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Effects of sunflower oil supplementation in cassava hay based-diets for lactating dairy cows.

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Abstract

The experiment was conducted at the Dairy Farming Promotion Organization of Thailand (DPO) in the central region of Thailand to investigate the effect of sunflower oil in cassava hay diets as a supplement for dairy cows. Twenty four multiparous Holstein Friesian crossbred dairy cows were randomly allocated in a Randomized complete block design (RCBD). There were 4 treatments and 6 replications, the treatments were: commercial concentrate as a supplement (CON), concentrate with cassava hay (CHSO-0), concentrate with cassava hay + 2.5 % sunflower oil (CHSO-2.5) and concentrate with cassava hay + 5 % sunflower oil (CHSO-5). The cows were offered a concentrate with ratio to milk yield of 1:2. Urea-treated rice straw was given *ad libitum* as a roughage source. Dry matter intake (DMI), digestion coefficients and live weight changes of cattle were not significantly different among treatments, but tended to be lower with sunflower oil supplemented group. The ruminal fluid NH_3-N concentration of the cattle on CHSO-5 was lower ($P<0.05$) than those of CHSO-0 and CON, while the ruminal pH did not differ among treatments. VFA concentrations were similar among treatments except for acetate, which was higher in the CHSO-0 ($P<0.05$) than in the CHSO-5, while the rest of the treatments did not differ from each others. BUN and MUN were not significantly different among treatments, but tended to be lower with sunflower oil supplemented group. Milk yield was higher in the CHSO-2.5 ($P<0.05$) than in the CON, while milk compositions were not significantly different among treatments. Unsaturated fatty acids in milk fat for the sunflower oil supplemented group were significantly increased ($P<0.01$), likewise conjugated linoleic acid (CLA) was significantly increased ($P<0.01$) by increasing sunflower oil levels especially at 5% level. Income over feed was higher in all of the cassava hay based-diets than in the CON and was highest in the CHSO-2.5 as compared with other treatments. Conclusions can be made that sunflower oil can be used at 2.5 % in the cassava hay based-diet with greatest profitable advantages in income over feed, milk yield and composition especially CLA content.

Keywords: Cassava hay; Conjugated linoleic acid, CLA; Dairy cows; Ruminants; Sunflower oil; Urea-treated rice straw.

1. Introduction

The basal diet for dairy cattle in Thailand is based on unimproved pasture and crop residues. Feeding of dairy cattle are often difficult because of deficiencies in feed supply in both quality and quantity (Wanapat and Devendra, 1992). To increase milk production, particularly in the dry season farmers feed a concentrate as a supplement at the raito of 1 kg concentrate to every 2 kg milk. In some areas farmers feed a lot of high priced concentrate, therefore the more concentrate used the less profit. Although high level of concentrates feed usually achieve greater levels of milk production, but this is not often economically efficient (Rowlinson, 1997). It is, hence, imperative to find and use local feed resources to improve the nutritional condition for ruminants and to reduce feed cost. Cassava hay has been used successfully as a source of high protein roughage for lactating dairy cows to improve both milk production and quality (Wanapat *et al*., 2000a; 2000b) and to reduce both cost and the use of concentrate (Wanapat et at., 2001; Nguyen et at., 2002; Kiyothong and Wanapat, 2003).

In early lactation, dairy cows are typically in negative energy balance. That is, energy intake is less than what is needed to meet the nutrient demands of milk production. An increased energy concentration in the feed ration, with no change in the ratio of concentrate to bulky feed, maybe achieved by adding fat (Espindola *et al*., 1997; Drackley *et al*., 1998). Feeding fat for dairy cows can increase milk yield (Amaral *et al*., 1997; Avila *et al*., 2000; Ruppert *et al*., 2004) as well as an increase in milk fat and long-chain fatty acid content in milk (Aldrich *et al*., 1997). However, feeding fat above a certain level reduces feed intake and reduces fiber digestion by inhibiting microbial fermentation that occurs in the rumen. Looper (2001) suggested that limit of total fat in the ration is 6-7% percent of the ration dry matter. Sunflower oil is one source of fat that can be used for supplement, which contains 12% saturated fatty acid and 88 % unsaturated fatty acid (Grant and Kubik, 1990). Palmquist (1988) reported sunflower oil consisting of 8% palmitic ($C_{16:0}$), 3% stearic($C_{18:0}$), 13.5% oleic($C_{18:1}$), 75% linoleic($C_{18:2}$) and 0.5% linolenic ($C_{18:3}$). Incorporating sunflower oil into rations maybe a successful way to get more energy into the cow with the same feed volume. Feeding fat by using sunflower oil (supplies extra fat for absorption) in concentrate with cassava hay (supplies extra bypass protein as protein tannin complex) for lactating cows could be a way to meet energy nutrient requirements and to improve rumen ecology (control protozoa and provide ammonia and minerals) as well as milk yield and quality. Therefore, the objective of this experiment was to investigate the effect of supplementation of sunflower oil in cassava hay based-diets on diet utilization, milk yield and composition in crossbred dairy cows fed on urea-treated rice straw as a basal roughage.

2. Materials and methods

2.1 Location of the experimental site

This experiment was conducted on-station in the rainy season (May – August, 2004) at the Demonstration farm, Dairy Research and Development Department, Dairy Farming Promotion Organization of Thailand (DPO), Muaglek district, Saraburi province, in the central part of Thailand. During experimental period mean temperature was 27°C and mean value of THI was 79. The monthly minimum, maximum temperature and rainfall during experimental period are shown in Figure 1 and monthly mean THI value is shown in Figure 2.

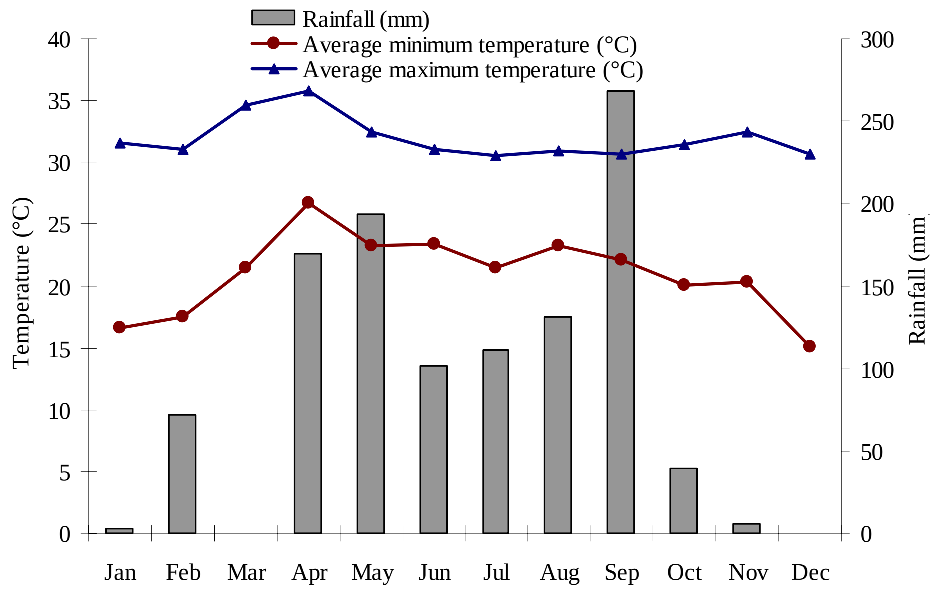

Figure 1. Monthly weather data in 2004 at experiment site which coducted the experiment during May - August, 2004.

Source : Demonstration farm section, Department of Dairy Research and Development, DPO. (2004).

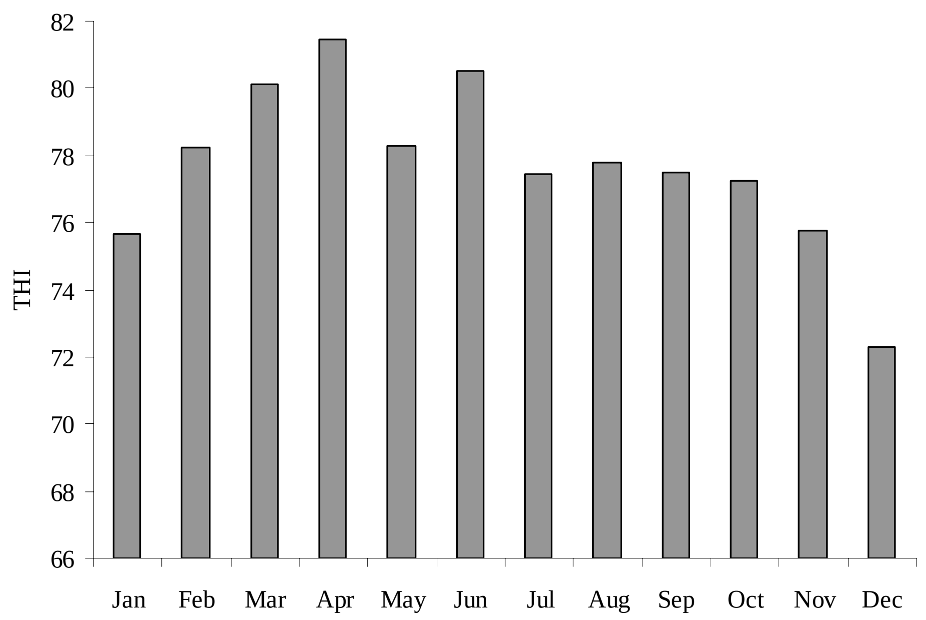

Figure 2. Mean temperature humidity index (THI) in 2004 at experiment site which conducted the experiment during May - August, 2004.

2.2 Experimental design and treatments

The experiment was a Randomized complete block design (RCBD) with 4 treatments and 6 replications. Twenty four multiparous Holstein Friesian crossbred dairy cows were blocked according to their day-in-milk (DIM) and lactation. Cows within each block were randomly assigned to treatments. The diets comprised of a basal roughage, urea-treated rice straw (UTRS) fed *ad libitum* and were supplemented with four respective experimental concentrates. The proportion of concentrate to milk was 1:2. Sunflower oil was mixed well with concentrate which was prepared for every 10 days. The ingredients and compositions of the experimental concentrates are shown in Table 1. Four experimental concentrates were as follows:

Treatment 1: Control, using commercial concentrate as a supplement (CON)
Treatment 2: Concentrate with cassava hay (CHSO-0)
Treatment 3: Concentrate with cassava hay + 2.5 % sunflower oil (CHSO-2.5)
Treatment 4: Concentrate with cassava hay + 5 % sunflower oil (CHSO-5)

2.3 Urea-treated rice straw preparation

Rice straw was placed on a polyethylene sheet in the wood box. Urea was dissolved well with fresh water then poured over rice straw. The proportion of rice straw: fresh water: urea were 100:100:5 (by weight). The stack was covered well with polyethylene sheet for 10 days before feeding. Other details of urea-treatment followed the method of Wanapat *et al*. (1983).

Table 1. Ingredients and compositions of experimental concentrates

Ingredient	CON[1/]	CHSO-0	CHSO-2.5	CHSO-5
		% Dry basis		
Sunflower oil		-	2.5	5
Cassava chip		50	50	50
Wheat bran		5.5	3	0.5
Chopped cassava hay		20	20	20
Sunflower meal		10	10	10
Brewer's grain		8	8	8
Molasses		1.5	1.5	1.5
Urea		2.5	2.5	2.5
Sulphur		0.5	0.5	0.5
Mixed minerals		2	2	2
Total		100	100	100

[1/] comprised with cassava chip, wheat bran, soybean meal, ground mungbean, sunflower meal, palm kernel cake, brewers' grain, kapok seed meal, molasses, urea, sulphur, mixed minerals and vitamin ADE (could not shown the proportion)
CON = control (using commercial concentrate as a supplement)
CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

2.4 Animals management

Twenty-four, multiparous Holstein Friesian crossbred dairy cows were selected within average 53 ± 4.7 days-in-milk and live weight 396 ± 8.8 kg with initial milk yield 14 ± 0.8 kg/day. The cows were fed urea-treated rice straw *ad libitum* and were supplemented with concentrate containing of 19% CP. The concentrate was offered in two equal portions during milking times and they were on experimental diets for adaptation for 14 days and were fed for 3 months during experimental period. Clean water was available at all times. Cows were milked by bucket type milking machine twice a day at 05.00 h in the morning and 16.00 h in the evening at the milking barn. After milking, the cows were confined together in the barn where UTRS was available at all times. In the last 14 days of each month, cows were individually confined at milking barn for feed intake measurement and samplings. Live weights of cows were weighed at initial of the experiment and after feed intake determination of each month for live weight gain measurement.

2.5 Sampling, data collection and analysis

Daily milk yields in the morning and in the evening of each individual cow were recorded. During the last 14 days of each month, daily feed intake was recorded. Milk samples were taken once a month from two consecutive a.m. and p.m. milking of each cow and were analysed for milk compositions, milk-urea nitrogen (MUN) and fatty acid contents by using Milko scan, Sigma diagnosistics procedure and Gas Chromatography, respectively. Ruminal fluid were taken at 0 and 4h-post feeding from each cow via a stomach tube; ruminal pH was determined immediately by using pH meter. Then 50 ml of fluid was fixed by adding 5 ml of 1M H_2SO_4 and stored in the freezer (-20°C) until further analysis. Ruminal fluid was analysed for NH_3-N by Kjeltec 1002 system and volatile fatty acids (VFA) by using High Pressure Liquid Chromatography (HPLC) (Samuel *et al.*, 1997). Blood samples were taken at 0 and 4h post feeding (at the same time as rumen fluid sampling), 5 ml of blood were drawn from the coccygeal vein into a tube by using needle. Blood samples were analysed for blood-urea nitrogen (BUN) using Sigma diagnosistics procedure. Faecal samples were collected monthly from the rectum and were dried in hot air oven (60°C) to be analysed for acid insoluble ash (AIA) (Van Keulen and Young, 1977), to be used as an internal indicator to calculate for digestion coefficients. The experimental concentrates and roughage were randomly sampled twice a month to be analysed for proximate analysis (AOAC, 1990). Neutral-detergent fiber (NDF), acid-detergent fiber (ADF) and acid-detergent lignin (ADL) were analyzed according to the method of Van Soest *et al.* (1991).

2.6 Statistical analysis

The various data were subjected to the analyses of variance (ANOVA) procedure according to a Randomized complete block design using the General Linear Models (GLM) of the SAS System for Windows (SAS, 1989). Treatment means were compared using Duncan's New Multiple Range Test (Steel and Torrie 1980). The statistical model was:

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

Where: Y_{ij}: observation in block i (i = 1-6) and treatment j (j = 1-4), μ = overall sample mean, α_i = effect of block i, β_j = effect of treatment j and e_{ij} = error

3. Results

3.1 Chemical composition of the experimental feeds

Chemical compositions of the experimental feeds are presented in Table 2. The CP and fat of concentrates were 19.5, 19.1, 19.6, 19.1 and 3.2, 2.7, 5.3, 7 % for CON, CHSO-0, CHSO-2.5 and CHSO-5, respectively. While, chemical compositions of urea-treated rice straw were 49.4% DM, 7.8% CP, 15.2% Ash, 1.2% fat, 74.8% NDF, 45.8% ADF, 5.2% ADL and pH 8.5 with the cost 0.025 USD/kg (on fed basis).

Table 2. Chemical compositions and price of experimental concentrates

	CON	CHSO-0	CHSO-2.5	CHSO-5
DM, %	89.2	88.9	88.9	89.5
CP, %	19.5	19.1	19.6	19.1
Fat, %	3.2	2.7	5.3	7.0
Ash, %	8.7	6.8	6.7	6.8
NDF, %	27.8	26.4	31.8	27.3
ADF, %	16.3	18.8	23.1	20.9
ADL, %	2.7	6.7	8.8	8.0
Price/kg, Baht (fed basis)	6.13	4.99	5.80	6.61

DM = dry matter, CP = crude protein, NDF = neutral-detergent fiber, ADF = acid-detergent fiber, ADL = acid-detergent lignin, 1 USD = 40 Baht
CON = control (using commercial concentrate as a supplement)
CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

3.2 Feed intake and body weight

The effect of sunflower oil in cassava hay based-diets on feed in take and body weight are presented in Table 3. Daily DM intake was not significantly different among treatments but all of cassava hay based-diet treatments (CHSO-0, CHSO-2.5 and CHSO-5) tended to have higher in UTRS intakes than in CON. While, concentrate dry matter intake tended to be lower. Increasing sunflower oil in the diets resulted in lower UTRS and concentrate dry matter intakes. Cattle could maintain live weight in all treatment groups.

3.3 Digestion coefficients and nutrient intake

Digestion coefficients, estimated nutrients and energy intake are shown in Table 4. Digestion, nutrients and energy intakes were not significantly different among treatments. However, all of the cassava hay based-diet treatments tended to be higher in nutrient digestion than in the CON. Increasing sunflower oil in the diets tended to lower the nutrient digestion.

3.4 Rumen ecology BUN and MUN

The rumen ecology, blood-urea nitrogen (BUN) and milk-urea nitrogen (MUN) are presented in Table 5. The pH was similar at 0 and 4h-post feeding and among treatments. Ammonia nitrogen concentration (NH_3-N, mg %) in the rumen fluid was significantly lowest ($P<0.05$) in CHSO-5, while in other treatments were not significantly different. The mean value of VFA concentrations in rumen fluid were similar among treatments except for acetate which was higher ($P<0.05$)

in CHSO-0 (67.6 mM) than in CHSO-5 (52.8 mM). BUN and MUN were highest in the CON, but did not differ among treatments. Increasing sunflower oil up to 5 % in the diets tended to lower the concentration of BUN, MUN, NH_3-N and VFAs (except for butyrate).

Table 3. Effect of sunflower oil in cassava hay based-diets on feed intake and live weight changes of cattle

	CON	CHSO-0	CHSO-2.5	CHSO-5	SEM
UTRS DMI, kg/day	6.74	7.08	6.96	6.82	0.20
% BW	1.68	1.83	1.79	1.66	0.05
g/kg $W^{0.75}$	82.4	86.5	85.1	83.4	2.44
Concentrate DMI, kg/day	5.90	5.26	4.99	5.19	0.33
% BW	1.45	1.37	1.28	1.24	0.07
g/kg $W^{0.75}$	72.1	64.4	61.0	63.5	4.00
Total DMI, kg/day	12.63	12.33	11.95	12.01	0.43
% BW	3.13	3.20	3.07	2.91	0.09
g/kg $W^{0.75}$	154.5	150.9	146.1	146.9	5.22
Live weight, kg					
Initial	408	386	389	401	8.76
Final	429	418	400	435	8.69
Live weight gain, kg/day	0.26	0.25	0.12	0.26	0.04

ADG = average daily gain, UTRS = urea-treated rice straw, DMI = dry matter intake, BW = body weight, SEM = standard error of mean
CON = control (using commercial concentrate as a supplement)
CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

3.5 Milk yield and milk composition

The effect of sunflower oil in cassava hay based-diets on milk yield and milk compositions are shown in Table 6. Milk yield and 4% FCM in CHSO-2.5 were highest and were significantly higher ($P<0.05$) than in the CON. In addition, milk yield and 4% FCM in all of the cassava hay based-diet treatments tended to be higher than in the CON, while milk compositions did not differ among treatments. Supplementation with sunflower oil in the diets tended to be higher in milk yield and 4% FCM than those without supplementation. However, increasing sunflower oil in the diets tended to decline in milk yield and milk fat, while other milk compositions were not affected.

3.6 Milk fatty acid and conjugated linoleic acid (CLA)

The effect of sunflower oil in cassava hay based-diets on milk fatty acid and conjugated linoleic acid (CLA) are shown in Table 7. The control treatment had highest SFA while supplementation of sunflower oil significantly reduced SFA and increased UFA especially C_{18}. CLA in milk fat for the two sunflower oil treatments were significantly higher ($P<0.01$) than in the CHSO-0 and CON. CLA was increased by increasing sunflower oil in the diets. About 80% of total CLA in all of treatments were *cis* 9, *trans* 11 CLA. The proportion of UFA: SFA in all of the cassava hay based-diets treatments were significantly higher ($P<0.01$) than in the CON. In addition, the proportion of UFA: SFA was significantly increased by increasing sunflower oil.

Table 4. Effect of sunflower oil in cassava hay based-diets on nutrient digestibility and digestible nutrient intake

	CON	CHSO-0	CHSO-2.5	CHSO-5	SEM
Digestion coefficients, %					
DM	56.4	57.9	57.6	56.3	0.74
OM	61.7	62.9	62.9	61.6	0.71
CP	55.6	56.8	54.7	51.2	0.95
NDF	61.1	59.3	60.4	56.2	1.98
ADF	24.2	33.0	31.8	28.6	2.06
Estimated digestion nutrient intake, kg/d					
DM	7.12	7.15	6.88	6.76	0.25
OM	6.78	6.87	6.65	6.52	0.24
CP	0.93	0.88	0.85	0.82	0.04
NDF	3.90	3.97	4.08	3.66	0.09
ADF	0.93	1.38	1.37	1.24	0.09
Estimated energy intake [1/]					
Mcal ME/d	25.88	26.08	25.25	24.76	0.89
ME/kg DM	2.05	2.10	2.10	2.08	0.02

[1/] 1 kg of digestible organic matter (DOM) = 3.8 Mcal ME (Kearl, 1982)
DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral-detergent fiber, ADL = acid-detergent fiber, Mcal = mega calorie, ME = metabolism energy, SEM = standard error of mean
CON = control (using commercial concentrate as a supplement)
CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

3.7 Economical returns

The effect of sunflower oil in cassava hay based-diets on economical returns is shown in Table 8. Income over feed from cows for treatment CHSO-2.5 was highest as compared with other treatments, and all of cassava hay based-diet treatments were higher in income over feed (1.95, 2.22 and 1.89 USD/hd/day for the CHSO-0, CHSO-2.5 and CHSO-5, respectively), than the control treatment (1.65 USD/hd/day). Increasing sunflower oil in the diets tended to reduce income over feed.

Table 5. Effect of sunflower oil in cassava hay based-diets on rumen ecology, blood-urea nitrogen and milk-urea nitrogen

		CON	CHSO-0	CHSO-2.5	CHSO-5	SEM
pH						
	0h post feeding	7.1	7.0	7.0	7.1	0.02
	4	6.9	6.8	7.0	7.0	0.04
	Mean	7.0	6.9	7.0	7.0	0.03
NH_3-N, mg/dl						
	0h post feeding	4.8	5.8	4.7	5.5	0.23
	4	18.6[a]	18.7[a]	16.4[ab]	12.8[b]	1.03
	Mean	11.7[a]	12.2[a]	10.5[ab]	9.0[b]	0.52
VFA, mM						
- Acetate,	0h post feeding	63.5	69.9	71.9	54.6	3.74
	4	55.4[ab]	65.3[a]	51.9[b]	51.1[b]	2.42
	Mean	59.4[ab]	67.6[a]	59.6[ab]	52.8[b]	2.42
- Propionate,	0h – post feeding	30.9	33.8	36.8	29.1	2.04
	4	30.5	32.3	27.3	26.3	1.61
	Mean	30.7	33.0	32.4	27.7	1.27
- Butyrate,	0h – post feeding	8.6[b]	11.6[ab]	13.9[ab]	16.7[a]	1.08
	4	18.2[a]	16.2[ab]	12.3[b]	15.8[ab]	0.83
	Mean	13.4	13.4	14.3	16.2	0.70
BUN, mg/dl						
	0h post feeding	16.1	15.2	14.3	13.7	0.64
	4	17.7	17.2	16.3	14.8	0.64
	Mean	16.9	16.2	15.3	14.3	0.63
MUN, mg/dl		16.0	15.2	14.9	14.6	0.31

[a,b] Means in the same row with different superscripts differ ($P<0.05$)
NH_3-N = ammonia nitrogen, VFA = volatile fatty acid, BUN = blood-urea nitrogen, MUN = milk-urea nitrogen, SEM = standard error of mean
CON = control (using commercail concentrate as a supplement)
CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

Table 6. Effect of sunflower oil in cassava hay based-diets on milk yield and milk composition

	CON	CHSO-0	CHSO-2.5	CHSO-5	SEM
Milk production, kg/day					
Milk yield	10.2[b]	10.4[ab]	11.5[a]	10.8[ab]	0.66
4% FCM	10.9[b]	11.1[ab]	12.3[a]	11.6[ab]	0.73
Milk composition, %					
Fat	4.13	3.91	3.80	3.84	0.12
Protein	3.38	3.16	3.08	3.19	0.05
SNF	9.09	8.65	8.52	8.73	0.09
Lactose	5.00	4.77	4.71	4.79	0.05
Total solids	13.22	12.57	12.33	12.57	0.18

[a,b] Means in the same row with different superscripts differ ($P<0.05$)
FCM = fat corrected milk, 4 %FCM = 0.432 × (kg of milk) + 15 × (kg of fat),
SNF = solids-not-fat, SEM = standard error of mean
CON = control (using commercial concentrate as a supplement)

CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

Table 7. Effect of sunflower oil in cassava hay based-diets on fatty acid, conjugated linoleic acid in milk fat and the proportion of unsaturated fatty acid to saturated fatty acid

Fatty acid, mg/g fat	CON	CHSO-0	CHSO-2.5	CHSO-5	SEM
$C_{14:0}$	113.8[a]	102.1[b]	94.2[bc]	92.9[c]	2.01
$C_{16:0}$	332.0[a]	334.7[a]	273.0[b]	257.2[b]	7.74
$C_{18:0}$	111.0[b]	80.8[c]	127.8[b]	175.8[a]	7.92
Other SFAs	149.8[a]	132.9[b]	121.5[b]	136.2[ab]	2.81
$C_{18:1}$ (*cis*-9)	93.7[c]	111.8[c]	156.2[b]	195.9[a]	8.52
$C_{18:1}$(*trans*-9)	12.6[b]	8.6[b]	15.8[b]	24.4[a]	1.44
$C_{18:2}$(*cis*-6)	14.2[b]	10.8[c]	13.0[b]	16.3[a]	0.48
$C_{18:2}$(*trans*-6)	0.5[b]	0.5[b]	0.4[b]	0.8[a]	0.03
$C_{18:2}$(*cis*-9, *trans*-11) CLA	2.1[c]	2.4[c]	4.3[b]	5.9[a]	0.34
Total CLA	2.6[c]	2.8[c]	5.2[b]	7.3[a]	0.42
Other UFAs	14.0[d]	24.5[a]	18.9[c]	20.78[b]	0.83
UFAs : SFAs	0.20[d]	0.25[c]	0.34[b]	0.40[a]	0.02

[a,b,c,d] Means in the same row with different superscripts differ (P<0.01)
CLA = conjugated linoleic acid, SFAs = saturated fatty acids,
UFAs = unsaturated fatty acids, SEM = standard error of mean
CON = control (using commercial concentrate as a supplement)
CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

Table 8. Effect of sunflower oil in cassava hay based-diets on economical returns

	CON	CHSO-0	CHSO-2.5	CHSO-5
4 % FCM, kg/hd/d	10.9	11.1	12.3	11.6
Milk sales, USD/hd/d	3.00	3.05	3.38	3.19
Concentrate intake, kg/hd/d[1/]	6.61	5.92	5.61	5.80
Concentrate cost, USD/hd/d	1.01	0.74	0.81	0.96
UTRS intake, kg/hd/d[1/]	13.64	14.32	14.08	13.80
UTRS cost, USD/hd/d	0.341	0.358	0.352	0.345
Income over feed:				
USD/kg of milk	0.15	0.17	0.18	0.16
USD/hd/d	1.65	1.95	2.22	1.89
USD/hd/month	49.50	58.50	66.60	56.70

[1/] on fed basis
FCM = fat corrected milk, 4 %FCM = 0.432 × (kg of milk) + 15 × (kg of fat),
UTRS = urea-treated rice straw, 1 kg milk = 0.275 USD, kg UTRS = 0.025 USD, concentrates price are shown in Table 2., 1 USD = 40 Baht
CON = control (using commercial concentrate as a supplement)
CHSO-0 = concentrate with cassava hay
CHSO-2.5 = concentrate with cassava hay + 2.5 % sunflower oil
CHSO-5 = concentrate with cassava hay + 5 % sunflower oil

4. Discussions

4.1 Feed intake

UTRS and concentrate dry matter intakes were not significantly different among treatments. This result was similar with Wanapat *et al*. (2001) who found that intakes of UTRS were similar both with and without cassava hay supplementation. However, UTRS intakes in the cassava hay based-diet treatments tended to be higher, while intakes of concentrate tended to be lower as compared with the control treatment. The result agreed with Wanapat (2001); Wanapat *et al*. (2001); Nguyen *et al*. (2002); Kiyothong and Wanapat (2003) who reported that, supplementation of cassava hay reduced concentrate use, without affecting on milk yield. Supplementation of sunflower oil slightly lower in total DMI than those recommended by NRC (2001), however total DMI was not significantly different among treatments. The result was agreed with Sackmann *et al*. (2003). Others have reported no reduction in DM intake when supplementing yellow grease (Zinn *et al*., 2000), 0.5-4% soybean oil or 1% linseed oil (Dhiman *et al*., 2000) or high-corn oil (Duckett *et al*., 2002). However, DM intake expressed in %BW tended to be lower by increasing sunflower oil supplemented. It was found that adding fat was apt to cause reduced feed intake Church (1976).

4.2 Nutrients Digestibility

According to Church (1977) who stated that in practice 2-4 % fat is commonly added to dairy for lactating dairy cows. Supplementation sunflower oil up to 5% in this study was not affected to nutrient digestion. Kalscheur *et al*. (1997b) reported no changes in apparent ruminal NDF digestibility in dairy cows supplemented with 3% sunflower oil or vegetable oil. Similarly, Sackmann *et al*. (2003) dietary sunflower oil level (2 and 4%) did not alter apparent ruminal DM, NDF and ADF digestibility. The results of DM digestion were also similar with Nowak *et al*. (2003). However, increasing sunflower oil in the diet tended to lower digestion coefficients. Therefore, adding oils at high level to the rumen caused a depression in digestibility of fibrous components (Church, 1976; Preston and Leng, 1987).

4.3 Rumen ecology, BUN and MUN

The ruminal pH was similar among treatment. The mean values of VFA concentration was also similar among treatment except acetate which was significantly lowest in CHSO-5. The result agreement with Church (1976) who points out that adding fats to diets also influences the pattern of rumen fermentation and resultant VFA production, most evidences indicates that there is apt to be a reduced percentage of acetate.

The everage values of NH_3-N, in this study were 9.0 to 12.2 mg/dl. Preston and Leng (1987) reported that the opimum level of NH_3-N concentation in ruminal fluid for microbial growth ranges from 5 to 25 mg/dl and 8.5 to over 30 mg/dl by McDonald *et al*. (1996). The everage values of NH_3-N in the present study were within the ranges of those reported above. Increasing sunflower oil supplementation tended to decline the NH_3-N concentration, which in the CHSO-5 was significantly lower ($P<0.05$) than those in the CON and CHSO-0. The result was agreed with Church, 1976 and Preston and Leng, 1987 who reported that adding high levels of fat was affected to microbs activities. Normally, lipid content of ruminant diets is low (< 50 g/kg) and if it increased above 100 g/kg the activities of rumen microbs are reduced (McDonald *et al*., 2002). The lipid content in concentrate of the present study was highest of 70g/kg in the CHSO-5. The value of the BUN and MUN in this study ranged from 14.3 to 16.9 and 14.6 to 16.0 mg/dl, respectively. BUN has been known to be related to inefficiency utilization of dietary CP in ruminants (Lewis, 1957). The ruminal NH_3-N, BUN and MUN were positive corelated with dietary CP reported by Promkot and Wanapat (2003) agrees with Broderick and Clayton (1997) who reported MUN was very strongly relationship with dietary protein and BUN was highly correlated with MUN (Baker *et al*., 1995; Butler *et al*., 1996). In lactating dairy cows, an increase of BUN and MUN was caused by excess CP (Baker *et al*., 1995). BUN concentration can estimate by measuring MUN. All the factors which influence BUN will influence the concentration of MUN. Since milk is an easy fluid to collect and MUN slightly less volatile than blood sample. Typically, the concentration of BUN will be highest about 4 to 6 hours post feeding and lowest just prior to feeding (Gustafsson and Palmquist, 1993). Schroeder (2002) reported that cows with MUN levels less than 10 to 12 mg/dl, or more than 16 to 18 mg/dl are reported to be losing nutrients, which results in higher feed costs, reduced health and productive performance and low milk production. Similarly, the standard of MUN of 11 to 17 mg/dl were recommented by Hutjens and Barmore (1995); Hwang *et al*. (2000) and agreed with Ferguson *et al*. (1988); Sato *et al*. (1996), which was stated that MUN level less than 11 mg/dl reflects an inadequate protein intake whereas more than 17 mg/dl indicates an excess protein intake. According to those references above, the MUN of all treatments in the present study were within range and were an adequate protein intake.

4.4 Milk yield and milk composition

Milk yield and 4% FCM were 10.2, 10.4, 11.5, 10.8 and 10.9, 11.1, 12.3 11.6 kg/day for CON, CHSO-0, CHSO-2.5, CHSO-5, respectively. There was significantly higher ($P<0.05$) in the group supplemented with sunflower oil in cassava hay based-diet. Adding sunflower oil tended to increase milk yield. This result agrees with those of Amaral *et al*. (1997); Avila *et al*. (2000); Ruppert *et al*. (2004), who reported that feeding fat for dairy cows can increase milk yield. Supplementing cassava hay in lactating dairy cows tended to increase milk yield, and was similar to the work of Wanapat *et al*. (2001); Kiyothong and Wanapat (2003). Milk compositions were not significantly different among treatments. Thus, supplementation of cassava hay did not affect on milk composition. The result disagreed with Wanapat *et al*. (2000a) who found that cassava hay improved milk fat, protein, lactose and solids-not-fat. The reasons could possibly be the differences in the ingredients and compositions of concentrate and cassava hay suppleentation. As in the above work, cassava hay was supplemented at 0, 2.85 and 4.02 kg DM/d with the ratio of concentrate: milk 1:2. 1:3 and 1:4, respectively. In the present study, the concentrate was comprised with cassava hay at 20 % (Table 1.) and supplemented cows at the ratio of concentrate: milk 1:2. Suplementation of sunflower oil in the diets did not differ on milk compositions and was similar with LaCount *et al*. (1995) who reported that milk yield and compositions were not affected by feeding high oil corn grain. However, increasing sunflower oil in the diets tended to decline in milk fat, and agreed with those of Jenkins (2001) who stated unsaturated oils cause milk fat depression when fed to dairy cows.

Fatty acid compositions of milk, UFAs were increased while SFAs were decreased when cows were fed with cassava hay. Furthermore, UFAs were more incremented by adding sunflower oil. Jenkins (2001) reported that a typical fatty acid composition of milk fat was 70-80 % saturated and 20-30% unsaturated. Of the UFA the majority (>70%) was oleic acid. The CLA is formed in the rumen as an intermediate product in the biohydrogenation to utilize of dietary fatty acid by autotrophic bacteria (Hazlewood and Dawson, 1979). Plant oils high in $C_{18:2}$ and $C_{18:3}$ appeared to be particularly effective increasing amount of C_{18} especially milk CLA (Dhiman *et al*., 2000; Chouinard *et al*., 2001). CLA found in milk fat originated from two sources, *trans*-11 $C_{18:1}$, which was absorbed and used for endogenous synthesis of CLA and from CLA that is absorbed and used directly (Griinari *et al*., 2000). CLA have been found in whole milk generally was about 4.5 to 5.5 mg/g fat (approximately 0.45 to 0.55 %) (Song and Kennelly, 2002). CLA isomers (*cis*-9, *trans*-11 CLA) which measured in this study, it has been reported to have impact on health benefits in humans consuming the milk such as anticarcinogenic and antiobesity properties (Song and Kennelly, 2002; Chouinard *et al*., 2001). The concentrations of total CLA and *cis*-9, *trans*-11, CLA in this study were higher ($P<0.01$) when cows were fed with sunflower oil (5.2, 4.3 and 7.3, 5.9 mg/g fat for CHSO-2.5 and CHSO-5, respectively) as compared with CON (2.6, 2.1 mg/g fat). In addition, Martin and Jenkins (2002) observed ruminal pH influence of biohydrogenation by low pH decrease the biohydrogenation of *cis*-$C_{18:2}$ and *cis*-$C_{18:3}$ with a decrease of *trans*-$C_{18:1}$ and CLA. Troegeler *et al*. (2003) also summarized and suggested to optimize the CLA content in the milk could be obtained with diets leading to a ruminal pH that is nearly neutral, and with feeds containing high amount of *cis*-$C_{18:2}$. According to the report above, the average ruminal pH in the present study, in animals fed on urea-treated rice straw as a basal roughage were 6.9 to 7.0. It could be the suitable level of ruminal pH to enhance the CLA content in the milk.

4.5 Economical returns

Approximately 60 % of the cost of milk production was attributed by concentrate feed (Office of Agricultural Economics, 1997 and Wongnen *et al*., 1998). Therefore, the reduction of feed cost is importance for higher profitable in dairy farming. Based on the current price of concentrate, all of cassava hay based-diet treatments as compared with the control could reduce feed cost of 19, 14 and 3%, while in income over feed was higher of 18, 33 and 15% for the CHSO-0, CHSO-2.5 and CHSO-5, respectively. The result similar with the work of Wanapat (2000a; 2000b) who reported that cassava hay supplementation was allowed to reduction in concentrate use which would provide higher income. The result was also agrees with Hong *et al*. (2003); Kiyothong and Wanapat (2003). However, increasing sunflower oil in cassava hay based-diets tended to reduce income over feed due to the price of sunflower oil was relatively high at present time.

5. Conclusions and recommendations

Based on the results of this experiment, it could be concluded that:

- DMI tended to decrease with increasing sunflower oil levels in the diets.
- Digestion coefficient was higher with cassava hay based-diets and tended to decrease with increasing sunflower oil levels.
- Daily milk yield tended to be higher with cassava hay in the diets, but increasing sunflower oil from 2.5 to 5 % in the diet, resulted in lower milk yield.

- Milk compositions (fat, protein, lactose, SNF and solids-not-fat) tended to lower with sunflower oil supplementation.
- CLA in milk fat were significantly increased with increasing sunflower oil levels in the diets.
- UFAs were higher with cassava hay based-diet, and were remarkably increased with increasing sunflower oil in the diet.
- Income over feed was higher with cassava hay based-diets, which was highest in 2.5 % sunflower oil in cassava hay diet, but increasing sunflower oil up to 5 % tended to decrease in income over feed.
- The use of cassava hay in the diets especially for dairy cows should be highly recommended as a protein source, as it could reduce dairy production cost and the use of local feed efficiently.
- Sunflower oil can be used at 2.5 % in the diet with greatest profitable advantages in milk yield and composition especially CLA content.

Further research relating to sunflower oil supplementation in cassava hay based-diets should be conducted as an on farm trial as well as scaling up for producing high-quality milk.

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