THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Master of Science (Veterinary Clinical Studies)

DEGREE

Veterinary Clinical Studies — **FIELD**

Veterinary Medicine — **FACULTY**

TITLE: Effects of Extruded Soybean on Milk Fatty Acid Profiles in Dairy Goats

NAME: Miss Rachanikorn Srikong

THIS THESIS HAS BEEN ACCEPTED BY

(Assistant Professor Pipat Arunvipas, Ph.D.) **THESIS ADVISOR**

(Associate Professor Theera Rukkwamsuk, Ph.D.) **THESIS CO-ADVISOR**

(Miss Soontaree Petchdee, Ph.D.) **GRADUATE COMMITTEE CHAIRMAN**

APPROVED BY THE GRADUATE SCHOOL ON _____

(Associate Professor Gunjana Theeragool, D.Agr.) **DEAN**

THESIS

EFFECTS OF EXTRUDED SOYBEAN ON MILK FATTY ACID PROFILES IN DAIRY GOATS

RACHANIKORN SRIKONG

A thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Science (Veterinary Clinical Studies)
Graduate School, Kasetsart University
2013

Rachanikorn Srikong 2013: Effects of Extruded Soybean on Milk Fatty Acid Profiles in Dairy Goats. Master of Science (Veterinary Clinical Study), Major Field: Veterinary Clinical Studies, Faculty of Veterinary Medicine. Thesis Advisor: Assistant Professor Pipat Arunvipas, Ph.D. 47 pages.

To determine the effects of extruded soybeans on milk fatty acid profiles in goat milk. Ten Saanen goats (BW = 45 ± 5 kg; X ± SD) were used in a cross-over design with 35 days periods to evaluate, 14 days for animal adaptation and 21 days for data collection. Two treatments consisting of a control diet and extruded soybean treatment. Diets were fed according to individual milk yield. Pangola hay were offered ad libitum. Results showed that feeding full fat extruded soybeans in the high concentrate diet did not have a negative effect on milk yield, milk fat content, milk protein of mid-lactation goats and that long chain fatty acid profiles were significantly increased. At the time of experiment the treated diet was a lower cost that the control diet, this would be advantageous in productive system.

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ACKNOWLEDGEMENTS

I would like to give thanks with all my heart to my beloved advisers; Dr. Pipat Arunvipas, co-adviser; Dr. Theera Rukkwamsuk, family and friends who helped and supported me during my education. All of you were there for me, a connecting the dots. It is very meaningful on my learning journey. Appreciation is also extended to department of Large Animal and Wildlife Clinical Sciences, Faculty of Veterinary Medicine, Kasetsart University for financial support for the thesis project.

Rachanikorn Srikong
March 2013

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LIST OF ABBREVATIONS

°C	=	degree Celsius
°F	=	degree Fahrenheit
µm	=	micrometer
ACC	=	acetyl-CoA carboxylase
ADF	=	acid detergent fiber
CLA	=	conjugated linoleic acids
cm	=	centimeter
cm^2	=	square centimeter
CP	=	crude protein
DHA	=	docosahexaenoic acid
DM	=	dry matter
EPA	=	eicosapentaenic acid
FA	=	fatty acid
FAS	=	fatty acid synthase
FFA	=	free fatty acids
GC	=	gas chromatography spectroscopy
GPAT	=	glycerol phosphate acyltransferase
LA	=	linoleic acid
LCT	=	long chain fatty acids
LNA	=	linolenic acid
LPL	=	lipoprotein lipase
MCT	=	medium chain triglycerides
MFD	=	milk fat depression
ml	=	milliliters
mRNA	=	messenger ribonucleic acid
MUFA	=	monounsaturated fatty acid
NDF	=	neutral detergent fiber
NEFA	=	non-esterified fatty acid
NRC	=	National Research Council
OM	=	organic matter

LIST OF ABBREVATIONS (Continued)

PUFA	=	polyunsaturated fatty acid
RA	=	rumenic acid
SNF	=	solid not fat
VA	=	vaccenic acid
VFA	=	volatile fatty acid
VLDL	=	very low density lipoproteins
β-HB	=	β-hydroxybutyrate

Effects of Extruded Soybean on Milk Fatty Acid Profile in Dairy Goat

INTRODUCTION

Dairy goat industry is becoming an economic valuable source for many small farmers all over the world. Especially, goat milk is of particular economic interest in Southeast Asia, where goat milk is viewed the healthy option by consumers. The most interesting aspect of goat milk is its fat and fatty acids content such as short- and medium-chain saturated, branched, mono- and poly-unsaturated, cis and trans, conjugated fatty acid. In addition, Goat milk is a nutritive value-added product as it is rich in conjugated linoleic acids (CLA), lower saturated and higher unsaturated fatty acid when compared to cow milk, so giving health benefits to consumers.

In high production dairy cows, feeding high dietary fat is not only an energy source, it also improves milk yield, milk fatty acid profile and increases milk CLA yield. A high dietary fat has a high polyunsaturated fatty acid (PUFA). It is also used as a tool to improve fatty acid profiles and increase milk yield in dairy cows. As dairy goats have a different response when compare with dairy cows, as their PUFAs differ in many aspects. Therefore, extrude soybeans will be used to increase goat milk performance and fatty acid profiles to be used as strategies to develop farm production and economic viability. This will be of benefit to both consumers and farmers. This thesis focuses on the effect of extruded soybeans on milk fatty acid profiles in goat milk.

OBJECTIVE

To determine the effects of extruded soybeans on milk fatty acid profiles in goat milk.

LITERATURE REVIEW

Milk is the product of mammary gland and its composition varies among animal species (Table 1). Nowadays, milk is not only the nutritional value but has attracted interest also other physiological properties, especially milk fat.

Table 1 Milk composition from human, goat, cow, and sheep

Species	Fat %	Protein %	Fat/Protein	Lactose %	Ash %	Total solids %
Human	4.5	1.1	4.09	6.8	0.2	12.6
Goat	3.5	3.1	1.13	4.6	0.79	12.0
Cow	3.5	3.1	1.13	4.9	0.7	12.2
Sheep	5.3	5.5	0.96	4.6	0.9	16.3

Source: Jensen (1995)

Goat milk and its fat content

Goat milk contains of 87.91% of water, 4.6% of lactose, 3.1% of protein, 3.5% of fat, 0.79 % of Ash, and 0.1% of minerals and vitamins (Jensen, 1995). The goat milk can be a functional food as it can promote biological functions and physiological functions also modulated by its component. Milk fat globule and its fatty acids have been shown to possess various bioactive properties (Fontecha et al., 2011).

Milk fat is small globule that is an emulsion in the milk (Attaie and Richter, 2000). The milk fat globules are formed by the endoplasmic reticulum in the alveoli and coated with proteins and polar lipids (Heid and Keenan, 2005). The milk fat comprises approximately 98% triglycerides, while diacylglycerol, cholesterol, phospholipids and free fatty acids (FFA) form a very small amount as seen in cow milk. (Jensen and Newburg, 1995). Goat milk fat globules range from 0.73 to 8.58 μm in diameter, which is less than the fat globule in bovine milk (0.92 to 15.75 μm).

The average diameter of particles based on volume to surface area ratio was 2.76 μm, which was less than the bovine milk (3.51 μm). The specific surface area of particles in goat milk was 21,778 cm^2 /ml, whereas the specific surface area of particles in cow milk was 17,117 cm^2 /ml. (Attaie and Richter, 2000).

Milk fat synthesis

Milk fat biosynthesis involves three important stages (Bauman et al., 2006):

1. An accumulation of fatty acids (de novo synthesis or absorption from the blood stream) into the mammary cells.
2. Triacylglycerol construction.
3. Fat globule assembly and secretion.

Triglycerides are the major type of lipid in milk. They are composed of a glycerol and tree fatty acids. The fatty acids of milk fat come from fraction of plasma lipids, approximately 60% and from the intramammary de novo synthesis of fatty acids approximately 40% (Glascock, 1956). The plasma lipids are derived from the feed and the microbial activity in the rumen (Chilliard et al., 2000). Mammary gland synthesizes fatty acids with short to medium chain fatty acids. This de novo synthesis from acetate and beta-hydroxybutyrate to be the 4:0-14:0 fatty acids and about half of the 16:0. Acetic acid and butyric acid are derived from the rumen microbial fermentation of feed components. The butyric acid is converted to beta-hydroxybutyrate during absorption through the rumen epithelium. The remaining 16:0 and other long-chain fatty acids originate from dietary lipids and from lipolysis of adipose tissue (Månsson, 2008).

There are many factors which influence the variations in the amount and fatty acid composition of goat milk lipids. They can be related to genetics, breed, stage of lactation, feed and feeding such as fiber, energy intake, and dietary fats (Palmquist et al., 1993).

Milk fatty acids synthesis

In milk, 60% of fatty acid come from the blood and 40% from de novo synthesis of mammary gland. Fatty acids are de novo synthesis from acetate and β-hydroxybutyrate (β-HB). Acetate, the main product in the rumen and in a less portion, propionate and butyrate are the precursors for the initiation of lipogenesis in both adipose tissue and mammary gland. Acetate is transformed into pyruvate and then further transformed into acetyl-CoA in mitochondria. Acetyl-CoA is the principal construction of fatty acids formation. The overall reaction can be summarized by the equation: The biosynthesis of palmitate from acetyl-CoA as figure 1 (Laliotis et al., 2010).

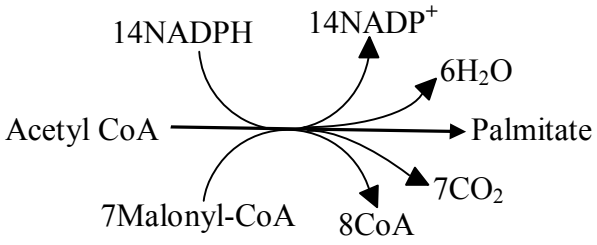

Figure 1 The biosynthesis of palmitate from acetyl-CoA

The main metabolic pathway involves acetyl-CoA carboxylase (ACC) and FA synthase (FAS) (Barber et al.,1997). The malonyl-CoA is derived from acetate under the catalytic action of ACC and FAS catalyses condensation cycles of malonyl-CoA with either acetyl-CoA or butyryl-CoA, which arise from acetate or β-HB metabolism, respectively. In small ruminants, propionyl-CoA can be used in place of acetyl-CoA as the primer molecule for fatty acids synthesis giving rise to odd-numbered fatty acids (Laliotis, 2010). The FAS in ruminant mammary gland brings up a two to twelve carbon chain length. The chain-termination reaction produces C14:0 and part of C16:0 (Knudsen and Grunnet, 1982).

Milk fatty acids taken up by the mammary glands are 60% come from blood, either from plasma non-esterified fatty acid (NEFA) or from plasma triglyceride-rich lipoproteins (chylomicron and very low density lipoproteins, VLDL). The plasma NEFA concentration is related to NEFA uptake and to body fat mobilization. Moreover the mammary gland uptake of triglycerides is generally well correlated to plasma triglycerides concentration (Chilliard et al., 1984). The ability of mammary gland to utilize fatty acids from plasma chylomicron and VLDL is determined by the activity of the enzyme lipoprotein lipase (LPL). LPL activity is high in the lactating mammary gland of ruminants (Iverson et al., 1995).

The ruminant mammary cells synthesize CLA by action of the delta-9 desaturase. The vaccenic acid (VA) (trans-11 C18:1) is desaturated to rumenic acid (RA) (cis-9, trans-11 C18:2) by the delta-9 desaturase activity in mammary secretory cell (Griinari and Bauman, 1999). The mammary gland also converts stearic acid to oleic acid (cis-9 C18:1) (Kinsella , 1972). About 52% of the oleic acid is secreted into milk fat by mammary gland desaturation of 18:0 to cis-9 C18:1, thus the rest of the desaturated stearic acid is taken up by the gland (Enjalbert et al., 1998). The delta-9 desaturase activity can be inhibited by polyunsaturated FA as well as by cyclopropenoic FA in cottonseed (Chillard et al., 2003). The mammary adipocyte shut off its mechanisms when dietary fat increases due to the lipogenic genes that are suppressed by PUFA (Sessler and Ntambi, 1998).

Fatty acids in goat milk

Nowadays, in human, there is a need to consider the quality as well as the quantity of fat in diets. One of fat quality issues is concentrated on specific fatty acids (e.g., short- and medium-chain saturated, branched, mono- and poly-unsaturated, cis and trans, conjugated FA). The fatty acids have positive and negative effects on human health.

One of the most interesting aspects of goat milk is the nature of its fat. It is a fat rich in medium chain triglycerides (MCT). MCTs have a metabolic pathway of triglycerides different from long chain triglycerides (LCT). The smaller molecular weight of MCTs facilitates the action of pancreatic lipase. Consequently, MCTs are hydrolyzed both faster and more completely than LCTs. The free fatty acids from MCT absorbed without reesterification into the intestinal cells then directly transport to liver and peripheral tissues (Bach and Babayan, 1982).

The monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), and medium chain triglycerides (MCT) present in goat milk more than cow milk. Goat milk is much higher in butyric (C4:0), caproic (C6:0), caprylic (C8:0), capric(C10:0), lauric (C12:0), myristic (C14:0), palmitic (C16:0), linoleic (C18:2), but lower in stearic (C18:0), and oleic acid (C18:1). The C6, C8 and C10 fatty acids have been named after goats, because of their predominance in goat milk more than other milk (Haenlein, 2004).

Conjugated linoleic acid

Conjugated linoleic acid (CLA) is an intermediate result of linoleic acid and /or linolenic acid in the rumen, which presents in ruminant milk and meat. Milk fat is the richest natural source of CLA. It is one of the most important bioactive components in milk fat.

These are a series of positional and geometric isomers of linoleic acid (cis9, cis12-C18:2, n-6) with conjugated double bonds. The isomer cis9, trans11-CLA named rumenic acid (RA) is representing more than 90% of the CLA isomers. CLAs are an intermediate of linoleic acid in the ruminal biohydrogenation (Song and Kennelly, 2002). It has antiatherogenic, antidiabetogenic, antiadipogenic, immunomodulating, bone growth enhancing properties and anticarcinogenic which has been demonstrated in rodent models (McGuire and McGuire, 1999; Parodi, 2009).

Trans-11 C18:1 (vaccenic acid) is a common intermediate in ruminal biohydrogenation of linoleic and α- and γ-linolenic acids (LNA). In the rumen, more gathering of trans C18:1 but rarely CLA, because the trans C18:1 reduction is usually limiting rate for the complete hydrogenation of unsaturated C18-FA, whereas a major portion of milk CLA is synthesized by the mammary gland (Song and Kennelly, 2002.). In dairy cows, some CLA isomers have a relation to the milk fat depression, such as trans10, cis12-C18:2 has an inhibitors potential of milk fat synthesis (Chouinard et al., 1999). The trans10, cis12-C18:2 reduced milk fat synthesis in lactating dairy goats in a manner similar to that observed for lactating dairy cows and dairy sheep. However, the degree of reduction in milk fat synthesis is less in dairy goats compared with dairy cows and dairy sheep (Lock et al., 2008).

The ruminant mammary cells are able to synthesize cis-9, trans-11 CLA from trans-11 C18:1 by action of the delta-9 desaturase on trans C18:1 at the onset of lactation. Three-quarters of total milk RA are produced by this enzyme (Castillo et al., 2010). Some CLAs are absorbed from the digestive tract and taken up by the mammary gland (Chouinard et al., 1999).

Rumenic acid is produced in the rumen as a consequence of biohydrogenation reactions by the rumen bacteria: *Butyrivibrio fibrisolvens* (Kepler et al., 1967). It transposes the cis-double bond at C-12 of dietary linoleic acid (cis-9, cis-12-18:2) to C-11, and trans-configure to produce RA. Some of RA is subsequently reduction to trans-11-18:1 (VA) and stearic acid (18:0) (Figure 2).

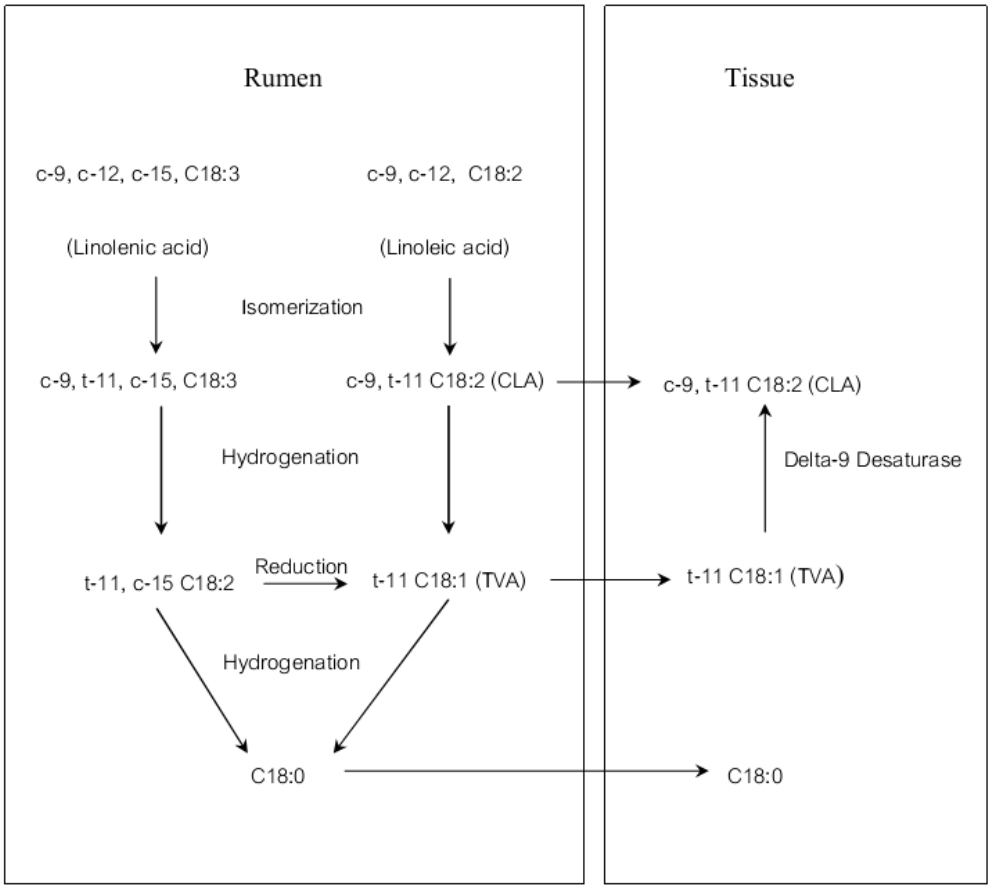

Figure 2 Ruminal biohydrogenation and mammary lipogenesis pathway

Milk fat depression (MFD) was also characterized by the appearance of trans-10, cis-12 CLA in the milk fat. The diet-induced MFD involves coordinated effects on mRNA for mammary lipid synthesis pathways, and provides support for a mechanism involving alterations in transcriptional activation of genes. The reductions in mRNA activity for were also correlated with the appearance of trans-10, cis-12 CLA in the milk fat for acetyl-CoA carboxylase (ACC), fatty acid synthase (FAS), glycerol phosphate acyltransferase (GPAT), and lipoprotein lipase (Peterson et al., 2003).

The trans-7,cis-9 CLA is the CLA isomer in milk fat (3 to 16% of total CLA isomers). Similar to cis-9, trans-11 CLA isomer, trans-7, cis-9 CLA can be produced from trans-7 C18:1 by delta-9 desaturase (Yurawecz et al., 1998).

Ruminal lipolysis and biohydrogenation

The rumen is the site of the main biochemical mechanisms of microbial lipid metabolism. Lipolysis of dietary glycolipids, phospholipids and triglycerides leads to free FAs which are hydrogenated to a large extent by flows of absorbable FAs. Also degraded and ferment dietary carbohydrates and proteins in rumen are hydrogenated to a volatile fatty acid (VFA). The most important VFAs are acetate, propionate, and butyrate. Acetate and butyrate are precursors of milk short and medium chain FAs. Propionate is a precursor for producing lactose in milk (Nozière et al., 2000).

The most efficient way to increase propionate production in rumen is to increase concentrate diet, especially rumen rapidly degradable cereals. Decreasing the proportion of fiber in the diet results in decreased acetate: butyrate ratio and increased propionate. Intake of dietary lipids in particular by vegetable or fish oils and use of ionophore antibiotics can also increase propionate content in the rumen (Wang et al., 2005).

Ruminal lypolysis

Dietary lipids are usually triglycerides, phospholipids and galactolipids. The predominant lipids in cereal and plant oils are triglycerides whereas forage contains little triglycerides, comprising mainly galactolipids, sulfolipids and phospholipids (Harfoot, 1981). The lipolysis in the rumen starts with hydrolysis of the ester linkages releasing free FA. The first hydrolysis of the forage lipid ester linkages use the plants own lipases and microbial lipases (Kim et al., 2009). In cereal and plant oil, the triglycerides is hydrolized by microbial lipases predominantly (Dawson et al., 1977), whereas forage lipid is mainly hydrolyzed by active plant lipases (Lourenc et al., 2010) (Figure 3).

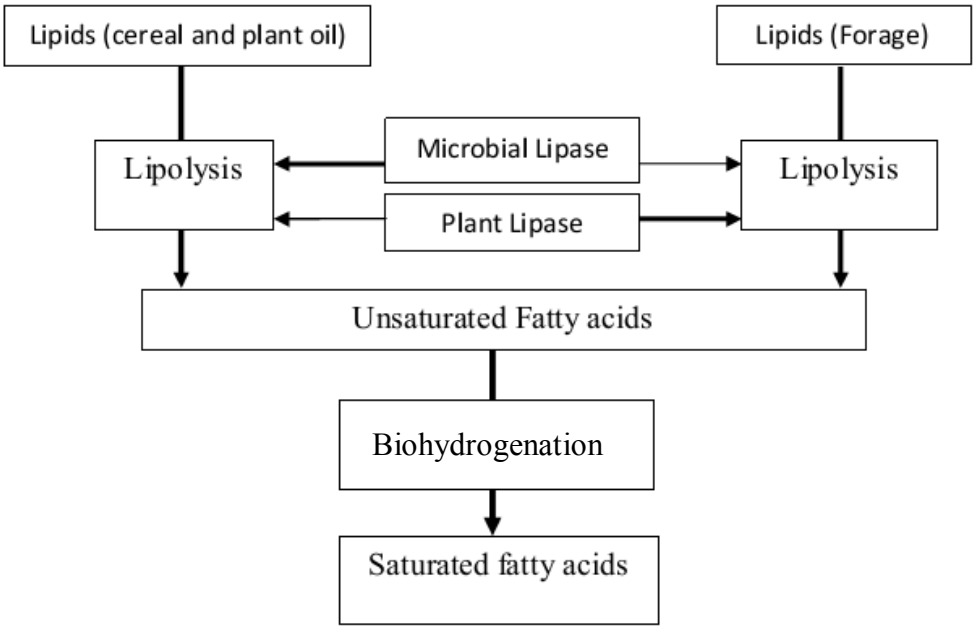

Figure 3 Ruminal lipolysis and biohydrogenation pathway

Lipolytic ruminal microorganisms

Ruminal bacteria are the most active in lipolysis among a various types of ruminal microorganisms. The most active bacterial species isolated selectively using triglycerides as substrate is *Anaerovibrio lipolytica*, produced extracellular lipase enzyme and hydrolyses diglycerides more readily than triglycerides (Henderson, 1971). Animals receiving mainly concentrate feeds have *A. lipolytica* as the dominant ruminal lipase, whereas grazing animals have other lipolytic species. *A. lipolytica* lacks of ability to hydrolyse galactolipids and phospholipids in forage (Lourenc et al., 2010). The *Butyrivibrio* species are hydrolyses phospholipids and galactolipids. *Butyrivibrio fibrisolvens* and a *Butyrivibrio* strain named LM8/1B have phospholipase activity (Hobson and Stewart, 1997). The *Butyrivibrio spp*. appeared to have all the phospholipase A, phospholipase C, lysophospholipase and phosphodiesterase activities typical of the mixed rumen contents while the *Butyrivibrio spp*. did not break down triacylglycerols. These bacteria also possess the ability to biohydrogenate unsaturated fatty acids (Harfoot and Hazlewood, 1997). The toxicity of nonesterified

PUFA released by the lipase would then have to be removed by biohydrogenation (Maia et al., 2007).

A ciliated rumen protozoon also has a strongly-associated with bacteria to hydrolyses dietary lipid (Hobson and Stewart, 1997). Lipolytic ruminal protozoa, *Epidinium spp*. produced 30% to 40% of total lipolytic activity in the rumen. *Epidinium ecaudatum* has galactosidase activity to liberate galactose from galactolipids (William, 1986). *Entodinium caudatum*, has phospholipase activity, but this activity is more relevant to the internal economy of the protozoa than to the digestion of dietary lipids (Coleman et al., 1971).

Dietary effects on ruminal lipolysis

Dietary lipids in ruminant are plant and marine oils. The lipolysis rate of structural plant lipids is lower than unprotected oils due to the need to remove surrounding cellular matrices before lipolysis. Lipolysis is considered to be limiting rate for biohydrogenation (Harfoot and Hazlewood, 1997). The rate of lipolysis *in vitro* is altered by diet composition, forage maturity, and particle size (Kim et al., 2009).

Ruminal biohydrogenation

Ruminal biohydrogenation and microbial ecosystem mainly depends on the diet type. When pH drops due to the increasing concentrates to roughage ratio, lipolysis is much more sensitive to low pH values than biohydrogenation thus hydrogenation which occurs only on free FA (Van Nevel and Demeyer, 1996). Content of VA in rumen is depending on amount of either linolenic acid or linoleic acid (LA) and a decrease in the rate of biohydrogenation (Noble et al., 1974). Biohydrogenation also occurs on 20- and 22-carbon FA, which are hydrogenated in numerous intermediate compounds but do not end up completely saturated [Doreau and Chilliard, 1997). Due to the component in the fish oil, C20:5 (EPA) and/or C22:6

(DHA) modifying the rumen environment, to increases the ruminal production of transvaccenic acid and CLA (Abu-Ghazaleh et al., 2002).

Rumen biohydrogenation bacteria can be grouped (i.e. Group A and B). Group A bacteria are classified based on their ability to hydrogenate PUFA to VA, the major is *B. fibrisolvens*. (Kim et al., 2009). Group B bacteria are categorised based on the ability to hydrogenate PUFA through to 18:0, the greater effect is *Clostridium proteoclasticum* (Wallace et al., 2006). The other facultative anaerobic bacteria, *Streptococcus, Staphylococcus, Enterococcus, Lactobacillus and Pediococcus* have the capacity to hydrate 18:2n-6 in the rumen to 13-hydroxy-9-octadecenoic. *Pediococci* have the capacity to hydrate unsaturated fatty acids, suggesting that lactic acid bacteria are the major unsaturated fatty acid hydrating bacteria in the rumen (Hudson et al., 2000). The trans-10, cis-12 CLA forming bacteria is *Megasphaera elsdenii* (Kim et al., 2002). There may be many more bacteria involved in biohydrogenation pathways. The isomers of 10, 12 CLA may synthesized by a different mechanism compared to the synthesis of 9, 11 isomers (Wallace et al., 2007).

PUFA, some butyrate-producing bacteria, the stearate producer: *Clostridium proteoclasticum, Butyrivibrio hungatei and Eubacterium ruminantium* are toxic to cellulytic bacteria. LA toxicity is linked to metabolism in butyrate-producing bacteria. Ranking of the most toxicity to bacteria growth was EPA, DHA, LNA, LA, respectively. Whereas the *Butyrivibrio* group and *C.proteoclasticum* were not sensitive to the toxic effects. This may explain why biohydrogenation occurs by *Butyrivibrio* group mainly (Maia et al., 2007).

The saturation of both 18:2n-6 and 18:3n-3 involves an isomerisation reaction that converts the cis-12 double bond to a trans-11 isomer then add hydrogen to cis-9 and cis-15 bond to be the VA by microbial reductase. The final step in the ruminal biohydrogenation pathway is hydrogenation of the trans-11 double bond producing saturated 18:0 (Kim et al., 2009) (Figure 1).

Microorganism related to ruminal biohydrogenation

The saturation pathway in biohydrogenation is carried out almost exclusively by rumen bacteria. Recently, the data showed that rumen protozoa also were associated with ruminal biohydrohenation. *In vitro* data showed that the protozoa produced much higher CLA concentrations than bacteria, but did not possess delta-9 desaturase activity suggesting that protozoa preferentially incorporate bacteria to produce CLA and VA (Devillard et al., 2006). *In vivo* experiment also showed that protozoa were high in PUFA and CLA ratio than bacteria (Or-Rashid et al., 2007). The rumen protozoa may increase the supply of CLA and other unsaturated fatty acids for lower gut absorption by ruminants (Nam and Garnsworthy, 2007).

Dietary effects on ruminal biohydrogenation

Across a wide range of diet types, biohydrogenation of 18:3n-3 in the rumen is higher than 18:2n-6 (Jenkins et al., 2008). The major factors which influenced biohydrogenation included: ruminal pH, forage: concentrate ratio, level of intake and fish oil supplementation. Cis-9, trans-11CLA producing rumen bacteria may be less acid-tolerant and aero-tolerant than trans-10, cis-12 CLA (Choi et al., 2005). High levels of forage intake increased 18:3n-3 biohydrogenation. It has a negative effect on the flows of 18:2n-6 and 18:3n-3 to duodenum. The response to fish oil is dependent on level of supplemented oil. However, the use of 3% of DM intake fish oil has been very inhibiting the final biohydrogenation step to 18:0 by its toxic effect on certain bacterial species then the flow of trans-11 18:1 to the duodenum was increased (Kim et al., 2008).

Other approaches have decreased lipid toxic effect on certain bacterial species by protection technologies to by-pass the action of the rumen microorganisms. The use of calcium salts, fatty acid acylamides and encapsulation of lipid also give beneficial increases in some FA, including CLA and n-3 PUFA (Kim et al., 2009).

Nutritional manipulation of milk fat concentration and milk fat composition

Milk fat content is high after parturition and then starts to decline during the peak of lactation in the goat. This is related to a dilution effect and decrease in fat mobilization. Dilution effect is due to the increase in milk volume until the lactation peak. A decrease in fat mobilization decreases the availability of plasma NEFA, especially C18:0 and C18:1, for mammary lipid synthesis (Bernard et al., 2005).

A fat mobilization is correlated with energy status. The energy status is highly variable, according to animal milk genetic potential and lactation stage, as well as composition and nutrient density of the diet. When animals have a negative energy balance, they mobilize lipids stored in adipose tissues, mainly in the form of NEFA to make energy equilibrium (Chillard, 2003).

The energy balance of lactating animals can be estimated by the difference between their ingested nutrients and requested nutrients for body maintenance and for milk fat secretion. The calculated energy balance is increased or decreased according to respective effects on intake of DM, energy intake, and milk fat secretion (Coppock and Willrs, 1991).

Between milk fat content and either energy balance, plasma NEFA content or milk fat C18:1 percentage have a high correlations, respectively (Chillard et al., 2003). Milk fat content is dramatic decreased by low fiber, high concentrate, and by feeding unprotected, unsaturated plant oil, especially fish oils, whereas yields of milk and other milk components remain unchanged (Bauman and Griinari, 2001).

It has long been observed that goats are less sensitive to low-fat milk syndrome than cows. When goats are fed with a varied forage/concentrate ratio while energy intake remains constant, the change in milk fat concentrations is either small or insignificant (Tufarelli et al., 2009). The energy balance of the animal is more important than the forage/concentrate ratio (Schmidely et al., 2005). Furthermore, when goats are fed carbohydrates differing in nature, it does not affect milk fat and

protein concentrations (Schmidely et al., 1999). Moreover the forage fraction provided by alfalfa hay, either in long-fiber or in pelleted form, milk production and milk fat concentration were unaffected (Sanz Sampelayo et al., 1998). In addition, this indicated that the dilution effect may be the net affect, when increasing energy intake with high concentrate diet, milk yield increased and fat content slightly decreased, whereas milk fat yield increased (Santini et al., 1992; Chilliard and Ferlay, 2004).

The buffer supplement such as sodium bicarbonate or magnesium oxide can limit the rumen pH decreasing, promotes acetate production in the rumen, and reduces the risk of milk fat decreasing, but does not affect fatty acid composition of the milk fat or content of short chain fatty acids and unsaturated fatty acids (Schmidely et al., 2005).

Effect of lipid supplementation on the milk fat concentration

Dairy goats are normally raised indoor and fed a concentrate diet in order to maintain production levels, the forage to concentrate ratio may be relatively low and this may cause a rumen acidosis. In this situation, dietary lipid supplementation can increase the energy intake and reducing the need for cereal and leading to a more appropriate forage to concentrate ratio The increasing fat intake can compensate a reduction of fiber in the diet (Casals and Caja et al., 1999).

The use of different types and levels of fat in the diet has the most effect on milk fat and can increased milk fat. Such as polyunsaturated fatty acid (PUFA) in plant oils even with diets rich in starchy concentrate (Bernard et al., 2012). The supplement of 20% extruded soybean (Schmidely et al., 2005) or sunflower or linseed oil (Chilliard et al., 2005) in dietary DM with a high concentrate proportion (30/70 forage to concentrate ratio) increased the milk fat content and the fat yield. The fat supplementation even in the form of calcium soaps obtains a higher milk fat content. Whereas unprotected fish oil supplementation sharply decrease dry matter intake and milk yield, while milk fat content increases (Kitessa et al., 2001).

The fat supplementation has variable effects on milk fat content. The fat content largely dependent on the level of fat in the diet, the animal species, the productive capability of the animal, and the period of lactation (Figure 4) (Chillard, 2003). In early lactation period, supplementation with either protected sunflower seeds (Mansoori et al., 2011), extruded soybeans (Faldet and Satter, 1991) or calcium soaps of palm oil (Teh et al., 1994), increase milk production, milk fat content, and milk protein content is variable. In contrast, feeding very low lipids diets decrease both goat milk yield and fat content. In the mid or late lactation period, when goat dietary is supplemented with fat, milk fat content always increased sharply, but milk yield is not increased, while the protein content is variable (Morand-fehr and Sauvant, 1980). Whereas fish oil in the form of calcium salts is supplemented in mid lactation, it does not change dry matter intake, milk production, and milk fat content. When fish oil in the form of calcium salts supplement is administered in late lactation increases milk production, milk fat and protein content; moreover, the lactation period is extended (Sanz Sampelayo et al., 2004). The response of milk fat secretion to fat supplementation could be lower during mid lactation than during early lactation.

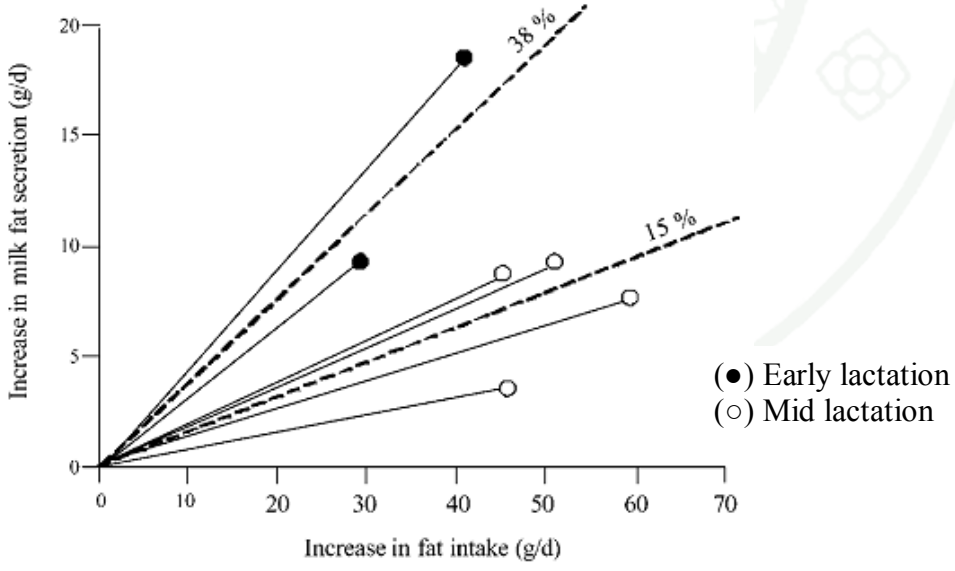

Figure 4 The response of milk fat secretion on fat supplementation during mid lactation and during early lactation

Source: Chillard (2003)

During early lactation, milk fat content is a positive relation to energy balance. This can be related to body lipid mobilization and fat de novo. This is also favor the partitioning of dietary FA towards the mammary gland (Chilliard, 1993). While during mid or late lactation, the greater part of the exogenous FA is taken up by the adipose tissue (Chilliard et al., 1991). However, the highest milk fat content responses are observed in late lactating or low yielding goats, probably because of the dilution effect.

In early lactation without fat supplement, the correlations of the FA in goat milk shows a negative effect between the long-chain (C18-FA) and C10 to C16-FA. Also the C4 to C8-FA has a negative correlation to C16:0 (Figure 5) (Chilliard, 2003).

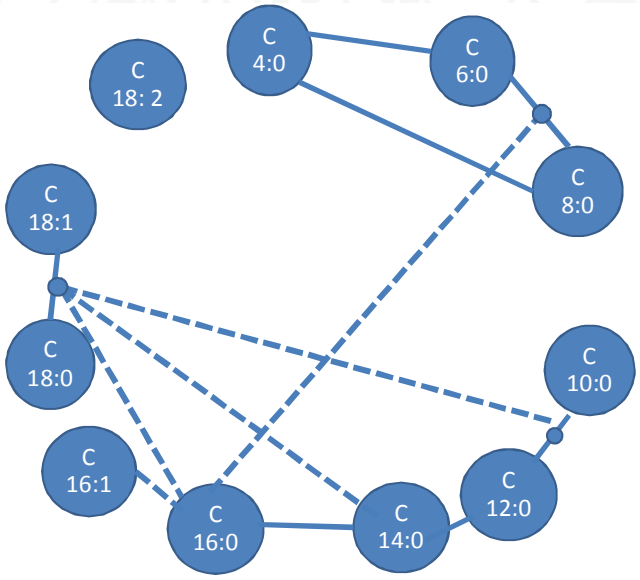

Figure 5 Lines showed positive correlation and dot lines showed a negative correlation between fatty acids in goat milk

Source: Chilliard (2003)

According to animal species, dairy cows (Chilliard et al.,2001), dairy goats (Chilliard and Bocquier, 1993), and dairy sheep (Nudda et al., 2003) have a different response to fat supplementation. Milk yield increases in mid lactation dairy cows, but not in goats and ewes. Milk fat content sharply increases in dairy ewes and goats, but

in dairy cows either decreasing or no change. The differences may be linked to species specific. Goats have a higher digesta passage rate (Ranilla, 2005). This could be related to some differences in the rumen microbial metabolism of trans FA or in the mammary lipogenesis (Chilliard et al., 2000).

Remarkably, goat milk fat content does not decrease when feed a low forage diet supplemented of polyunsaturated (FA) from plant oil. Therefore, the positive effects of almost all types of fat supplementation on milk fat content could be useful to solve the technological problems in the goat cheese industry which are linked to the low milk fat and high milk protein content in cheese processing.

Effect of lipid supplementation on the milk fat composition

Milk fat composition has attracted much interest as the quantity of fat in diets such as a short- and medium-chain saturated, branched, mono- and poly-unsaturated, cis and trans, conjugated FA, as it has a positive or negative factors on human health. Most of the FA arising from de novo synthesis are saturated (C4:0 to C16:0), although a small proportion of C14:0 and C16:0 is desaturated to C14:1 and C16:1. The long-chain FAs (with 16 or more carbon atoms) are potent inhibitors of mammary FA synthesis, through a direct inhibitory effect on Acetyl-CoA carboxylase (ACC). Thus, when long-chain FAs are available either from the diet, or from body fat mobilisation, there is a decrease in the percentage of medium-chain FAs (C8:0 to C14:0 or C16:0) in milk fat (Barber et al., 1997).

The effect of dietary fat is complex, the FA composition, the presentation (oilseeds, protected or unprotected oils) and the amount of dietary fat, the interactions with forages and/or concentrates in the basal diet. They affect ruminal biohydrogenation and rumen bacterial population, due to decreased availability of acetate and butyrate (or β-HB) and changes in rumen VFA production.

A higher content of beneficial unsaturated fatty acids in goat milk fat especially CLA can be manipulated by feeding. The composition of dietary fat

reflects in the composition of goat milk (Sanz Sampelayo et al., 2000). Some CLA is absorbed from the digestive tract and taken up by the mammary gland (Chouinard et al., 1999). CLA concentration in goat milk fat is influenced by dietary factors such as pasture feeding and supplementation with full fat oilseeds. The effects are more prominently apparent when dietary fat is protected against the ruminal metabolism (Sanz Sampelayo et al., 2004). The dietary provides lipid substrates for formation of trans C18:1 or CLA in the rumen and change the microbial activity associated with ruminal biohydrogenation. Plant oils with high linolenic and linoleic acids are very efficient at increasing milk CLA content (Griinari and Bauman, 1999). Moreover, the important role played by delta-9 desaturase in mammary glands regulates the corresponding monounsaturated fatty acids of milk fat, particularly the fatty acids of 18 carbon atoms (Chilliard and Ferlay, 2004).

The vegetable oils are more efficient to increasing milk CLA content than extruded seeds and raw seeds, respectively (Chilliard et al., 2000). If PUFAs in vegetable oils or oilseeds are fed to ruminants in an unprotected form, rumen microbes can biohydrogenate the unsaturated fatty acids to saturate in the rumen. The unsaturated 18-carbon fatty acids in whole oilseeds are hydrogenated to trans-11-18:1 (VA) and 18:0 (stearic acid) in the rumen, VA converts to CLA (Cis-9, trans-11-18:2 ; RA) by the activity of a delta-9 desaturases mainly in the mammary gland. So supplement PUFAs in a form protected, such as feeding protected canola seeds could increase goat milk C18:1, C18:2, and C18:3 proportionally to the respective percentages of these FA in canola oil. Whereas, the supplementation of unprotected oil increased mainly C18:0 and C18:1 (Delbecchi et al., 2001). These demonstrate that both total and partial hydrogenation of unsaturated FA in the rumen (Figure 1). As same as palm oil, rich in palmitic and oleic acids, feed calcium soap of palm oil to lactating goats increased the percentage of C18:1and C16:0 in milk fat (Teh et al., 1994). But cotton seed supplementation is different. Cotton seed is poor in C18:0 and contains only 16% of C18:1, the effect of feeding protected cottonseeds is largely increase C18:2 percentage in the milk and the C18:0 to C18:1 ratio, differed from other vegetable oils. This is related to cyclopropenoic FA in cotton seed, which are strong inhibitors of mammary delta-9 desaturase activity (Chillard et al., 2003). The

protected PUFA potency could be highly efficient to increasing milk CLA content related to ruminal biohydrogenation. On the other hand, supplementation with animal fats is not very efficient at increasing CLA content because of their low PUFA content. (Chilliard et al., 2000).

The forage affects ruminal biohydrogenation and rumen bacterial population. The major forage fatty acid is α-linolenic (cis-9, cis-12, cis-15-18:3), isomerization to cis-9, trans-11, cis-15 C18:3 and reduction to trans-11, cis-15 C18:2 and subsequently reduction to VA (trans-11 C18:1) and C18:0. Some portions of the VA were produced and pass from the rumen to the intestine. It is absorbed from the digestive tract and transported in the circulation and the lactating mammary gland. Delta-9 desaturases enzyme in mammary gland converts it to RA in milk (Loor, 2001) (Figure 1)

MATERIALS AND METHODS

Materials

Animals and diets

Ten primiparous Saanen goats were studied in mid lactation. Goats (BW = 45 ± 5 kg; X ± SD) were used in a cross-over design with 35 day periods to evaluate, 14 days for animal adaptation and 21 days for data collection. The experimental diets were formulated to meet NRC (1981) nutrient requirements. Two treatments consisted of a control diet and treated diet. Diets were fed according to individual milk yield. Goats were fed individually twice daily, at each milking 0600 and 1600 h according to individual milk yield. Diets used in the experiment are shown in Table 2. Pangola hay, mineral choice and water was offered ad libitum. Feed samples were taken on the first day of each period. Orts and daily samples were recorded.

Table 2 Composition of experimental diets

Ingredients (% of DM)	Experimental diets	
	Control	Treated
Soybean meal	45.17	26.71
Crack Corn	8.50	8.50
Rice bran	15.80	15.78
Soybean husk	36.63	36.42
Full fat extruded soybean	0	20.64
Calcium soap of palm oil	3.66	0
Mineral	1.21	1.21

Table 3 Chemical analysis of concentration diet and pangola hay

Chemical composition (%)	Concentration diets		Pangola hay
	Control	Treated	
DM	90	91.50	87.3
CP	23.37	22.42	3.69
Ether extract	5.03	7.97	1.32
Gross energy (Mcal/kg of DM)	4.1	4.6	4.3
ADF	17.47	14.87	33.93
NDF	27.51	22.35	64.23
Ash	7.03	6.75	6.56

The diets were isonitrogenous. The soybean diets had higher gross energy (4.6 Mcal/kg of DM) and lower ADF content (14.87%). These findings were expected because of the substitution of 3% calcium soap of palm oil, 20% full fat extruded soybean and soy bean meal.

Methods

Feeding trial

All experimental goats were housed at Farm Dee, Nakhon Pathom. Goats were divided into two dietary treatment groups of five goats in each. They were housed in pens of suitable size (1.8 square meters) and were managed as any commercial goats flock. Having free access to pangola hay, mineral block, sodium bicarbonate, and water and were fed individually twice daily, at each milking 0600 and 1600 h according to individual milk yield. These goats had been 120 days in milk when the first batch of milk was collected. Milk yield of each group was weighed daily throughout the experiment which lasted for 70 days.

Sampling procedures

Feed were mixed for each period and collected at Day 0. The feed samples were pooled then samples taken for analysis purposes.

Milk samples from individual goats were collected at the end of adaptation period (Day 14), at the end of each treatment period (Day 35 and Day 70), and at the end of washing period (D 49). The individual milk was collected at the morning and evening milking and were combined. 50 Milk samples were divided into two portions; the first portion was stored at 4°C and then analyzed for milk composition analysis. Another portion was placed in long term storage at -20 °C for later milk fatty acid profile analysis.

Sample analysis

All feed samples were analyzed for DM, OM, CP, ether extract, NDF, and ADF following proximate analysis and Bomb Carolimeter.

Milk samples were analyzed for fat, protein, and total solids percentages by calibrated milk analyzer (EKOMILK, Milkana KAM 98-2A, Bulteh 2000 Ltd., Stara Zagora, Bulgaria)

Milk fatty acid profiles were analyzed by gas chromatography (GC). Fatty acids were methylated and extracted in hexane according to the method of Folch et al. (1957). Samples were hydrolyzed and methylated according to the method of O'Fallon et al. (2007). The fatty acid composition of fatty acid methyl esters (FAME) was determined by gas chromatography on a 100m x 0.25mm x 0.25 μm GC capillary column. Fatty acids were identified by comparing their mass spectrometer (MS), retention times, and mass weight with the fatty acid methyl ester (FAME mixed standard) and 9,11 octadecadienoic acid methyl ester standard.

In the mammary gland of ruminants, monounsaturated FA arise from direct uptake from the blood, or from desaturation of saturated FA via a delta-9 desaturase. The C14:0, C16:0, and C18:0 FA are substrates for delta-9 desaturase in the mammary gland that introduces a double bond to producecis-9 C14:1, cis-9 C16:1, and cis-9 C18:1 (Chilliard et al., 2003). Consequently, Delta-9 desaturase index was calculated by the following equation (Nuernberg et al., 2011).

$$\text{Delta-9 desaturase index} = \frac{(\text{C14:1+C16:1+C18:1+C17:1}) \times 100.}{(\text{C14:1+C16:1+C18:1+C17:1+C14:0+C16:0+C17:0+ C18:0})}$$

Cost of feed was calculate in terms of baht per kilogram, per kilogram of milk , and cost of total concentrate and feed intake per 21 days (period).

Statistic analyses

Based on the measurements at the end of treatment period (milk yield, milk composition, and milk fatty acid profiles), ANOVA was performed for a replicated Latin square design using the GLM procedure of NCSS (Hintze, 2007). NCSS. NCSS, LLC. Kayville, Utah. (www. NCSS. com).

RESULTS AND DISCUSSION

Results

Milk yield and composition

Milk yield, milk fat, milk protein, milk total solid, milk solid not fat (SNF) percentage were not significantly different between control and treated groups. Treated group was not significantly different on milk fat to milk protein ratio compare with control group (Table 4).

Table 4 Milk yield and milk composition of goats fed control (n = 10) and treated diets (n = 10), data are expressed as mean ± s.d.

Parameters	Experimental diets		P-value
	Control	Treated	
Milk yield (kg/d)	1.77 ± 0.82	1.71 ± 0.86	0.87
Milk composition (%)			
Fat	4.27 ± 0.56	4.25 ± 0.82	0.56
Protein	3.28 ± 0.11	3.28 ± 0.11	1.00
Total solid	12.93 ± 0.66	13.12 ± 0.90	0.62
Fat to protein ratio	1.30 ± 0.17	1.36 ± 0.25	0.56

Milk fatty acid profiles

Short and medium chain fatty acid profiles were not significantly different between control and treated groups. Long chain fatty acid profiles were different in milk of treated group goats compared to the control group (Table 5). Treated group was not significantly different on CLA compare with control group. Total omega 3 between the treated and control group was not significantly different, but total omega 6 was increased significantly. Saturated to unsaturated fatty acids ratio was

significantly different. Delta-9 desaturase index was not significantly different between control and experimental groups.

Table 5 Milk fatty acid profiles of goats fed control (n = 10) and treated diets (n = 10), data are expressed as mean ± s.d.

Fatty acids	Experimental diets		P-value
	Control	Treated	
	(g/l)		
C6:0	0.371±0.005	0.39±0.010	0.588
C8:0	0.708±0.010	0.734±0.017	0.699
C10:0	3.007±0.051	2.611±0.105	0.2767
C11:0	0.089±0.004	0.091±0.002	0.888
C12:0	1.465±0.033	1.391±0.029	0.610
C13:0	0.06±0.002	0.056±0.002	0.655
C14:0	3.973±0.070	3.873±0.057	0.740
C14:1	0.065±0.003	0.056±0.002	0.430
C15:0	N/A	N/A	N/A
C15:1	N/A	N/A	N/A
C16:0	14.057±0.176	12.081±0.207	0.036
C16:1	0.175±0.005	0.146±0.007	0.303
C17:0	0.209±0.020	0.273±0.018	0.386
C17:1	N/A	N/A	N/A
C18:0	4.909±0.094	7.125±0.252	0.025
C18:1n9t	0.555±0.030	1.742±0.062	<0.001
C18:1c	1.290±0.246	1.858±0.276	0.649
C18:2t	0.073±0.003	0.116±0.004	0.016
C18:2n6c	1.324±0.029	1.587±0.030	0.061
C20:0	0.126±0.004	0.149±0.005	0.284
C18:3n6	0.005±0.001	0.007±0.001	0.686

Table 5 (Continued)

Fatty acids	Experimental diets		P-value
	Control	Treated	
	(g/l)		
C20:1	0.017±0.002	0.010±0.001	0.287
C18:3n3	0.111±0.004	0.139±0.005	0.176
Cis-9,trans-11	0.036±0.002	0.021±0.001	0.059
C21:0	N/A	N/A	N/A
C22:0	N/A	N/A	N/A
C20:3n6	0.025±0.002	0.034±0.002	0.330
C22:1n9	N/A	0.003±0.001	0.242
C20:3n3	N/A	N/A	N/A
C20:4n6	N/A	N/A	N/A
C23:0	0.077±0.004	0.079±0.003	0.870
C22:2	N/A	N/A	N/A
C24:0	N/A	N/A	N/A
C20:5n3	N/A	N/A	N/A
C24:1	N/A	N/A	N/A
C22:6n3	N/A	N/A	N/A
Total omega 3	0.111±0.004	0.139±0.005	0.176
Total omega 6	1.426±0.030	1.743±0.031	0.0301
Omega 6 to omega 3 ratio	136.54±3.148	132.11±2.529	0.733
Saturated fatty acids	29.051±0.357	28.853±0.546	0.925
Unsaturated fatty acids	13.677±0.283	15.726±0.330	0.154
Saturated to unsaturated fatty acids ratio	21.737±0.357	18.606±0.267	0.050
Delta-9 desaturase index	341.161±3.580	371.158±3.182	0.077

N/A Not Applicable

Cost of feed and milk yield

At the time of experiment, the full fat extruded soybean diet had a lower cost of diet than control both by price per kilogram of feed and price per kilogram of milk (Table 6).

Table 6 Cost of feeding trial and milk yield

Parameters	Experimental diets	
	Control	Treated
Cost of diet (Baht/kg.)	14.83	13.98
Cost of total concentrate (Baht/14 days)	3337.20	3065.03
Cost of total feed intake (Baht/14 days)	4003.60	3731.43
Milk yield (Litre/14 days)	247.20	243.45
Feed cost per kg of milk (Baht)	16.19	15.33

DISCUSSION

The analysis of milk samples indicated that the milk yield and composition from treated group was not significant different when compare with the control group in mid lactation dairy goats. This result agreed with previous data that suggested milk yield increases in mid lactation dairy cows (Chilliard et al., 2001), but not in goats (Chilliard and Bocquier, 1993) and ewes (Nudda et al., 2003).

When supplemented with fat, milk fat content was not significant is different when compare with control. This may be linked to the fact that the control diet had been supplemented with 3% calcium soap of palm oil which increased fat yield (Teh et al., 1994). According to the milk fat content and percentage of concentrate relationship (Schmidely and Sauvant, 2001), it can be considered that the control diet induced a high milk fat content.

The result of feeding full fat extruded soybeans in a high concentrated ratio feed has no effect on milk fat and protein. It is also give a normal the milk fat to protein ratio. These results agree with when extruded soybean was supplemented 20% dry matter of 70:30 concentrate to forage ratio (total mix ratio) in mid lactation goats (Schmidely, 2005). These result agree with when supplement fat in goat dietary in the mid or late lactation period, milk protein content is variable (Morand-fehr and Sauvant, 1980). This latter point is of importance to goat cheese production because the milk fat to milk protein ratio affects cheese quality.

The analysis of milk fatty acid profiles indicated that the short and medium chain and conjugated linoleic acids from treated group was not significantly different from the control group. However, this finding is in contrast to Schmidely et al. (2005), fed 20% full fat extruded soybean of dry matter of high concentrate diets (30:70 forage-to-concentrate ratio) in mid lactation goats dramatic decreased the proportions of the short and medium chain FAs. It is possible that goats are lower milk production so total amount of full fat extruded soybean in treated group as fed individually requirement was low.

When treated group was compared with control group for long-chain FA concentration in milk, C16:0 concentration in milk was decreased, whereas C18:0 concentration in milk was increased by 45%. These were in line with Abu-Ghazaleh et al., 2002 when fed 2.5% of soybean oil from extruded soybeans in early lactation. Diets were composed of 50% of concentrate mix, 25% of corn silage, and 25% of alfalfa hay (dry basis) early lactation dairy cows, C16:0 concentration in milk was decreased, whereas C18:0 concentration in milk was increased by 39%. In early lactation dairy goats, Bouattour et al. (2008) fed 6% soybean oil as feed in the concentrate. Goats were fed dehydrated fescue (ad libitum), alfalfa pellets (0.5 kg/d), and concentrate (1 kg/d) increased milk concentration of stearic acid but reduced level of palmitic acid. Also Schmidely et al. (2005) fed extruded soybean in mid lactation dairy goats increased proportions of stearic acid and decreased palmitic acid in milk. The increased of C16:0 probably due to C16:0 from *de novo* synthesis were similar

between treated and control group. The other half of C16:0 came from palmitic acid in a calcium soup of palm oil in control diet which has more than treated diet.

Trans-9 C18:1 concentration in milk fat was more than triple that of control group, trans-9, trans-12 C18:2 was increased by 65%. The concurrent increases agreed with assertions by Abu-Ghazaleh et al. (2002) that indicated that Trans-9 C18:1 increased when cows were fed extruded soybean and Whitelock et al. (2002) that indicated it increased when cows were fed extruded soybean in early lactation with 50:50 ratio of forage to concentrate (DM basis). Also agrees with Bouattour et al. (2008) that indicated it increased when goats were fed extruded soybean. The trans-9 C18:1 is the incomplete ruminal biohydrogenation product. Kalscheur et al. (1997) observed an increase in the flow into the duodenum when fat was added to the diet of lactating cows. The increase of the trans-9 C18:1 in this study demonstrated that incomplete biohydrogenation occurred when goats were fed full fat extruded soybean

The milk contents of C16:0 was decreased and C18:0 and C18:2 were increased. Because the FA profile of the full fat extruded soybean was basically characterized by concentration of 54% of C18:2, 20% of C18:1, and small amount of C18:3 and C18:0 (Bailoni et al., 2004). These differences in the FA composition of the diets may explain the decreased in C16:0 and the increased in C18:0, C18:1 and C18:2 content in milk and probably be a) a result of the ruminal biohydrogenation of these unsaturated FA, and/or b) The higher proportion of long-chain fatty acids, then in turn decreased of C16:0 proportion, and/or c) the higher C16:0 content from calcium soap of palm oil in the control diet.

Linoleic acids (C18:2n6c) tended to increased. This result generally agreed with Abu-Ghazaleh et al. (2002), Whitelock et al. (2002), Schmidely et al. (2005), and Bouattour et al. (2008), who reported milk C18:2n6c increases when supplemented extruded soybean in the diet. It was probably due to dietary C18:2n6 in small intestine flow to mammary gland by blood plasma in a form of micelle.

In contrast to other data reported in feeding goats with extruded soybean, cis-9, trans-11 CLA was not increased. The cis-9, tran-11 CLA is an intermediate product of ruminal biohydrogenation. It tended to decrease probably because a) ruminal biohydrogination produce more C18:0, C18:1, and other isomer of C18:2, then in turn the proportion of CLA decrease, and/or b) The low total linoleic acid intake due to low milk yield. When supplemented with low total amount of LA, rumen microbial can work to complete RBH product easily than high amount of LA. Therefor the most of RBH products were C18:0, a completed product not a CLA, an intermediate product.

The saturated to unsaturated fatty acids ratio tended to decrease. This result agrees with other reports of feeding extruded soybeans (Abu-Ghazaleh et al., 2002; Whitelock et al., 2002; Schmidely et al., 2005). This may be favorable from a nutritional point of view for humans.

When supplemented with full fat extruded soybean, delta-9 desaturase index was not significant different when compare with the control diet, in agreement with the results described by Bouattour et al. (2008) which calculated for each pair of FAs, the desaturase indexes were not significantly different for C16, C18, and CLA, but were decreased ($P<0.05$) for C14 when extruded soybean was fed to Murciano-Granadina dairy goats. As with in cows, the pairs of fatty acids, C14, C16, and C18 were relate to delta-9 desaturase irrespective of diet (Ntambi, 1999).

At the experiment time, the lower cost of diet was observed in goats fed the soybean diet. This figure from the experiment show the economic feasibility of feeding such type of ingredients and saving that can be achieved as shown in Table 6. This economic feasibility is up to varying feed ingredients prices.

CONCLUSIONS AND RECOMMENDATION

Conclusions

1. Supplemented full fat extruded soybeans in the diet did not effect on milk yield, milk fat content, and milk protein when compare with the control diet.

2. Milk long chain fatty acid profiles; C16:0, C18:0, trans-9 C18:1, and trans-9, trans-12 C18:2 in the mid-lactation goats were significant different and saturated to unsaturated fatty acids ratio tended to decrease (P=0.05).

3. In this experiment, supplemented full fat extruded soybeans in the diet tended to decrease milk CLA content when compare with the control diet.

4. Lower cost of diet was observed in goats fed the full fat extruded soybean diet when compare with control diet at that experiment period.

Recommendation

The results obtained from this research can be used as a tool used to consider a high CLA milk production by supplemented linoleic or linolenic acids in a concentrated diet that should be done in high production goats, as total linoleic or linolenic acids intake is greater so producing higher level of CLA in the milk product. Also farm economic feasibility of feeding soybean compare with calcium soap of palm oil to get more an economics of dairy goat farms should be consider depending on the feed ingredient price.

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CURRICULUM VITAE

NAME : Ms. Rachanokorn Srikong

BIRTHDAY : April 6, 1976

BIRTH PLACE : Ratchaburi, Thailand

EDUCATION :

YEAR	INSTITUTE	DEGREE/DIPLOMA
1999	Khonkaen Univ.	D.V.M.

POSITION/TITLE : -

WORK PLACE : -