Effects of supplementation vegetable oil on milk production in lactating cows

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Abstract

Vegetable oil have long been studied and added to concentrates rations in order to improve the energetic value of the diet and enhance dairy cows to express their productive potential. This study was conducted to examine if vegetable oil supplemented would affect milk production. Sixteen cows were obtained for an experiment and received 20 kg corn silage and 7.5 kg concentrate, on dry matter basis containing 6.2% palm oil, for 4 weeks. Subsequently, the animals were assigned into three experimental groups, which were given different oil rich diets; palm oil served as control (PO; n=4), soybean oil (SB; n=6), and sunflower oil (SF; n=6). During 4 weeks of receiving the experimental diets, milking data was recorded daily and milk samples were collected on days 0, 7, 14, 21 and 28. Supplementation with all vegetable oils did not alter milk production but decreased 3.5% fat corrected milk at week 1 in SF compared to PO (P = 0.042). The percentages of milk fat were significantly lower in cow fed diet rich in SB and SF at week 1 (P = 0.029 and P = 0.001, respectively) and week 2(P = 0.025 and P = 0.015, respectively) compared to cow fed PO with far more significant lower in cow fed SF compared to SB (P = 0.048). Moreover, lower milk fat yield was also observed in cows fed SF rich diet at week 1 (P = 0.003). Furthermore, dietary SB caused lower in milk protein yield at week 3 (P = 0.028), and supplemented SF caused higher in the percentages of SNF in milk at week 4 (P = 0.038). However, all treatments did not affect the content and yield of lactose in milk. It is concluded that the supplementation of diet with vegetable oils could alter milk performance and production, however, these effects tended to occur during a rather short period of time.

Keywords: vegetable oil, milk production, milk composition, cow

ผลของการเสริมน้ำมันพืชในอาหารต่อผลผลิตน้ำนมในโค

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บทคัดย่อ

การทดลองครั้งนี้มีจุดประสงค์เพื่อศึกษาผลของการเสริมน้ำมันพืชในอาหารต่อผลผลิตน้ำนม ทั้งปริมาณน้ำนม และองค์ประกอบในน้ำนม โดยทำการศึกษาในโคที่กำลังให้นม 16 ตัว ซึ่งใน 4 สัปดาห์แรก โคแต่ละตัวจะได้รับข้าวโพดหมัก วันละ 20 กิโลกรัม และอาหารข้นซึ่งมีน้ำมันปาล์มเป็นส่วนประกอบร้อยละ 6.2 ในวัตถุแห้ง อีก 7.5 กิโลกรัม เพื่อเป็นการปรับการให้อาหารก่อนการทดลอง จากนั้นจึงแบ่งโคออกเป็น 3 กลุ่ม ได้แก่ กลุ่มควบคุม (PO) 4 ตัว โดยให้อาหารข้นสูตรเดิมที่มีน้ำมันปาล์มเป็นส่วนประกอบ กลุ่มเสริมน้ำมันถั่วเหลือง (SB) 6 ตัว และกลุ่มเสริมน้ำมันเมล็ดทานตะวัน (SF) 6 ตัว โดยโคทั้ง 3 กลุ่มจะได้รับอาหารที่มีสมดุลพลังงานและมีสัดส่วนของไขมันและองค์ประกอบต่างๆ ในอาหารข้นที่ไม่แตกต่างกัน จากการบันทึกข้อมูลปริมาณน้ำนมตลอดการทดลองเป็นระยะเวลา 4 สัปดาห์ และทำการเก็บตัวอย่างน้ำนมวันที่ 0, 7, 14, 21 และ 28 ของการทดลอง เพื่อนำมาวิเคราะห์องค์ประกอบในน้ำนม พบว่าปริมาณน้ำนมในแต่ละกลุ่มการทดลองไม่มีความแตกต่างกัน อย่างไรก็ตาม พบว่าน้ำนมที่ระดับไขมันที่ 3.5 เปอร์เซ็นต์นั้น จะลดลงในกลุ่ม SF อย่างมีนัยสำคัญในช่วงสัปดาห์แรก (P = 0.042) ส่วนเปอร์เซ็นต์ไขมันในน้ำนมจะลดลงอย่างมีนัยสำคัญในกลุ่ม SB และ SF ในสัปดาห์ที่หนึ่ง (P = 0.029 และ P = 0.001ตามลำดับ) and สัปดาห์ที่สอง (P = 0.025 และ P = 0.015 ตามลำดับ) ยิ่งไปกว่านั้นน้ำนมของกลุ่ม SF ยังมีเปอร์เซ็นต์ไขมันในน้ำนมต่ำว่ากลุ่ม SB (P = 0.048) และมีปริมาณไขมันนมที่ลดลงอย่างมีนัยสำคัญในสัปดาห์ที่หนึ่ง (P = 0.003) นอกจากนี้ยังพบว่าปริมาณโปรตีนในน้ำนมจะลดลงในสัปดาห์ที่สามสำหรับกลุ่ม SB (P = 0.028) ส่วนเปอร์เซ็นต์ธาตุน้ำนมไม่รวมไขมันนั้นพบว่าสูงขึ้นในสัปดาห์ที่สี่สำหรับกลุ่ม SF (P = 0.038) จากการทดลองนี้อาจสรุปได้ว่าการเสริมน้ำมันพืชในอาหารโครีดนมอาจส่งผลกระทบต่อปริมาณผลผลิตและคุณสมบัติต่างๆ ของน้ำนมได้ อย่างไรก็ตามผลกระทบดังกล่าวนั้นมีเพียงเล็กน้อยในช่วงระยะเวลาอันสั้นเท่านั้น

คำสำคัญ : น้ำมันพืช ปริมาณน้ำนม องค์ประกอบน้ำนม โคนม

Introduction

At present, many consumers are concerned about their health and are more selective for health enhancing products. Previous studies have revealed that milk fats play an important role in human health. The increasing consumption of milk and butter has significantly increase the risk of developing cardiovascular diseases. Saturated fatty acids (e.g. myristic acid; C14:0 and palmitic acid; C16:0) elevate the concentration of cholesterol in the blood circulation (Ashes et al., 1997; Maijala, 2000) leading to vascular diseases as well as contributing to obesity in humans.

Richer polyunsaturated fatty acids (PUFA) in milk fat could meet consumer demands for healthier dairy products. PUFAs have been studied and added to concentrates ration in order to improve the energy value of the diet, especially during negative energy balance (NEB) period of highly productive or postpartum cows, and enhance dairy cows to express their productive potential such as the positive effects on reproductive

(Robinson, et al., 2002; Petit, et al., 2004; Zheng, et al., 2005; Ambrose, et al., 2006) and immune regulation Lessard et al., 2004); (Thanasak et al., 2004; Thanasak et al., 2005. Moreover, there was a report indicated that n-3 fatty acids play dramatically importance role in health as they are not only essential nutrients but also may favorably modulate many diseases (Connor, 2000). The production of health-enhancing dairy products could be achieved in different ways. One particular method is to feed unsaturated fatty acid supplemented rations (e.g. grain, grain extracts and vegetable oils) to lactating dairy cows to gain unsaturated fatty acids in milk fat (Calder, 1997; Harbige, 1998; James et al., 2000; Lock and Bauman, 2004). In addition, supplementation with vegetable oils (e.g., soybean oil, corn oil and sunflower oil) to a concentrate diet has been shown that long chain fatty acid concentration (e.g., steric acid; C18:0 and oleic acid; 18:1) increases while short chain fatty acid (e.g., myristic acid; C14:0 and palmitic acid; C16:0) decreases in milk (AbuGhazaleh et al., 2002; Bett et al., 2004; Rego et al., 2005). Soybean and sunflower oils would be good choices as both are rich in polyunsaturated fatty acids, with soybean oil being a source of linolenic acid (n-3), while sunflower oil is rich in linoleic acid (n-6).

Concerning to the productivity, however, the obtained reports of vegetable oil supplementation indicate that the changes of milk production and milk composition are inconsistence and remain discussed. Vegetable oil supplementation increases the total energy in diet, which may result in lower feed intake (Ashes et al., 1997). If more than 7% is supplemented, the milk yield and milk composition may decrease (Mansbridge and Blake, 1997). Supplementation with sunflower and soybean oils decreases milk fat yield and its content (Bet et al., 2004). High vegetable oil diets, which is rich in long chain fatty acids, have showed evidence of milk production increased but the percentage of milk fat decreased (Leonardi et al., 2005). Another report revealed that supplemental fat increased milk production, 4% FCM, milk fat content, yields of milk fat and protein, however, milk percentages of protein, lactose, casein, cholesterol and urea nitrogen were not affected (Salado et al., 2004). In contrast, there were reports showed identical results that feeding vegetable oil had no effect on milk production (Zheng et all., 2005; Ponter et al., 2006). Thus, the objective of this study is to evaluate the effects of supplementation vegetable oil on milk production and milk composition in order to improve milk quality.

Materials and Methods

Animals and Experimental design

Eighteen multiparous 75% Holstein Friesian cows, 2-4 year of age, average body weight 350-400 kg, mid to late lactation (70-210 days postpartum) were obtained. The animals were used in completely randomized design (CRD) to evaluate responses to supplementary vegetable oils. The study was performed with the approval of the Faculty of Veterinary Science-Animals Care and Use Committee (FVS-ACUC) of the Faculty of Veterinary Science, Mahidol University, Thailand.

Diets and Treatments

During the pre-experimental period (4 weeks), all cow (n=18) were fed a basal diet rich in palm oil, to allow cows to adapt to oil-supplemented diets and adjusted nutritional status. This diet consisted of 20 kg of corn silage and 7.5 kg of a concentrate containing palm oil (PO), which was fed daily (Table 1). Subsequently, during the experimental period (4 weeks), cows were assigned to three groups receiving diets rich in palm oil (PO; n=6) or soybean oil (SB; n=6) or sunflower oil (SF; n=6). The ingredients of the concentrate are presented in Table 1. The amounts of component supplied and the analyzed composition of the whole diets is shown in Table 2. The rations were fed four times a day at 8.00, 10.00, 16.00 and 20.00 h. Feed were restricted and refusals were checked.

Milk recording and sampling

Cow were milked and milk yield were recorded twice daily at 06.00 and 15.00 h. Milk sampling took place at the last day of the pre-experimental period (day 0) and subsequently at day 7, 14, 21 and 28 of the experimental period. Milk from individual cow was sampled approximately 60 ml per day, 30 ml of each time, and store at 4^{o}C before an analysis of milk composition.

Analysis of milk compositions

Milk samples were homogenized at 40°C then the compositions - fat, protein, lactose and solid not fat (SNF) - were measured using automated infrared analysis; MilkoScanTM Minor4 (IDF and AOAC approved IR-technology).

Statistical analyses

Data for milk production and milk compositions are reported as least squares means. Data were analyzed as a completely randomized using ANCOVA procedure of SAS; 1997. Overall differences between treatment means were considered significant when $P \leq 0.05$. All P values are presented in tables.

Table 1 Composition of the experiment concentrates.

Ingredients (kg dry matter)	Pre-experimental concentrate	Experimental concentrate		
	PO	PO	SB	SF
Constant component [a]	938	938	938	938
Palm oil	62	62	-	-
Soybean oil	-	-	62	-
Sunflower oil	-	-	-	62
Total	1,000	1,000	1,000	1,000

[a]The constant components consisted of the following *(kg dry matter)* : Cassava, 231; soybean meal,179; Palm meal, 192; Copra meal,192; Wheat bran,51; Grinded bone,15; Cotton seed,38; Sodium chloride,17; Premix,9; Urea, 17.

Table 2 Ingredient composition and analyzed macronutrient composition of experimental diets.

	Daily intake per cow[c] *(kg dry matter)*	Macronutrients *(%dy matter)*		
		Crude fat	Crude fiber	Crude protein
Corn silage[a]	4.02	1.45	28.52	6.07
Concentrate[b]				
PO	7.48	10.74	8.08	23.06
SB	7.48	10.24	8.20	21.27
SF	7.48	10.44	8.08	19.36

[a]The corn silage contained 201g dry matter/kg

[b]All vegetable oil supplement concentrate (PO, SB and SF) contained 997 g dry matter/kg

[c]R:C ratio = 35:65

Results

Animals

During the pre-experimental period, two cows suffered from mastitis. Therefore, they were rejected from the study. Subsequently, the number of animal were adjusted for PO treatment (n=4). During the experimental period, cows were housed in a free range barn. They showed no feed refusal as all diets were taken completely. No clinical sign of the remaining experimental animals was observed throughout the period of the study.

Milk production

Milk production recorded at weeks 1, 2, 3 and 4 was not different significantly among groups of cows receiving different oil rich diets. Subsequently, calculated for 3.5% fat corrected milk (FCM) (Dunlap et al., 1990) value showed that milk production was lower significantly in cow received SF rich diet ($P = 0.042$) compared to PO fed cows at the first week. However, there was no difference of 3.5% FCM production among PO, SB and SF fed cows in the following weeks (Table 3).

Milk composition

The percentages of milk fat were significantly lower in cows fed diets rich in SB and SF at week 1 ($P = 0.029$ and $P = 0.001$ respectively) compared to cow fed PO with far more significant lower in cows fed SF compared to cows fed SB ($P = 0.048$). At week 2, the percentages of milk fat were significantly lower in cows fed diet rich in SB and SF ($P = 0.025$ and $P = 0.015$ respectively) compared to cows fed PO rich diet. No differences in milk fat percentages were found among the different vegetable oils supplemented in the next two weeks (Table 4).

The amount of milk fat (kg per day) was significantly lower in cows fed SF rich diet ($P = 0.003$) compared to cows fed PO rich diet without any differences in SB supplemented cows at the first week. No difference in milk fat yield was found among the difference vegetable oils supplemented in the following weeks (Table 5).

The percentages of milk protein and lactose were within the normal range and did not differ significantly among groups of vegetable oil supplements in all weeks (Table 4). The amount of protein in milk (kg per day) was significant lower in cows fed SB rich diet ($P = 0.028$) compared to cows fed PO diet without any change in SF supplemented cows at the third week. No difference in milk protein yield was shown among diets in other weeks (Table 5).

There was no significant difference among the three sources of vegetable oils on the percentages of SNF from week 1 to week 3. The percentages of SNF in milk were significantly higher in cows supplemented with SF at week 4 ($P = 0.038$) (Table 4). The amounts of SNF and lactose (kg per day) were not different among the different diets in all weeks of the experiment (Table 5).

Table 3 Milk production (least square mean of kg per day) of cows fed diets supplemented with palm oil (PO; n = 4), soybean oil (SB; n = 6) and sunflower oil (SF; n = 6)

Measurement	Week	Supplement			Pooled S.D.	*P*
		PO	SB	SF		
Milk production	1	14.38	15.66	15.84	2.02	0.55
	2	14.82	14.45	14.90	2.70	0.96
	3	14.86	12.64	14.35	2.70	0.41
	4	14.68	13.95	15.29	2.16	0.58
Milk production	1	16.53^{a}	14.99^{ab}	13.06^{b}	2.36	0.11
(3.5% fat corrected	2	16.20	13.10	12.71	4.17	0.43
milk)	3	15.06	12.30	12.25	3.33	0.39
	4	15.94	14.28	14.62	3.40	0.75

^{a,b,c}Means within row with different superscript differ ($P \leq 0.05$)

Table 4 Milk composition (least square mean of percentage) of cows fed diets supplemented with palm oil (PO; n = 4), soybean oil (SB; n = 6) or sunflower oil (SF; n = 6)

Measurement	Week	Supplement			Pooled S.D.	*P*
		PO	SB	SF		
Fat	1	4.00[a]	3.26[b]	2.67[c]	0.46	0.00
	2	3.54[a]	2.85[b]	2.80[bc]	0.40	0.03
	3	3.23	3.27	2.76	0.66	0.39
	4	3.67	3.53	3.32	0.57	0.63
Protein	1	2.80	2.68	2.88	0.16	0.16
	2	2.66	2.92	2.89	0.36	0.52
	3	3.03	2.79	2.86	0.25	0.36
	4	2.66	2.83	2.96	0.21	0.14
Lactose	1	4.22	4.26	4.30	0.06	0.18
	2	4.28	3.69	4.33	0.63	0.23
	3	4.28	4.19	4.27	0.08	0.23
	4	4.17	4.29	4.28	0.09	0.15
SNF	1	8.06	8.04	8.24	0.16	0.13
	2	7.92	7.87	8.24	0.31	0.14
	3	8.29	8.10	8.19	0.23	0.45
	4	7.93[b]	8.19[ab]	8.30[a]	0.24	0.10

[a,b,c] Means within row with different superscript differ ($P \leq 0.05$)

Table 5 Milk composition (least square mean of kg per day) of cows fed diets supplemented with palm oil (PO; n = 4), soybean oil (SB; n = 6), or sunflower oil (SF; n = 6)

Measurement	Week	Supplement			Pooled S.D.	*P*
		PO	SB	SF		
Fat	1	0.62[a]	0.50[ab]	0.40[b]	0.09	0.01
	2	0.59	0.41	0.40	0.17	0.25
	3	0.53	0.42	0.38	0.15	0.34
	4	0.59	0.50	0.50	0.16	0.68
Protein	1	0.40	0.41	0.45	0.06	0.46
	2	0.39	0.41	0.42	0.07	0.86
	3	0.45[a]	0.35[b]	0.40[ab]	0.06	0.07
	4	0.39	0.39	0.44	0.06	0.30
Lactose	1	0.60	0.67	0.68	0.09	0.43
	2	0.63	0.55	0.64	0.17	0.64
	3	0.64	0.53	0.61	0.11	0.35
	4	0.62	0.60	0.65	0.10	0.64
SNF	1	1.15	1.25	1.30	0.16	0.45
	2	1.18	1.13	1.21	0.23	0.82
	3	1.24	1.01	1.16	0.21	0.28
	4	1.22	1.13	1.24	0.17	0.50

[a,b,c]Means within row with different superscript differ ($P \leq 0.05$)

Discussions

There was no significant difference in milk production throughout the experiment but 3.5% fat corrected milk (FCM) of SF decreased in week 1 compared to PO. Supplementation of SB and SF lowered the percentages of milk fat compared to PO in week 1 and week 2, with SF decrease milk fat yield compared to PO in week 1. In addition, the percentage of milk fat production of SB was higher than SF in the first week of the experiment. At week 3, the inclusion of SB in diets decreased milk protein yield compared to PO. Dietary supplemented with SF increased the percentage of SNF in milk compared to PO in week 4. No significant difference was observed as a change in lactose in milk during the experiment.

All treatments had no effect on milk production throughout the experiment. This phenomenon was similar to data previously reported in cows fed cottonseed oil (CS), linseed oil (LO) and soybean oil (SB) at a duration of 3 week experiment (Zheng, et al., 2005). The lack of change in milk production is consistent with previous research in feeding prepubertal heifers with 20% SB supplemented observed from week 4 to 18 of lactation (Thibault et al., 2003). There was an interesting result when infused 500g of LO into the duodenum shown neither significantly changes in milk production nor 4% FCM when samples were collected from day 15 to 35 of the study (Petit et al., 2002). Considering milk production of 3.5% FCM, they were significantly lower in animals fed SF compared to PO in the first week ($P = 0.042$) but not in the following weeks of the experiment. It is in agreement with literature study showing that there was no effect when corn oil (CO) was supplemented in cow, and milk samplings were taken from week 2 to 4 during a period of 4 weeks (Whitlock et al., 2003). In contrast, milk productions as well as 4% FCM were higher for cows fed supplemented fat using extruded soybeans and sunflower seeds (Schingoethe et al., 1996).

Supplementary SB and SF significantly lowered the percentages of milk fat at week 1 and 2 compared to PO ($P < 0.05$) by mean of percentage of milk fat in week 1 is significantly lower in SF compared to SB supplemented ($P = 0.048$). In addition, SF supplemented significantly lower milk fat yield compared to PO ($P = 0.003$) in week 1 of the experiment. These results were similar to a report of three weeks trial, which sample collection began in week 2, and feeding multiportions of fish meal and soybean meal caused lower in the percentages of milk fat (AbuGhazaleh, et al., 2001). In the same report, milk fat yields were decreased as the proportion of fish meal in diet increased. There was a study showed the similar effect when fed supplementation with SF and SB as percentages of milk fat and milk fat yield decreased in a period of 7 days (Rego, et al., 2005). Another study, by three weeks supplemented with cotton seed oil (CS), soybean oil (SB) and corn oil (CO), the result showed that the decreasing of milk fat percentages were influenced by SB and CO supplemented while milk fat yield were not altered (Zheng et al., 2005). In contrast, there was another report that sunflower oil (SF), linseed oil (LO) and fish oil (FO) had no effect on the percentages of milk fat and milk fat yield, however, the data were collected in week 4 of the experiment (Loor et al., 2005). Moreover, feeding formaldehyde treated flaxseed and sunflower seed were not differ the percentages of fat in milk but treating seed with formaldehyde increased production of milk fat (Petit, 2003). Another evidence occurred when supplemented 1 kg of sunflower oilseeds to cows in three lactation phases (0 to 60: 61 to 90: and 91 to 120 days in milk) caused no effect of such treatment to the percentages of fat in milk (Bett et al., 2004). Decreasing in milk fat contents and milk fat yield in this experiment might be explained by exogenous fatty acids, which compete for esterification with newly synthesized short-chain fatty acids in mammary cells leading to feedback inhibition of lipogenic enzymes (Palmquist et al., 1993). There are reports suggested that alterations in rumen fermentation result in an inadequate rumen production of acetate and butyrate to support milk fat synthesis or increased rumen production of propionate and enhanced hepatic rates of gluconeogenesis cause an increase in circulating insulin, thereby resulting in an insulin-induced shortage of precursors for mammary synthesis of milk fat (Zheng et al., 2005). Another interesting theory had been discussed in previous study is that mammary synthesis of milk fat is inhibited by unique fatty acids (*trans* fatty acid theory) that are produced as a result of the alterations in rumen biohydrogenation (Bauman and Griinari., 2003).

Inconclusive to others reports, SF may influence in a more pronounced decrease in new fatty acid synthesis resulting in lower milk fat concentration (Loor et al., 2005).

The percentage of milk protein remained unchanged for all treatments. However, they were relatively higher at week 4 (P = 0.531) in cows received SF compared to PO. Interestingly, milk protein yield of SB is significantly lower compared to PO in week 3 (*P* = 0.028). The unchanged of protein in milk observed in this study was similar to results obtained when fed 20% supplemented SB in diet to heifers and collected data from week 4 to 18 of lactation (Thibault et al., 2003). In other studies reported similar effects of fat supplemented in diet regarding on percentage of milk protein and protein yield. Diet inclusion of 5% SB, 5% LO or 2.5% FO in periods of 4 weeks and sample took place during the last 5 days of the final week had no effect on the percentages of milk protein and milk protien yield (Loor et al., 2005). Literature reviewed showed no effects on milk protein yield and content when cows were supplemented with 0.5 kg of SB and 0.5 kg of SF in periods of 28 days and data was obtained in the last 7 days of the experiment (Rego et al., 2005). An inclusion of 6% unsaturated fat either from extruded soybean or sunflower seed had no effect on the percentages of milk protein and protein yield when observed from week 3 to 5 of an experiment (Schingoethe et al., 1996). In contrast, there is evidence that feeding formaldehyde flaxseed and sunflower seed for 4 weeks could increase the production of milk protein (Petit, et al., 2003). In other experiment, the report suggested that diet supplemented with 0.7 kg hydrogenated vegetable oils dry matter per cow per day could increase milk protein production, without any effect on milk protein percentage (Salado et al., 2004). Interestingly, however, diet supplemented with 1 kg of sunflower oilseeds to cows in 3 lactating phases had been presented a reduction in the concentration of milk protein (Bett, et al., 2004). Concerning the results, the temporary reduction of protein yield in milk observed in this study may be directly related to an inhibition of ruminal microbial protein synthesis, resulting in a reduced flow of amino acids to the small intestine and mammary gland and a consequent fall in milk protein concentration.

In current study, the percentage of lactose in milk did not differ among treatments although they were relatively higher in cows fed SF compared to PO at week 1 (*P* = 0.072) and in cows fed SB compared to PO at week 4 (*P* = 0.075). These results looked similar to previous reports that supplementation of 1 kg sunflower oilseed to cows in 3 lactating phases did not affect the content of lactose in milk (Bett, et al., 2004). Another result showed no difference in the percentages of lactose among groups of the study conducted with 20% of SB added in a conventional concentrate and the samples were collected from week 4 to 18 of lactation (Thibault et al., 2003). In addition, cows fed diet supplemented with formaldehyde-treated whole flaxseed, formaldehyde-treated whole sunflower seed, whole flaxseed, and sunflower seed showed neither influence to the concentration of lactose in milk (Petit., 2003). In contrast, feeding concentrate to late gestation cows resulted in higher percentages of lactose has been reported (Keady et al., 2001)

The results of this study showed that the effects of SF supplementation significantly increased the percentage of SNF at week 4 (*P* < 0.05) of the experiment without any influence on SNF yield. Interestingly, a previous study reported that the SNF yield was higher when supplemented 6% of fat from extrude soybeans or sunflower seeds in 5 weeks duration of the study, however, the percentage of SNF in milk was not altered (Schingoethe et al., 1996). Although there was only significant finding in week 4, however, the percentage of SNF showed a relative higher in week 1 and week 2 when those animals received a diet rich in SF (*P* = 0.061 and *P* = 0.063, respectively). It might be indicated that supplementation of SF had positive influenced on milk SNF in this experiment. However, the data obtained in current study is considerably limited and these findings remain to be discussed.

Conclusions

The supplementation of dairy lactating cows with rations including vegetable oils, both soybean oil and sunflower oil, has the capacity to lower milk fat contents, milk fat yield and 3.5% FCM. However, this effect is found in the first few weeks after receiving supplemental diets. Despite the fact that the changes of milk protein and solid not fat in milk were observed in this experiment, these findings were rather small and might be due to the general side effects of high fat diet. These findings suggested that supplementation of vegetable oils to promote high energy diet to dairy cows or to obtain high proportion of polyunsaturated fatty acids in milk does not interfere with either performance or production of milk in lactating cows. Further study needs to be conducted to clarify the relationship between fatty acids metabolism and milk production in dairy cows.

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Rrferences

Ashes, J.R., Gulati, S.K., and Scott, T.W. 1997. Potential to alter the content and composition of milk fat through nutrition. J. Dairly Sci. 80:2204-2212.

AbuGhazaleh, A.A., Schingoethe, D.J., and Hippen, A.R. 2001. Blood amino acids and milk composition from cows fed soybean meal, fish meal, or both. J. Dairly Sci. 84:1174-1181.

AbuGhazaleh, A.A., Schingoethe, D.J., Hippen, A.R., Kalscheur, K.F., and Whitlock, L.A. 2002. Fatty acid profile of milk and rumen digesta from cows fed fish oil, extrude soybeans or their blend. J. Dairy Sci. 85: 2266-2276.

Ambrose, D.J., Kastelic, J.P., Corbett, R., Pitney, P.A., Petit, H.V., Small, J.A., and Zalkovic, P. 2006. Lower pregnancy losses in lactating dairy cows fed a diet enriched in alpha-linolenic acid. J. Dairy Sci. 89:3066-3074.

Bauman, D.E., and Griinari, J.M. 2003. Nutritional Regulation of Milk Fat Synthesis. Annu. Rev. Nutr. 23:203-27

Bett, V., Mauro, D.S., Makoto, M., Selwyn, A.H., and Nilson, E. 2004. Effect of sunfloweroilseed supplementation on fatty acid profile and milk composition from holstein cows. J. Anim Sci. 26:95-101.

Calder, P.C. 1997. n-3 Polyunsaturated fatty acids and cytokine production in health and disease. Ann Nutr Metab. 41:203-234.

Connor W.E. 2000. Importance of n-3 fatty acids in health and disease. Am J. Clinical Nutrition. 71: 171-175.

Harbige, L.S. 1998. Dietary n-3 and n-6 fatty acid in immunity and autoimmune disease. Proc Nutr Soc. 57: 555-562.

James, M.J., Gibson, R.A., and Cleland, L.G. 2000. Dietary polyunsaturated fatty acids and inflammatory mediator production. Am J Clin Nutr. 71:343S-348S.

Keady, T.W.J., Mayne, C.S., Fitzpatrick, D.A., and McCoy, M.A. 2001. Effect of Concentrate Feed Level in Late Gestation on Subsequent Milk Yield, Milk Composition, and Fertility of Dairy Cows. J. Dairy Sci. 84:1468-1479.

Leonardi, C., Bertics, S., and Armentano, L. E. 2005. Effect of increasing oil from distillers grains or corn oil on lactation performance. J. Dairy Sci. 88: 2820-2827.

Lessard M., Gagnon N., Godson D. L., and Petit H. V. 2004. Influence of parturition and diets enriched in n-3 or n-6 polyunsaturated fatty acids on immune response of dairy cows during the transition period. J. Dairy Sci. 87:2197-2210.

Lock, AL and Bauman, DE. 2004. Modifying milk fat composition of dairy cows to enhance fatty acids beneficial to human health. Lipids. 39:1197-1206.

Loor, J.J., Ferlay, A., Ollier, A., Ueda, K., Doreau, M., and Chilliard, Y. 2005. High-concentrate diets and polyunsaturated oils alter trans and conjugated isomers in bovine rumen, blood, and milk. J. Dairy Sci. 88: 3986-3999.

Maijala, K. 2000. Cow milk and human development and well-being. Livestock production science. 65:1-18.

Mansbridge, R.J. and Blake, J.S. 1997. Nutritional factors affecting the fatty acid composition of bovine milk. Br J Nutr. 78: S37-S47.

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

Petit, H.V., 2003. Digestion, milk production, milk composition, and blood composition of dairy cows fed formaldehyde treated flaxseed or sunflower seed. J. Dairy Sci. 86: 2647-2646.

Petit, H. V., Dewhurst, R.J., Sclazeollan, N.D., Proulx, J.G., Khalid M., Haresign W., Twagiramungu H., and Mann, G.E. 2002. Milk production and composition, ovarian function, and prostaglandin secretion of dairy cows fed omega-3 fats. J. Dairy Sci. 85: 889-889.

Petit, H.V., Germiquet, C., and Lebel, D. 2004. Effect of feeding whole, unprocessed sunflower seeds and flaxseed on milk production, milk composition, and prostaglandin secretion in dairy cows. J. Dairy Sci. 87: 3889-3898

Ponter, A. A., Parsy, A. E., Saade, M., Mialot, J. P., Ficheux, C., Duvaux-Ponter, C., and Grimard, B. Effect of a supplement rich in linolenic acid added to the diet of post partum dairy cows on ovarian follicle growth, and milk and plasma fatty acid compositions. 2006. Reprod Nutr Dev. 46: 19-29.

Rego, O.A., Rosa, H.J.D., Portugal P.V., Franco T., Vouzela C.M., Bor ba E.S., and Bessa R.J.B. 2005. The effects of supplementation with sunflower and soybean oils on fatty acid profile of milk fat from grazing dairy cows. Anim. Res. 54:17-24.

Robinson, R. S., Pushpakumara, P. G. A., Cheng, Z., Peters, A. R., Abayasekara, D. R. E., and Wathes, D. C. Effects of dietary polyunsaturated fatty acids on ovarian and uterine function in lactating dairy cows. Reproduction. 124:119-131.

Salado, E. E., Gagliostro, G. A., Becu-Villalobos, D. and Lacau-Mengido, I. 2004. Partial replacement of corn grain by hydrogenated oil in grazing dairy cows in early lactation. J. Daily Sci. 87: 1265-1278.

Schingoethe, D.J., Brouk, M.J., Lightfield, K.D., and Baer, R.J. 1996. Lactational responses of daily cows fed unsaturated fat from extruded soy beans or sunflower seeds. J. Daily Sci. 79: 1244-1249.

Thanasak, J., Muller, K.E., Dieleman, S.J., Hoek, A., Noordhuizen, J.P., and Rutten, V.P. 2005. Effects of polyunsaturated fatty acids on the proliferation of mitogen stimulated bovine peripheral blood mononuclear cells. Vet Immunol Immunopathol. 104: 289-295.

Thanasak, J., Rutten, V.P., Schonewille, J.T., Hoek, A., Beynen, A.C., Noordhuizen, J.P., and Muller, K.E. 2004. Effect of a dietary n-6 polyunsaturated fatty acid supplement on distinct immune functions of goats. J Vet Med A Physiol Pathol Clin Med. 51:1-9.

Thibault, C., Petitclerc, D., Spratt, R., Leonard, M., Sejrsen, K., and Lacasse, P., 2003. Effect of feeding prepubertal heifers with a high oil diet on mammary development and milk production. J. Dairy Sci. 86: 2320-2326.

Whitlock, L.A., Schingoethe, D.J., Hippen, A.R., Kalscheur, K.F., and AbuGhazaleh, A.A. 2003. Milk production and composition from cows fed high oil or conventional corn at two forage concentrations. J. Dairy Sci. 86: 2428-2437.

Zheng, H.C., Liu, J.X., Yao, J.H., Yuan, Q., Ye, H.W., Ye, J.A., and Wu, Y.M. 2005. Effects of dietary sources of vegetable oils on performance of high-yielding lactating cows and conjugated linoleic acids in milk. J. Dairy Sci. 88: 2037-2042.