiaume. 2004. *Situ* forestomach and Intestial Nutrient Digestibility of Sweet corn Residues. **Anim. Feed Sci. Tech.** 114: 287-293.

Mueller, I., J.D. Reed and R.D. Hartley. 1987. Characterisation of phenolic compounds, including flavonoids and tannins, often Ethiopian browse species by high performance liquid chromatography. **Journal of the Science of Food and Agriculture.** 39: 1-14.

Nath, H.C., K.K. Baruah, B.C. Sharma and D.J. Dutta. 2004. Serum cholesterol and total protein indices during different stages of reproduction in local goats of Assam. **Indian Vet. J.,** 81: 1100-1101.

NRC. 1984. **Nutrient requirements of beef cattle**. 6th Ed.. National Academy Press, Washington, DC.

NRC. 2001. **Nutrient requirements of dairy cattle**. 7th rev. ed. Natl. Acad. Sci., Washington, DC.

Ndlovu, L.R. and F.V. Nherera. 1997. Chemical composition and relationship to *in vitro* gas production of Zimbabwean browsable indigenous tree species. **Anim. Feed Sci. Technol.** 69: 121-129.

Newbold, C.J., R.J. Wallace, X.B. Chen and F.M. McIntosh. 1995. Different strains of *saccharomyces cerevisiae* differ in their effects on ruminal bacterial numbers in vitro and in sheep. **J. Anim. Sci.** 73: 1811-1818.

Nguyen, V. T., M. Wanapat, P. Khejornsart and P. Kongmun. 2012. Nutrient digestibility and ruminal fermentation characteristic in swamp buffaloes fed on chemically treated rice straw and urea. **Trop. Anim Health Prod.** 44: 629-636.

Nkosi, B.D. 2009. Potato hash silage as an alternative feed source for livestock farmers in the Gauteng Province. Ph.D. Thesis, University of the Free State, Bloemfontein, South Africa.

Nkosi, B.D. and R. Meeske. 2010. Effects of whey and molasses as silage adiitives on potato hash silage quality and growth performance and lambs**. South of Africa Journal of Animal Science.** 40(3): 229-235.

Nocek, J.E. and S. Tamminga. 1991. Site of digestion of Starch in the Gastrointestinal Tract of Dairy Cows and Its Effect on Milk Yield and Composition. **J. Dairy Sci.** 74: 3598-3629.

OAE. 2009. **Agricultural Statistics of Thailand 2009.** Available source: http://www.oae.go.th/download/download_journal/yearbook2552.pdf. September 8, 2012.

Oldham, J. D. 1984. Protein –Energy Interrelationships in Dairy Cows. **J. Dairy Sci.** 67: 1090-1114.

O΄ Mara, F.P., J.J. Fitzgerald, J.J. Murphy and M. Rath. 1998. The effect on milk production of replacing grass silage with maize silage in the diet of dairy cows. **Livest. Prod. Sci**. 55: 79-87.

Pahlow, G., R.E. Muck, F. Driehuis, S.J. Elferink and S. Spolestra. 2003. **Microbiology of ensiling**, pp. 31-93 *In* Buxton, D.R., Muck, R.E. Harrison, J.H. (Eds.). Silage Science and Technology. ASA Inc., Madison, WI, USA.

Pan, J., T. Suzuki, S. Koike, K. Ueda and Y. Kobayashi. 2003. Effect of urea infusion into the rumen on liquid and particle associated fibrolytic enzyme activities in steers fed low quality grass hay. **Animal Feed Science and Technology.** 104: 13-27.

Parker, B.N. and R.W. Blowey. 1976. Investigations into the relationship of selected blood components to nutrition and fertility of the dairy cow under commercial farm conditions. **Vet. Rec.** 98: 394-404.

Pate, F.M. 1981. Fresh chopped sugar cane in growing-finishing steer diets. **J. Anim. Sci.** 53: 881-888.

Parrakasi, A. 1999. **Ilmu Nutrisi dan Makanan Ternak Ruminansia.** Universitas Indonesia. Press, Jakarta.

Palmquist, D.L., A. Denise Beaulieu, and D.M. Barbano. 1993. Feed and animal factors influencing milk fat composition. **J. Dairy Sci.** 76: 1753-1771.

______, A.L. Lock, K.J. Shingfield and D.E. Bauman. 2005. Biosynthesis of conjugated linoleic acid in ruminants and humans. **Adv. Food. Nutr. Res.** 50: 179-218.

Parodi, P.W. 1997. Cows' milk fat components as potential anticarcinogenic agents. **J. Nutr.** 127: 1055-1060.

Parnaudeau, V., N. Condom, R. Oliver, P. Cazevieille and S. Recous. 2008. Vinasse organic matter quality and mineralization potential, as influenced by raw material, fermentation and concentration processes. **Bioresource Technology.** 99: 1553–1562.

Payne, J.M. and S. Payne. 1987. **The metabolic Profile Test.** Oxford University Press. Oxford, 17-143.

Perdok, H.B. and L.A. Leng. 1990. Effect of supplementation with protein meal on the growth of cattle given a basal diet of untreated ammoniated rice straw. **Asian-Aust. J. Anim. Sci.** 3: 269-279.

Pereira, S.Y. 2008. **Environmental aspects in ethanol production related to vinasse disposal and groundwater.** In: Proceedings of 33 rd International Geological Congress, August 6–14, 2008, Oslo, Norway.

Phipps, R. H., J.A. Bines, P.J. Fulford and R.F. Weller. 1984. Complete diets for dairy cows: a comparison between complete diets and separate ingredients. **J. Agric. Sci., Cambridge.** 103: 171-180.

Phipps, R. H., J.D. Sutton and B.A. Jones. 1995. Forage mixtures for dairy cows: the effect on dry-matter intake and milk production of incorporating either fermented or urea-treated whole-crop wheat, brewer´s grains, fodder beet or maize silage into diets base on grass silage. **Anim. Sci.** 61: 491-496.

Phipps, R.H., R.F. Weller and A.J. Rook. 1992. Forage mixtures for dairy cows: the effect on dry matter intake and milk production of incorporating different proportions of maize silage into diets based on grass silages of differing energy value. **J. Agric. Sci. (Camb.).** 118: 379–382.

Piva, G., S. Belladonna, G. Fusconi and F. Sicbaldi. 1993. Effects of yeast on dairy cow performance, ruminal fermentation, blood components and milk manufacturing properties. **J. Dairy Sci.** 76: 2717-2722.

Pond, W. G., D. C. Church and K. R. Pond. 1995. **Basic Animal Nutrition and Feeding.** 4th ed. John Wiley&Sons. New York.

Preston, R.L., D.D. Schnakanberg and W.H. Pander. 1965. Protein utilization in ruminants. 1. Blood urea nitrogen as affected by protein intake. **J. Nutr.** 86: 281-288.

Preston, T.R. 1995**. Tropical Animal feeding a manual for research worker**. FAO Animal Production and Health Paper 126. Rome, Italy.

Prudhvi Reddy, K., K. Radha Krishnaiah and P. Rama Rao. 2003. Studies on sero biochemical changes in bullocks in field out breaks of Myrothecio. **India ver. J.** 80(80): 913-916.

Ørskov, E.R. 1999. Supplement strategies for ruminants and management of feeding to maximize utilization of roughage. **Prev. Vet. Med.** 38: 179-185.

Ørskov, E.R. and P. McDonald. 1978. The estimation of protein digestibility in the rumen from incubation measurements weighed according to rate of passage. **J. Agric. Sci., Cambridge.** 92: 499-503.

Rahman, A. U., A. Khan, M. Amjed and N. Ahmad. 2003. Effect of substitution of whole crop maize versus maize stover silages with commercial concentrates on milk yield and its composition in Sahiwal cows. **Pakistan Vet. J.** 23(3): 150-152.

Rekaya, R., M. J. Carabano and M. A. Toro. 2000. Bayesian analysis of lactation curves of Holstein-Friesian cattle. **J. Dairy Sci**. 83: 2691-2701.

Rekik, B., A. Ben Gara, M. Ben Hamouda and H. Hammami. 2003. Fitting lactation curves of dairy cattle in different types of herds in Tunisia. **Livest. Prod. Sci**. 83: 309-315.

Rivers, D.B. 1988. Factors affecting the enzymatic hydrolysis of bagasse and rice straw. **Biological Wastes.** 2: 85-95.

Robert, J. and K. W. Prease. 1998. Veterinary Laboratory Medicine. Department of Veterinary Pathology, College of Veterinary Medicine. Univ. of Geogia, Geogia.

Robinson, P.H. and L.J. Erasmus. 2009. Effects of analyzable diet components on responses of lactating dairy cows to *Saccharomyces cerevisiae* based yeast products: A systematic review of the literature. **Anim. Feed Sci. Technol.,** 149: 185-198.

Robinson, P. H., R. E. McQueen and P. L. Buress. 1991. Influence of rumen undergradable protein levels on feed intake and milk production of dairy cows. **J. Dairy Sci.** 74: 1623-1631.

Robeiro, M.E.R., R.C. Rodrigues, N.L. Costa and R.W. Coelho. 1993. Utilização de residues da agroindústria na alimentação animal (Agroindustrials waste utilization in the animal feeding). **In: Reunião Annual da Sociedade Brasileira de Zootecnia,** vol. 30. SBZ, Rio de Janeiro. RJ. P. 509.

Rohweder, D.A., R.F. Barnes and Neal Jorgensen. 1978. Proposed Hay Grading Standards Based on Laboratory Analyses for Evaluating Quality. **J. Anim. Sci.** 47: 747-759.

Rook, J.S., G. Scholman, S. Wing-Proctor and M.E. Shea. 1990. Diagnosis and Control of Neonatal Losses in Sheep. **Veterinary Clinics of North America, Food Animal Practice,** 6(3): 531-62.

Rook, J.A.F. and C.C. Balch. 1961. The effects of intraruminal infusions of acetic, propionic, and butyric acids on the yield and composition of the milk of the cow. **Br. J. Nutr.** 15: 361–369.

Roseler, D. K., J.D. Ferguson, C.J. Sniffen and J. Herrema. 1993. Dietary protein degradability effects on plasma and milk urea nitrogen and milk non-protein in Holstein cow. **J. Dairy Sci.** 76: 525-534.

Rotz, C.A., Muck, R.E. 1994. **Change in forage quality during harvest and storage,** pp. 828-868 *In* Fahey Jr., G.C., *et al.* (Eds.), Forage Quality, Evaluation, and Utilization. America Inc., Soil Science Society of America Inc., Madison, WI,

Saha, B.C. 2003. Hemicellulose bilconversion. **J. Ind. Microbiol. Biotechnol.** 30: 279-291.

Samuel, M., S. Sagathewan, J. Thomas and G. Mathen. 1997. An HPLC method for estimation of volatile fatty acid of ruminal fluid. Indian. **J. Anim. Sci.** 67: 805-807.

Sandoval-Castro, C.A. S. Anderson and J.D. Leaver. 2000. Production responses of tropical crossbred cattle to supplementary feeding and to different milking and restricted suckling management. **Livest. Prod. Sci.** 66: 13-23.

SAS. 1996. **SAS/STATTM User's Guide (Release 6.03)**. SAS Inst., Inc. Cary, NC.

Satter, L.D. and L.L. Slyter. 1974. Effect of ammonia concentration on rumen microbial protein production in vitro. **Br. J. Nut.** 32: 199-208.

Schroeder, J. W. 2002. Optimizing the level of corn gluten feed in the diet lactating dairy cows. **J. Dairy Sci.** 86: 844-851.

Sharp, R., P.G. Hooper and D.G. Armstrong. 1994. The digestion of grass silages produced using inoculants of lactic acid bacteria. **Grass Forage Sci.** 49: 42-53.

Siang-Chong, N. 2010. **Effects of Molasses and vinasse as feed additives on chemical properties of *Leucaena leucocephala* silage for ruminant feed.** M. Sc. Thesis, Thammasat University.

Slein, M. W. 1963. **Methods of enzymatic Analysis.** Academic Press, New York.

Slyter, L.L. 1976. Influence of acidosis on rumen function. **J. Anim. Sci.** 43: 910-929.

Slyter, L., L.D. Satter and D.A. Dinius. 1979. Effect of ruminal ammonia concentration on nitrogen utilization by steers. **J. Anim. Sci.** 48: 906-912.

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.

Squires, E. T. 2003. **Applied Animal Endocrinology.** CABI Pub., Wallingford.

Sruamsiri, S., P. Silman and W. Srinuch. 2007. Agro-industrial by-products as roughage source for beef cattle: Chemical composition, nutrient digestibility and energy values of ensiled sweet corn cob and husk with different levels of Ipil-Ipil leaves. **Mj. Int. J. Sci. Tech**. 1: 88-94.

Steel, R. G. and J. H. Torrie. 1980. **Principles and Procedures of Statistics**: A Biometrical Approach, 2nd ed. McGraw-Hill, New York, pp. 132-168.

Stemme, K., B. Gerdes, A. Harms and J. Kamphues. 2005. Beet vinasse (condensed molasses solubles) as an ingredient in diets for cattle and pigs nutritive value and limitations. **J. Anim. Physiol. Anim. Nutr. (Berl).** 89: 179-183.

Suksathit, S., W. Chalong and Y. Opatpatanakit. 2011. Effects of levels of ensiled pineapple waste and pangola hay fed as roughage sources on feed intake, nutrient digestibility and ruminal fermentation of Southern Thai native cattle. **Songklanakarin J. Sci. Technol.** 33 (3): 281-289.

Suksombat, W. 1996. The effect of four different roughage-mixed on dairy cow performances in late lactation. **Suranaree J. Sci. Technol.** 3: 139-145.

Suksombat, W. and P. Mernkrathoke. 2005. Feeding of Whole Sugar Cane to Dairy Cattle during the Dry Season. **Asian-Aust. J. Anim. Sci.** 18(3): 345-349.

Sutton J.D., J.A. Bines, S.V. Morant and D.J. Napper. 1987. A comparison of starchy and fibrous concentrates for milk production, energy utilization and hay intake by Friesian cows. **J. Agric. Sci. (Camb.).** 109: 375–386

Suwannasin, N. 2009. **Production Efficiency and Economic Return of Crossbred Dairy cow Fed Partial Mixed Ration (PMR) in the dry season**. M.S. Thesis, *Kasetsart University*.

Swamiphak, S. 1996. Tri-party agreement on the evaluation and pricing system of raw milk. **Dairy Cattle Magazine.** 15: 37-53.

Tamminga, S. 1992. Nutrition Management of Dairy Cows as a Contribution to Pollution Contral. **J. Dairy Sci.** 75: 345-357.

Tang, S.X., G.O. Tayo, Z.L. Tan, Z.H. Sun, M. Wang, G.P. Ren and X.F. Han. 2008. Use of In vitro Gas Production Technique to Investigate Interactions between Rice Straw, Wheat Straw, Maize and Alfalfa or Clover. **Asian-Aust. J. Anim.Sci.** 21(9): 1278-1285.

Tawila, M.A., H.A.A. Omer and S.M. Gad. 2008. Partial replacing of concentrate feed mixture by potato proceesing waste in sheep rations. **American-EurasianJ. Agric. Environ. Sci** 4(2): 156-164.

Teller, E., M. Vanbelle and P. Kamatali. 1993. Chewing behavior and voluntary grass silage intake by cattle. **Livest. Prod. Sci.** 33: 215-227.

Thai Meteorological Department. 2004. **Weather in Thailand.** The Thai Metereorological Department. Minist. Transport. Bangkok Thailand,

Thomas, C. and P.C. Thomas. 1988. **Factors affecting nutritive value of grass silages**, pp. 274-307 *In* Haresign, W., Cole, D.J.A. (Eds.), Recent Developments in Ruminant Nutrition2, Butterworths, London.

Tiffany, T. O., J. M. Jansen, C. A. Burtis, J. B. Overton and C. D. Scott. 1972. Enzymatic kinetic rate and end point analyses of substrate by the use of a GeMSAEC fast analyser. **J. Clin. Chem.** 18: 829-840.

Titterton, M. and F.B. Bareeba. 1999. **Grass and legume silages in the tropics**. In: L.'t Mannetje (Ed.) Proc. FAO e-conf. on Trop. Silage. **FAO Plant Prod. And Protect.** Paper 161. 1 Sept.-15 Dec. 1999. 43-50.

T' Mannetje, L. 1999. **Introduction to the conference on Silage Making in the tropics.** *In* Proc. FAO e-Conf. on Trop. Silage 1 September-15 December 1999.

Troccon, J.L. and C. Demarquilly. 1989. La vinasse de mélasse de betteraves pour les ruminants. **INRA Prod. Anim.** 2: 245-248.

Tudsri, S. and S. Sawasdipanit. 1993. Managerial approach to pasture production in Thailand. 3 rd Proc. Forage RWG of S.E. Asia. Khonkaen, Thailand. pp. 111-125.

Tumwasorn, S. 2007. **Annual Report on PMR.** Mitrphol Sugar Company Limited. Thailand.

Twigge, J.R. and L.G.M. Van Gils. 1988. **Practical aspects of feeding protein to dairy cows,** pp.196 *In* W. Haresign and D.J.A. Cole (Editors). Recent developments in ruminant nutrition. Univ. of Nottingham School of Agric., Butterworths (London).

Valadares Filho, S.C. 1985. Digestáo total e parcial da material seca e carbohydrates em bovines e bubalinos. Ph.D. Thesis, Federal University of Vicosa, Brazil.

Valadares, R.F.D., G.A. Broderick, S.C. Valadares and M.K. Clayton. 1999. Effect of replacing alfalfa silage with high moisture corn on ruminal protein synthesis estimated from excretion of total purine derivatives. **J. Dairy Sci.** 82: 2686-2696.

Van Keulen, J. and B. A. Young. 1977 . Evaluation of acid-insoluble ash as a natural marker in ruminant digestibility studies. **J. Anim. Sci.** 44: 282-287.

Van Soest, P.J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: Voluntary intake in relation to chemical composition and digestibility. **J. Anim. Sci.** 24: 834.

______. 1968. Determination of lignin and cellulose in acid detergent fiber with permanganate. **J. Assoc. Official Agric. Chem**. 51: 780–785.

______. 1987. Nutritional Ecology of the Ruminant. Cornell University Press, Ithaca, New York, USA.

______. 1994. **Nutrition Ecology of the Ruminant**. 2nd Edition. Cornell University. Press, USA.

Van Soest, P.J. and J. B. Robertson . 1985. **A Laboratory Manual for Animal Science**. Cornell University Press, Ithaca, NY, p. 612.

Visek, W. J. 1984. Ammonia: its effects on biological systems, metabolic hormones and reproduction. **J. Dairy Sci.** 67: 481.

Viviani, R. 1970. Metabolism of long-chain fatty acids in the rumen. **Adv. Lipid Res.** 8: 267–346.

Walker, G. P., C. R. Stockdale, W. J. Wales, P. T. Doyle and D. W. Dellow. 2001. Effect of level of grain supplementation on milk production responses of dairy cows in mid-late lactation when grazing irrigated pastures high in paspalum (Paspalum dilatatum Poir.) **Aust. J. Agric**. **Res.** 41: 1-11.

Walstra, P. T., J. Geurts, A. Noomen, A. Jellamma and M. B. Van. 1999. Principles of milk properties and processes. **Dairy Technology.** New York: Marcel Dekker, Inc.

Wanapat, M. 1999. **Feeding of ruminants in the tropics based on local feed resources**. Khon Kaen Publishing Company Ltd., Khon Kaen, Thailand. pp. 236.

Wanapat, M. 1990. **Ruminant Nutrition.** 3rd Edition. Funny Press Publ.,Ltd. Bangkok. 473 pp. (in Thai).

Wanapat, M. 2000. **Rumen Manipulation to Increase the Efficient use Local Feed Resources and Productivity of Ruminants in the Tropics**. pp. 59-67. *In* Proc. of the 9th AAAP Congress. (Eds. G.M. Stone), July 3-7, 2000. University of New South Wales, Sydney, Australia.

Wanapat, M., S. Polyorach, K. Boonnop, C. Mapato and A. Cherdthong. 2009. Effects of treating rice straw with urea or urea and calcium hydroxide upon intake, digestibility, rumen fermentation and milk yield of dairy cows. **Livestock Science.** 125: 238–243.

Wanapat, M., F. Sundstol and T. H. Garmo. 1985. A comparison of alkali treatment methods to improve the nutritive value of straw. l. Digestibility and metabolizability. **Anim. Feed Sci. Technol**. 12: 295-309.

Wanapat, M. and O. Pimpa. 1999. Effect of ruminal NH_3-N levels on ruminal fermentation, purine derivatives, digestibility and rice straw intake in swamp buffaloes. **Asian-Aust. J. Anim. Sci.** 12: 904.

______, A. Cherdthong, P. Pakdee and S. Wanapat. 2008. Manipulation of rumen ecology by dietary lemongrass (*Cymbopogon citrates* Stapf.) power supplementation. **J. Anim. Sci.** 86: 3497-3503.

______, R. Pilajun and P. Kongmun. 2009. Ruminal ecology of swamp buffalo as influenced by dietary sources. **Anim. Feed Sci. Technol.** 151: 205-214.

Weinberg, Z. G. and R. E. Muck. 1996. New trends and opportunities in the development and use of inoculants for silage. **FEMS Microbiol. Rev.** 19: 53-68.

Wilkinson, J. M. 2005. **Silage. Chapter 19: Analysis and clinical assessment of silage.** Chalcombe Publications, UK.

Wong, C.C. 1999. **The place of silage in ruminant production in the humid tropics**, pp. 5-6 *In* L.'t Mannetje (Ed.) Proc. FAO e-conf. on Trop. Silage. FAO Plant Prod. And Protect. Paper 161. 1 Sept.-15 Dec. 1999.

Wood, P. D. P. 1967. Algebraic model of the lactation curve in cattle. **Nature.** 216: 164-165.

Woolford, K. 1984. **The silage Fermentation.** Marcel Dekker, New York.

Yang, C. M., J. S. C. Haung, T. Chang, Y. H. Cheng and C. Y. Chang. 2004. Fermentation acids, aerobic fungal growth and intake of Napier grass ensiled with non-fiber carbohydrates. **J. Dairy Sci**. 87: 630-636.

Yousef, M.K. and H.D. Johnson. 1966. Calorigenesis of cattle as influenced by growth hormone and environmental temperature. **J. Anim. Sci.** 25: 1076–1082.

Zamudio, D.M., J.M. Pinos-Rodriguez, S.S. Gonzalez, P.H. Robinson, J.C. Garcia and O. Montanez. 2009. Effects of agave salmania otto ex salm-dyck silage as forage on ruminal fermentation and growth in goats. **Anim. Feed Sci and Tech.** 148: 1-11.

Zobell, D. R., E. K. Okine, K.C. Olson, R. D. Wiedmeier, L. A. Goonewardene and C. Stonecipher. 2004. The feasibility of feeding whey silage and effects on production and digestibility in growing cattle. **J. Anim. Vet. Advances.** 3(12): 804-809.

APPENDIX

Appendix Table 1 Physical quality analysis standard of Silage characteristics

Characteristic	Good quality	Intermediate quality	Poor quality	
			Poorly fermented	Overheated
color	bright, light green-yellow green brown depending upon material ensiled	yellowish green to brown green	very dark green, blue green, grey or brown	brown to dark
smell	lactic acid[1] odor with no butyric odor[2]	slight butyric acid and ammonia[3] odor	strong butyric acid, ammonia odor, rancid odor	burnt sugar or tobacco smell
texture	firm with softer material not easily rubbed from fiber	softer material can be separated from fiber	slimy, soft tissues easily rubbed from fiber, moldy	dry, easily broken down when rubbed, moldy
moisture	60-70% horizontal silos 60-65% concrete towers 40-50%oxygen limiting	tends to be above 65%	usually over 72%	usually less than 55% depend on types of structure
pH	below 4.2 for wet crops, below 4.8 for wilted silages	4.2 to 5.2	over 5.2	pH is not reliable quide
Cause	-	too much moisture, not enough plant sugars	too much moisture and insufficient plant sugars	too little moisture, poor packing, poor sealing, length of cut too long slow silo filling

[1]lactic acid odor is similar to that of sour milk

[2]butyric acid odor is similar to that of rancid butter or fat, putrid

[3]ammonia odor is similar to that in some household cleansers or anhydrous ammonia

Source: Rohweder *et al.* (1978)

Extraction of Water soluble carbohydrate (WSC) by anthrone method

Fructose, one of polysaccharide, and mono, di saccharide in silage are soluble in the water and used for fermentation. We can measure these water soluble carbohydrate by Anthrone method.

1. Drying of original silage

For measuring WSC, original silage should be dried at 100 ºC for 1 to 2 hours to terminate enzyme activity in plant and then at 60 ºC till silage will dried

2. Extraction of soluble carbohydrate by hot water

2.1 weigh 1g of sample in filter paper, fold and dry 100 ºC for 2 hours

2.2 remove crude fat by Soxhlet (crude fat can be measured at this time)

2.3 transfer residue into 500ml beaker

2.4 add 150ml distillated water and boil for 2 hours by using apparatus for crude fat and cool it by addition of 50ml of water and putting it into water

2.5 filtrate by glass filter or filter paper (whatman 41, 15cm) (residue on filter paper is not used)

2.6 fill filtrated solution up to 500ml by mess flask

2.7 It is better not to take too much time for the procedure from extraction to measurement by anthrone method, because WSC is residued and flask is stained.

Simple method 2.1, 2.2 and 2.3 as listed above and weigh the beaker by 0.1g unit. Add 150ml of distillated water and boil for 2hr using apparatus for crude fiber and cool it by addition of 50ml of water and by putting it into water. Add warer so as to total water become s 250g. Mix well by grass lod. Filtrate aliqut of solution by filter paper (whatman 41, 15cm).

3. Anthrone method

3.1 Reagent

Anthrone: Add 393 ml of conc. H_2SO_4 to 153ml of distillated water and cool it in water to room temperature. And then dissolve thiourea 500mg and anthrone 500mg. Keep it in refrigerator. This reagent is stable for 1 to 2 weeks.

Glucose standard: Dissolve 100mg of glucose into water and fill up to 11concentration of glucose is 0.1mg/ml

3.2 Procedure

3.2.1 Sample solution is diluted to make the glucose concentration less than 0.1mg/ml (if silage contain 2% WSC in fresh matter, it is about 10% on the basis of air dry matter and 1g of air dried sample contains 100 mg WSC. If we extract samples to 250 ml water, 1ml of sample contains 0.4(100/250) mg WSC. It will be diluted 5 times)

3.2.2 Put 2ml of sample solution, standard solution and distilled water (blank) into test tube and pour 10ml of anthrone reagent on it gently with cooling in water and mix it not to heat. Blank is one test tube. Glucose standard is prepared triplicate. Sample solution is prepared duplicate.

3.2.3 Keep all test tubes in water for a while after mixing

3.2.4 Put glass beads on each test tube

3.2.5 At the same time, put tubes into boiling water for 20 minutes correctly. It is important to maintain boiling condition as possible.

3.2.6 Cool it in water to room temperature soon and read absorbance at 625nm with spectrophotometer.

CURRICULUM VITAE

NAME : Ms. Thaintip Kraiprom

BIRTH DATE : November 5, 1981

BIRTH PLACE : Pattani, Thailand

EDUCATION :

YEAR	INSTITUTE	DEGREE/DIPLOMA
2004	Prince of Songkla Univ.	B.Sc.(Agriculture)
2007	Prince of Songkla Univ.	M.S. (Animal Science)

POSITION/TITLE : Lecturer

WORK PLACE : Faculty of Science and Technology, Prince of Songkla University, Pattani campus

SCHOLARSHIP/AWARDS : The Commission on Higher Education of Thailand Scholarship