ผลของการใช้น้ำมันมะพร้าวต่อพลาสม่าเมทาโบไลต์และสมรรถภาพของการให้น้ำนม ในแพะลูกผสม ช่วงต้นการให้นม

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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THE EFFECT OF COCONUT OIL SUPPLEMENTATION ON PLASMA METABOLITE AND LACTATION PERFORMANCE IN EARLY LACTATING CROSSBRED SAANEN GOATS

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เทียว เคย โฮ : ผลของการใช้น้ำมันมะพร้าวต่อพลาสม่าเมทาโบไลต์และสมรรถภาพของการให้น้ำนม ในแพะลูกผสม ช่วงต้นการให้นม (THE EFFECT OF COCONUT OIL SUPPLEMENTATION ON PLASMA METABOLITE AND LACTATION PERFORMANCE IN EARLY LACTATING CROSSBRED SAANEN GOATS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: สมชาย จันทร์ผ่องแสง, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: สัมพันธ์ ธรรมเจริญ, 51 หน้า.

น้ำมันมะพร้าวได้ถูกนำมาใช้ในการเพิ่มการกินอาหารและการผลิตน้ำนมในโคนม แต่อย่างไรก็ตามยังไม่พบข้อมูลการใช้น้ำมันมะพร้าวเป็นอาหารเสริมในแพะนมพันธ์ผสมที่มีการเลี้ยงในเขตร้อนชื้น ซึ่งการศึกษาครั้งนี้ต้องการศึกษาหาข้อมูลผลของการเสริมน้ำมันมะพร้าวต่อพลาสมาเมตาโบไลท์ และสมรรถภาพการผลิตนมในแพะนมพันธุ์ผสมในช่วงต้นของการให้นม รวมทั้งมีการศึกษาพฤติกรรมการกินอาหารของแพะ

การศึกษาในครั้งนี้จะใช้แพะนมตั้งท้อง พันธุ์ผสมซาเนน จำนวน 10 ตัว และก่อนคลอดแพะทั้งหมดจะถูกแบ่งสุ่มออกเป็น 2 กลุ่มๆละ 5 ตัว โดยกลุ่มควบคุมจะได้รับอาหารที่ไม่มีการเสริมน้ำมันมะพร้าว และกลุ่มทดลองจะได้รับอาหารที่มีการเสริมด้วยน้ำมันมะพร้าวในปริมาณ 2 % อาหารทั้ง 2 สูตรมีพลังงานและโปรตีนเท่ากัน แพะแต่ละตัวจะได้รับอาหารและน้ำอย่างไม่จำกัด มีการบันทึกปริมาณวัตถุแห้งที่กิน ปริมาณน้ำที่กิน และปริมาณน้ำนมของแพะแต่ละตัวตลอดการทดลอง รูปแบบการกินอาหารจะถูกประเมินในวันที่ 25 ของการทดลอง มีการเก็บเลือดในช่วงก่อนคลอด 3 สัปดาห์ และ 5 สัปดาห์หลังคลอด โดยผลการศึกษาพบว่า ปริมาณวัตถุแห้งที่กิน ปริมาณวัตถุแห้งที่กิน/เปอร์เซนต์น้ำหนักตัว ปริมาณน้ำที่กิน การย่อยได้ของสารอาหาร กระบวนการเมตาโบลิซึมของไนโตรเจน และผลผลิตน้ำนมในแพะทั้ง 2 กลุ่มไม่มีความแตกต่างกัน และการเสริมน้ำมันมะพร้าวไม่ส่งผลต่อปริมาณกลูโคส NEFA เบต้าไฮดรอกซีบิวไทเรต และคอร์ติซอล แต่น้ำมันมะพร้าวสามารถเพิ่มปริมาณไขมันและโปรตีนในน้ำนมได้ นอกจากนี้การเสริมน้ำมันมะพร้าวสามารถเพิ่มขนาดและช่วงเวลาของมื้ออาหารได้ ซึ่งแสดงให้เห็นว่าการเสริมน้ำมันมะพร้าว 2 % น่าจะมีผลต่อความน่ากินของอาหาร

ภาควิชา สัตวบาล ลายมือชื่อนิสิต .....

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THIEU KHOI HO: THE EFFECT OF COCONUT OIL SUPPLEMENTATION ON PLASMA METABOLITE AND LACTATION PERFORMANCE IN EARLY LACTATING CROSSBRED SAANEN GOATS. ADVISOR: PROF. SOMCHAI CHANPONGSANG, D.V.M., M.Sc., CO-ADVISOR: ASSOC. PROF. SUMPUN THAMMACHAROEN, D.V.M., M.Sc., Ph.D., 51 pp.

Coconut oil has been used to improve feed intake and lactation performance in dairy cattle. However, there was no information of coconut oil supplementation in crossbred dairy goat under tropical condition. Therefore, the current study designed to investigate the effect of coconut oil supplementation on eating behavior and lactation performance in crossbred dairy goat during early lactation. Ten crossbred Saanen goats were used in the current experiment. Before parturition, animals were randomly divided into two groups of five animals each. Diets were control diet (without coconut oil supplementation) and experimental diet (with 2% coconut oil supplementation). Both diets were isoenergetic and isonitrogenous. Each goat was fed ad libitum twice daily as total mix ration (TMR) with free access to water. Dry matter intake (DMI), water intake (WI) and milk yield (MY) of each animals were measured every day throughout experiment. Meal pattern of each animal was recorded at day 25 post-partum. Blood samples were collected at one week before parturition, week 3 and 5 post-partum. DMI, dry matter intake/body weight (DMI/BW), WI, nutrient digestibility, nitrogen metabolism, milk yield were not significant difference in both groups. In addition, concentration of blood glucose, plasma non-esterified fatty acid (NEFA), plasma β-Hydroxybutyrate (BHBA) and cortisol hormone were not affected by coconut oil supplementation. However, coconut oil supplementation increased milk fat and protein composition. The results from meal pattern revealed that coconut oil supplementation increased significantly meal size and duration of crossbred Saanen dairy goat. The latter information suggested that 2% coconut oil supplementation may influence the palatability of diet fed to crossbred Saanen dairy goat.

Department:	Animal Husbandry	Student's Signature	.....
Field of Study:	Animal Nutrition	Advisor's Signature	.....
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CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADF	=	Acid detergent fiber
BHBA	=	β-Hydroxybutyrate
BW	=	Body weight
CP	=	Crude protein
DIM	=	Day in milk
DM	=	Dry matter
DMD	=	Dry matter digestibility
DMI	=	Dry matter intake
DMI/BW	=	Dry matter intake/body weight
EE	=	Ether extract
MY	=	Milk Yield
N	=	Nitrogen
NDF	=	Neutral detergent fiber
NE	=	Net energy
NEFA	=	Non-esterified fatty acid
OMD	=	Organic matter digestibility

CHAPTER 1

INTRODUCTION

Milk and product from milk are good food for human consumption. The milk production of dairy animal is limited by energy and nutrition content of diet, feed intake and digestibility (Allen, 2000). During early lactation period, dairy animals require high energy for maintenance and production, but their feed intake is reduced (Herdt et al., 1988; Grummer, 1991). Many studies have been conducted to improve lactation performance during early lactation by dietary supplementation. Fat supplementation has been suggested because it is the direct way to increase both energy intake and utilization efficiency (Chilliard, 1993). Fat supplementation increased milk production in both cattle and goat (Chilliard et al., 2003; Mele et al., 2010). In dairy goat, milk production when fat supplementation increased in early lactation, but it was not increased in mid and late lactation (Chilliard et al., 2003). In dairy goat, fat supplementation increased milk protein and fat content (Ollier et al., 2009; Mele et al., 2010), but milk protein content was reduced when fat supplementation in dairy cattle (Chilliard, 1993).

The effect of fat supplementation on milk yield and composition relate with effect of fat on feed intake and nutrient digestibility (Coppock and Wilks, 1991; Doreau and Chilliard, 1997). Unfortunately, fat supplementation reduced DMI (Chilliard, 1993) and NDF digestibility in dairy cattle, but reduction in DMI when fat supplementation has not been shown in small ruminant as sheep and goat (Rossell, 1985; Martínez Marín et al., 2013). In dairy cattle supplemented with fat that contained high unsaturated fatty acid decreased DMI and meal size (Harvatine and Allen, 2006). Coconut oil is one of coconut by products (Storry et al., 1974; Lee et al., 2011; Hollmann and Beede, 2012) and it contains mainly saturated fatty acid (Rossell, 1985). Previous study found that coconut oil supplementation did not change DMI (Hristov et al., 2009), whereas other found that DMI was reduced in dairy cattle (Lee et al., 2011; Hollmann and Beede, 2012). In dairy cattle, effect of coconut oil supplementation on DMI was varied and depended on level of coconut oil in diet (Hristov et al., 2009).

Coconut oil supplementation at high level (4 or 5%) decreased DMI, while the low level of coconut oil supplementation (2 or 3%) decreased DMI in next two to six day of experiment (Hollmann and Beede, 2012). The difference in DMI when different level of coconut supplementation may be caused by palatable of diet when fed to dairy cattle (Hollmann and Beede, 2012) as a result eating behavior may be affected by coconut oil.

Although, many studies observed the effect of coconut oil supplementation on feed intake and lactation performance. However, the effect of coconut oil supplementation on lactation performance and eating pattern in dairy goat fed under tropical condition has not been investigated. In addition, the project aimed firstly at the effect of coconut oil supplementation on lactation performance and secondly on meal pattern during early lactation. The current experiment will provide the important information of the coconut oil supplementation effect in crossbred dairy goat fed under hot and humid condition of Thailand.

CHAPTER 2
LITERATURE REVIEW

2.1. Eating behavior and meal pattern

Eating behavior of ruminant has been studied for a long time (Ungar, 1996). This behavior consist of the two main activities in ruminant including eating and ruminating (Abijaoudé et al., 2000). In all living organism, the spontaneous eating pattern could be measured using an automatic weighing system and the variables consist of meal size, duration, rate and inter-meal interval. Research on eating behavior in ruminant focus mainly on effect of diet on satiation which is indicated in part by meal size and duration. The effect of diet on hunger is indicated by inter-meal interval, but less researches has been conducted about it (Allen, 2000). Dietary characteristics, management, housing, environment, and individual animal were factor affecting meal pattern (Dado and Allen, 1995). In ruminant, meal pattern differs between species and it has been recorded by visual observation techniques or advances in technology via electrical balance and recording by computer (Nielsen, 1999; Haddad and Husein, 2004). In goat, the new technology of electronic scale and computer programing supported the measurement of meal pattern in whole day (Nielsen, 1999). The variables from meal pattern are importance factor for estimate the DMI in ruminant (Senn et al., 1995).

2.2. Effect of fat supplementation on dry matter intake and nutrient digestibility

Fat supplementation had the negative effect on DMI (Chilliard, 1993). Negative effect on DMI when fat supplementation is variation in ruminant species, it happens in cow more than in ewe and goat (Martínez Marín et al., 2013). Soybean oil supplementation with 2.5 and 4.0% were no effect on DMI of dairy goat (Bouattour et al., 2008; Mele et al., 2010). In another vegetable oil source, Ollier et al. (2009) found that 4.4% sunflower oil supplementation did not decrease DMI in dairy goat.

Reduction of DMI when fat supplementation could relate with effect of fat on rumen activity and gut hormones secretion (Allen, 2000). Ruminant animals reduce the eating

time and DMI, because negative effect of fat in rumen activity increases ruminating time (Martínez Marín et al., 2013). Fat supplementation reduces emptying rumen due to appearance of long chain fatty acid in rumen (Chilliard, 1993). In dairy cow supplemented with fat, gut peptides concentration as insulin and cholecystokinin (CCK) were decreased and increased, respectively (Choi and Palmquist, 1996). Negative effect of CCK on DMI comes from the satiety effect of brain (Reidelberger, 1994). The satiety effect from brain could stimulate by oxidation of fat in the liver, but it did not show in the ruminants (Allen, 2000). So, the negative effect of fat on DMI related with hypophagic effect which stimulated by satiety signal from brain. The connection between DMI and nutrient digestibility have been suggested, but data was variation in this area. In dairy cow, DMI was no difference while DM digestibility was lower in fat diet compare with control diet (Murphy et al., 1987).

Fat supplementation reduced neutral detergent fiber (NDF) digestibility due to reduction on microorganism digestion in fiber coating with fat and negative effect of fat on rumen microorganism (Palmquist and Jenkins, 1980). Organic matter intake and NDF were reduced when fat supplementation (Pantoja et al., 1994). Organic matter (OM) and neutral detergent fiber digestibility (NDFD) were reduced when supplemented fat in diet. In dairy cow, sunflower seed with 4.1% reduced 18% of organic matter digestibility (OMD) (Beauchemin et al., 2009) and 5% of saturated tallow decreased 43.8% to 51.4% of NDF rumen digestibility (Pantoja et al., 1994).

2.3. Effect of fat supplementation on lactation performance

Dietary fat supplementation can affect lactation performance on both yield and major milk compositions (Chilliard et al., 2001). Fat supplementation apparently influences milk yield in 2 different ways. First, the high energy density in dietary fat has been shown to improve energy balance and thereby increasing in milk yield. Fat supplementation with 1.6 - 3.2% increased milk yield (Chilliard et al., 2001). However, fat supplementation has been shown to produce the negative effect on DMI and digestion. The latter mechanism of dietary fat on MY seems to be the indirect effect via DMI and depends on the percentage of fat. In goat, milk yield and DMI of animal were reduced when diet supplemented with 3% tuna oil (Kitessa et al., 2001).

In dairy goat, milk fat composition is higher in early lactation period than another period (Chilliard et al., 2003). Higher milk fat composition after parturition come from increase milk yield and available of plasma NEFA from fat mobilization for milk fat synthesis (Chilliard et al., 2003). The effect of fat supplementation on milk fat composition is partially influenced by the effects of fat in the rumen (Emmanuel, 1974; Emmanuel, 1978). The effect of fat supplementation on milk fat composition related with degree of protection fat sources (Martínez Marín et al., 2013). Protected fat sources increased amount of milk fat, while non-protected fat sources decreased milk fat content (Martínez Marín et al., 2013). Reduction of milk fat when non-protected fat supplementation come from negative effect of non-protected fat on rumen fermentation and concentration of acetate (Martínez Marín et al., 2013). The reduction of milk fat content when fat supplemented in dairy animals related with amount of unsaturation fatty acid in fat sources. Milk fat content was reduced 0.26% with 12.7% of extruded linseed (Gonthier et al., 2005) and 0.31% with 20% of sunflower seeds in diet (Casper et al., 1988). The unsaturation fatty acid reduced milk fat composition due to inhibit effect of unsaturation fatty acid on de novo synthesis of fatty acid in mammary gland (Chilliard et al., 2000). The response of cow, ewe and goat on milk fat content when fat added in diet were difference, ewe and goat increased milk fat content but it was not in dairy cow (Martínez Marín et al., 2013). In addition, in ewe, milk fat content was higher in early lactation than in late lactation. In opposite, milk fat content in dairy goat during early lactation (0.6 ± 0.1 g of fat/kg of milk) was lower than mid lactation (1.0 ± 0.2 g of fat/kg of milk) (Teh et al., 1994; Mir et al., 1999; Brown-Crowder et al., 2001; Bernard et al., 2005; Bouattour et al., 2008; Rapetti et al., 2009).

Milk protein content of cow and ewe were decreased by fat supplementation, but dairy goat fed with fat supplementation did not show reduction of protein content in milk (Martínez Marín et al., 2013). In cow, 3.5% fat supplementation decreased milk protein content, and 7% fat supplementation significantly reduced the ratio of casein in total nitrogen (DePeters and Cant, 1992). Fat supplementation could reduce 1.6 g protein/kg milk and 1.5 casein g/kg milk in dairy cow (Martínez Marín et al., 2013).

However, reduction of milk protein when fat supplementation does not usually happen in small ruminant, spectacularly goat (Sanz Sampelayo et al., 2007). In dairy goat, milk protein content was not depress when supplemented with 2.5% of soybean oil and with 4.4% of sunflower oil (Bouattour et al., 2008; Ollier et al., 2009). Lower milk protein content when fat supplementation manipulated by a simple dilution effect, because fat supplementation had an insufficiency of amino acid which was sources for protein synthesis (Smith et al., 1981; Wu and Huber, 1994). In another hand, an increase of gluconeogenesis from amino acid due to reduction of propionate concentration (Smith et al., 1981) or a decrease of rumen microbial protein population (Coppock and Wilks, 1991) occurs when fat supplementation. Another reason for the negative effect of fat on milk protein ratio comes from decrease amount of amino acid uptake in mammary glands because of reduction in release of insulin (Mackle et al., 2000). A simple dilution effect, glucose metabolism or release of insulin has been suggested as some hypothesis to explain for negative effect of fat supplementation on milk protein composition.

2.4. Coconut oil for supplementation in dairy animal feed

Coconut oil is the oil extracted from coconut by various method as dry and wet method (Marina et al., 2009). The dry method is the most popular extraction method that uses high temperature. On the other hand, the wet or cold press method is the extraction without using the high temperature. The cold extraction coconut oil is for human consumption (Dia et al., 2005). Coconut oil consists mainly of medium change fatty acid including lauric acid (47.5%), myristic acid (18%) and another fatty as palmitic acid (8.8%), caprylic acid (7.8%), capric acid (6.7%), oleic acid (6.2%), stearic acid (2.6%) linoleic acid (1.6%), caproic acid (0.5%). Coconut oil supplementation at 2 to 4% clearly decreased DMI of dairy cattle (Hollmann and Beede, 2012). However, 2.1% coconut oil supplementation did not effect on DMI in dairy cattle (Hristov et al., 2009).

In dairy cattle, coconut oil supplementation at the comparable level (2.1% versus 2.3%) produced either no effect or decrease in milk yield (Hristov et al., 2009; Lee et al., 2011). Coconut oil supplementation from 2 to 5% did not affect the major

milk composition (Hristov et al., 2009; Lee et al., 2011). However, coconut oil supplementation may increase lauric and myristic acid content of milk fat (Steele and Moore, 1968; Rindsig and Schultz, 1974; Dohme et al., 2004).

2.5. Mammary function

The lactation period of crossbred dairy goat in Thailand is about 5 months and peak of lactation was at day 35 post-partum (Thepparat et al., 2015). Milk provides the major sources of nutrient and growth factors to the young mammalian species: carbohydrate (lactose), protein (casein), fat (triglyceride) and mineral as well as water. Goat milk consists 12.1% of total solid, 3.6% of fat, 3.3% of protein, 4.6% of lactose and 0.8% of Ash (Harding, 1995). These composition of goat milk depend on both internal and external factors; feeding and management conditions, breed, parity, stage of lactation, environmental conditions, udder health, season of year or kidding. Moreover, the difference in milking practices and collection system also affected to goat milk composition (Park, 2005).

Milk synthesis depends in part on nutritional factors. The synthetic pathways can be separated into 3 main milk compositions including; lactose, protein and fat. For milk fat synthesis, the fatty acids in milk are derived from 3 main sources. The mammary epithelium has its own capacity to generate fatty acids, de novo synthesis, from acetate and BHBA. The product of de novo fatty acid synthesis is mainly the medium chain fatty acids (C8-C14). Dietary and depot fats are the other 2 sources provides long chain fatty acids for fatty acid in milk (Dils, 1986; Neville and Picciano, 1997; Bauman and Griinari, 2003). Amino acid from the circulation is the main substrate for protein synthesis from mammary gland (DePeters and Cant, 1992). Both of essential and non-essential amino acids are utilized for milk protein synthesis (Mepham, 1982). Finally, glucose is the main precursor for lactose synthesis, and it is utilized 85% of carbon in lactose (Bell, 1995). The uptake of glucose by mammary gland increases dramatically during early lactation and is related with increase in milk secretion (Bell, 1995; Chaiyabutr, 2012).

2.6. Metabolism during early lactation period

Dairy animals encounter one important physiological stress of the negative energy state. The energy demand of milk and the ability to eat during this period are usually uncoupling (Banos and Coffey, 2010; Weber et al., 2013). In many aspects of metabolism, this kind of stress is similar to fasting. However, the phenomenon has its own characteristic that is the cause of negative energy balance. While decrease in energy input or eating is the main cause of fasting, the high energy output for milk drives the dairy animals into energy deficit state. The characteristic of metabolism during this period will be shortly presented in this section.

Negative energy balance during early lactation, the increase in lipolysis and decrease in abdominal adipose tissue weight have been demonstrated (Tulloh, 1966; Sidhu and Emery, 1972; Yang and Baldwin, 1973). NEFA is widely used for synthesis of milk fat (Hartmann and Lascelles, 1964). During the balance state, the mobilization of body fat provides only for 10% of the fatty acids in milk fat. However, when dairy ruminant is in negative energy balance, fatty acids in milk come mainly from adipose tissues (Bauman and Griinari, 2003).

The negative nitrogen balance in cow and ewes have been demonstrated as well during early lactation. This is indicated by 25% reduction in muscle fiber diameter in dairy cows immediately after calving and a decline in muscle protein: DNA ratio during early lactation in ewes (Reid et al., 1980; Smith et al., 1981). In dairy goat, the negative nitrogen balance may occur due to an increase in protein degradation, a decrease in body synthesis, or both (Baracos et al., 1991). The amino acids for mammary metabolism or hepatic gluconeogenesis has been mobilized from the tissue protein (Bauman et al., 1983) and mostly from skeletal muscle (Bell, 1995).

During early lactation period, the metabolic status of dairy goat is significantly changed in part due to changing in endocrine profile. This change facilitates diversion of nutrients away from maternal stores toward the fetus during pregnancy and milk production (Sadjadian et al., 2012). The metabolic status of dairy animals could be identified in part by the concentration of plasma metabolites plasma as BHBA, NEFA

and glucose. Both of BHBA and glucose concentration are lower in pre-partum period than in early lactation period, but NEFA concentration is higher in pre-partum period than in early lactation period (Sadjadian et al., 2012).

Glucose plays the major role in carbohydrate metabolism during early lactation due to increment of the milk production. The glucose in the circulation of ruminant mostly be utilized by the lactating udder for lactose synthesis, so mammary glucose uptake is highly related with lactose synthesis or output (Bickerstaffe et al., 1974; Horsfield et al., 1974; Chaiyabutr, 2012). Therefore, the milk synthesis is highly correlated with the level of glucose which converted into lactose in the udder (Chaiyabutr, 2012). Glucose concentration was highest level on the day of parturition due to changing metabolic towards gluconeogenesis and enhancing glycogenolysis (Herdt et al., 1988; Vazquez-Anon et al., 1994). After day of parturition, glucose concentration has been shown to decrease and it is at the lowest level on day 13 of postpartum period because of elevation energy demands for lactation in high milk-producing breeds of goats (Sadjadian et al., 2012).

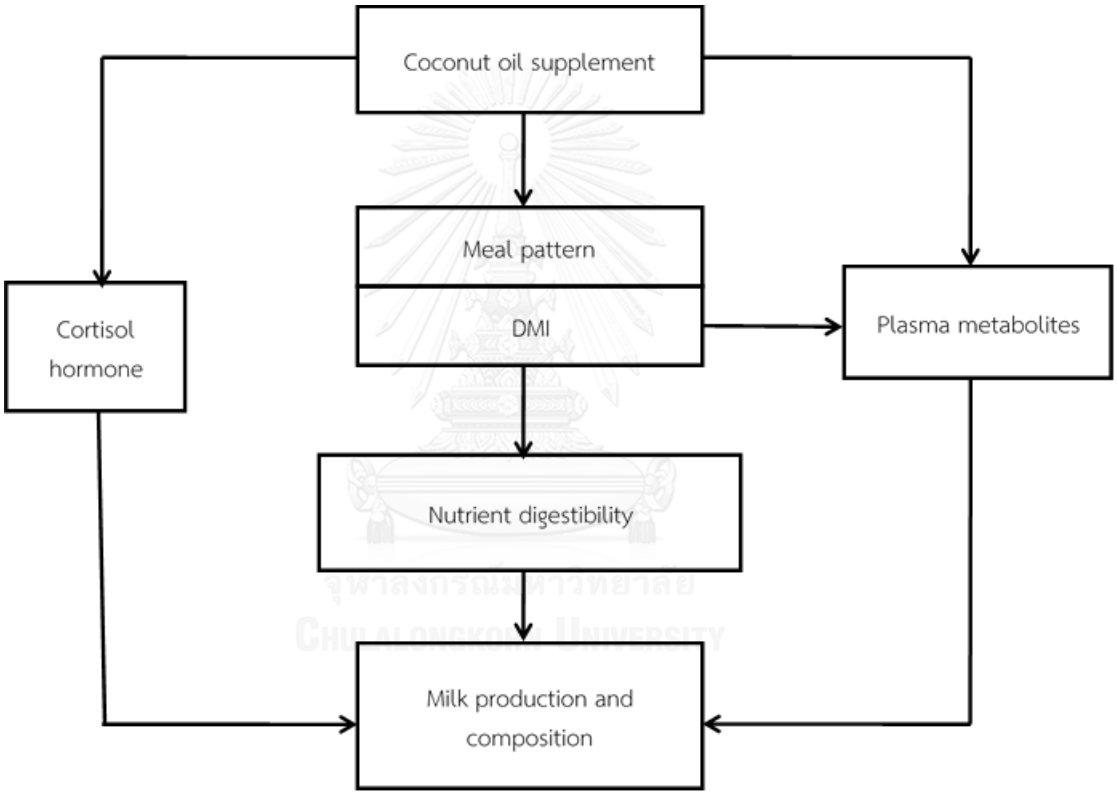
In dairy goat, BHBA concentration increases in early lactation period due to enhancement of energy requirement for milk secretion (Vazquez-Anon et al., 1994). During early lactation period, plasma BHBA concentration increased from parturition day to day 21, after that it reduced (Sadjadian et al., 2012).

The plasma NEFA concentration indicates the negative energy balance by reflects the fat mobilization rate from fat reserves (LeBlanc, 2006). NEFA concentration was highest level at parturition day (Busato et al., 2002; Taghipoor et al., 2011), because of elevation of energy demand for parturition and for milk production (Vazquez-Anon et al., 1994; Grum et al., 1996). During early lactation period, plasma NEFA decreased from day 13 until 35 post-partum period (Sadjadian et al., 2012).

The plasma cortisol level is related with the parturition time, milk secretion and stress. In addition, cortisol may influence glucose metabolism and increase plasma glucose concentration due to inhibition glucose tissue uptake (Kusenda et al., 2009). In dairy goat, plasma cortisol was higher in pre-partum period than in early lactation

period (Khan and Ludri, 2002). Increasing of plasma cortisol is in part required for the acceleration of mammary growth and the initiation of lactation (Kitts, 1984; Hydbring et al., 1999). In addition to the role of plasma cortisol during early lactation period, this hormone plays an important role during stress responses. In fasting period induced negative energy balance, plasma cortisol is increased and the concentration remains higher than the concurrent control dairy cow (Moyes et al., 2009).

Conceptual frame work



CHAPTER 3
MATERIAL AND METHOD

3.1. Location and environmental temperature of the study area

The experiment was conducted at Veterinary Student Practice Center, Faculty of Veterinary Science, Chulalongkorn University, Nakhon Pathom province, Thailand. The average temperature in the shed was 25.02 ± 0.58°C at 0700 am to 32.62 ± 0.53°C at 0300 pm. The average relative humidity was 82.94 ± 2.29% at 0700 am to 65.64 ± 0.94% at 0300 pm. The calculated temperature humidity index (THI) according to the formula below (NRC, 1971) was 75.44 ± 1.10 at 0700 am to 84.69 ± 0.79 at 0300 pm throughout the experiment.

THI = (1.8 x dry bulk temperature + 32) - [(0.55 – 0.0055 x relative humidity) x (1.8 x dry bulk temperature – 26.8)]

3.2. Animals and management

Ten crossbred Saanen does goats, at first lactation period, average BW 33.9 ± 2.2 kg, were used in the current experiment. Two groups of experiment were control group (without coconut oil supplement) and experimental group (with 2% coconut oil supplement). The coconut oil was extracted by heated (hot methods) processes. Before parturition, animals were kept in the individual metabolic cage for adaptation and randomly assigned into two groups of five animals each. They were fed ad libitum with control and experimental diet as TMR, containing corn by product silage and concentrate, shown in table 1. Animal were fed twice daily at 0700 am and 0200 pm and free access with water and mineral block. The experimental period was 35 days after parturition (Fig 1). Animal and experimental protocols were approved by Faculty of Veterinary science, Chulalongkorn University, Thailand (Approval No.1431075).

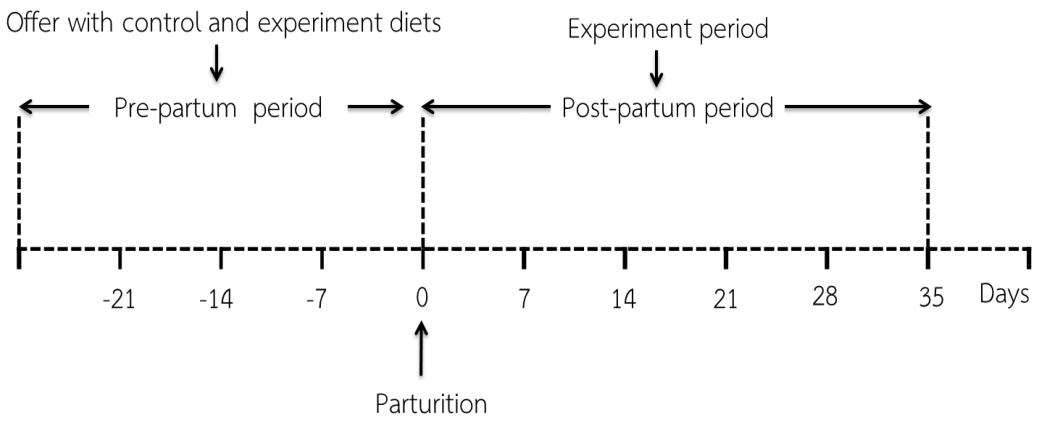


Figure 1 Experiment schedule.

Table 1 Ingredients of control and experimental diets (Dry matter basic).

Diet composition (%)	Diets	
	Control	Experimental
Corn by product silage	44.0	44.0
Cassava	3.3	8.8
Soybean meal	19.6	20.2
Coconut oil	0.0	2.0
Molasses	3.7	4.9
Corn meal	25.8	7.0
Rice bran	2.2	11.2
Premix	0.5	0.5
Limestone	0.9	0.9

3.3. Body weight measurement

After parturition, the weight of each animal was measured at day 0, 14, 25 and 35. All animals were weighed before morning feeding.

3.4. Determination of dry matter intake, water intake and nutrient digestibility

Feed offered and feed refusals were daily recorded in the morning starting from parturition to day 35 postpartum.

Daily dry matter intake was calculated by following formula:

Daily feed intake = feed offered - feed refusals (Dry matter basis)

Feed samples were collected from day 26 to 35 and divided into two sub-samples. First sub-sample was dried in 105^0C ovens for overnight to determine dry matter. The second sub-sample was kept at -20^0C for later proximate analysis. All feed samples in each animal were mixed thoroughly and dried at 55°C overnight (about 12h) and determined nutrient composition by proximate analysis (Association of Official Analytical Chemists, 2000), NDF and ADF by the procedure of Van Soest et al. (1991).

Total fecal collections were performed during day 26 to 35. Ten percent of total fecal amount was collected and divided into two sub-samples. The first sub-sample was dried at 105 °C in oven until constant weight to measure the dry matter of feces. The remaining sub-sample was kept at -20^0C for analysis of nitrogen, ash, NDF and ADF concentration.

Nutrient digestibility was determined by:

$$\text{Digestibility nutrients } (\%) = \frac{\text{Nutrients in feed intake-Nutrients in feces}}{\text{Nutrients in feed intake}} \text{x100}$$

Water intake (WI) was daily measured from parturition to day 35 postpartum. The measurement of water intake was performed by subtracting the weight of water offered with the weight of water refusal.

3.5. Determination of meal pattern

At day 25 post-partum, meal pattern was recorded continuously for 24h using digital balance equipped to data processing software (PBA 665 & Weigh Term 231G, Mettler Toledo, Zürich, Switzerland). Digital balance was fixed under the feed containers of goats. Balance with feed containers was protected by wood boxes. The actual weight of feed containers was checked and recorded automatically by a personal computer in 2 times/minute. Parameters recorded were meal size, meal duration, meal frequency and inter-meal interval (Fig 2). Meals were defined as feed removals exceeding 5g that are separated by at least 15 minutes of non-feeding (Rossi et al., 1998).

Animal was fed two times each day, morning and afternoon feeding. The first meal immediately after providing the feed is defined as meal 1. The meals that animal spontaneously eat after the first meal (meal 2 and meal 3) are defined as the resting meal. Meal size and duration are the weight of feed and time of eating in each meal. Meal frequency is the number of meal during 24 h. The inter-meal interval is the time between 2 meals and correspond to the time that the feed could not interest the animal eating behavior.

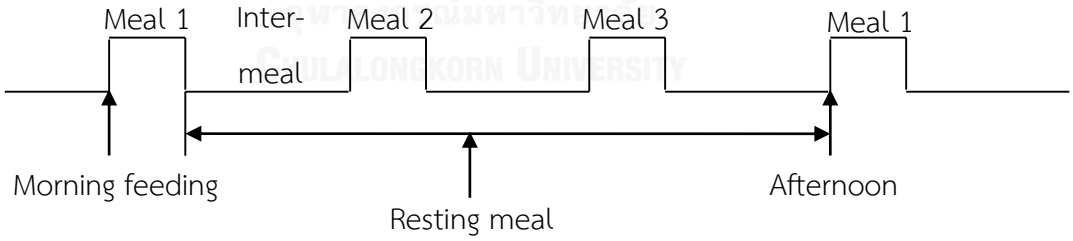


Figure 2 The diagram determined the meal patterns in ruminant

3.6. Determination of milk yield and milk composition

Daily milk yield from each animal was the sum of milk that was manually collected by hand at 0730 am and 0230 pm. Milk was weighed from parturition to day 35 post-partum.

Milk samples (30 ml) were collected during morning and evening milking on day 26 to 35. The milk samples were kept at -20 ^{o}C until analysis. Milk samples were

analyzed for total solids, protein, fat, lactose and solid not fat using Milkoscan FT 6000 (Foss Electric, Hillerød, Denmark).

4% fat corrected milk (FCM) was calculated by formula below (NRC, 2001):

4% FCM (L/day) = (0.4 x milk yield) + (15 x milk fat yield)

3.7. Determination of nitrogen balance

Total urine was collected on the same day as feces using plastic containers with 10% sulfuric acid solution (13 ml H_2SO_4 10% in 100 ml urine) to prevent nitrogen loss (final pH of urine was kept below 3). Ten percent of total volume urine for each day was collected. All urine samples were kept in refrigerator and pooled at the end of each period and kept at -20^{0}C till analysis. The urine was measured for nitrogen content by the Kjeldahl method (Association of Official Analytical Chemists, 2000).

To determine the nitrogen retention the following formula was performed:

Nitrogen retention = Total nitrogen in feed intake – (total nitrogen in feces + total nitrogen in urine + total nitrogen in milk)

3.8. Determination of blood glucose, plasma BHBA, NEFA and cortisol

From one week before parturition and week 3 and 5 of post-partum, blood samples were collected at two hours after morning feeding. Blood samples were obtained from the jugular vein, placed in Ethylenediaminetetraacetic acid (EDTA) tube and kept under crushed ice. To separate plasma, blood samples were centrifuged at 3,000 rpm for 10 minutes, aliquot of plasma was kept at -20 C for further analysis. Blood glucose was immediately determined by ACCU-CHEK® advantages glucose meter (Roche interamericana S.A). The plasma samples were analyzed for plasma NEFA by free fatty acid quantification kit (Abcam plc, catalog number ab65341), plasma BHBA by β-hydroxybutyrate assay kit (Abcam plc, catalog number ab83390), plasma cortisol hormone by goat cortisol ELISA (The enzyme-linked immunosorbent assay) kit (Biovision inc, catalog number MBS935829).

3.9. Statistical analysis

All data were reported as the mean value ± the standard error of the mean (SEM). Effect of treatment and time were analyzed by analysis of variance (ANOVA). The means difference between groups were compared using the unpaired t test at $P<0.05$. The meal frequency between treatments was analyzed by Wilcoxon rank sum test.

CHAPTER 4

RESULTS

4.1. Chemical composition of control and experimental diets

The nutrient composition of control and experimental diets were shown in table 2. The composition of DM, CP, NDF, ADF, Ash and net energy (NE) were balance between both diets. Control and experimental diets contained 37.7 vs. 37.7% of DM, 16.4 vs. 16.7% of CP, 42.9 vs. 42.5% of NDF, 25.6 vs. 25.9% of ADF, 7.4 vs. 7.5% of Ash and 1.7 vs. 1.7 Mcal/kg DM of NE (NRC, 1981), respectively. In the other hand, Ether extract (EE) composition differed in both diets and higher for experimental diet. Ether extract composition was 3.0% in control diet, while experimental diet with 2% coconut oil contained 4.7% of ether extract.

Table 2 Chemical composition of control and experimental diets.

Items (% DM basic)	Diets	
	Control	Experimental
DM	37.7	37.7
CP	16.4	16.7
NDF	42.9	42.5
ADF	25.6	25.9
EE	3.0	4.7
Ash	7.4	7.5
NE (Mcal/kg DM)*	1.7	1.7

*Calculated from (NRC, 1981)

4.2. Effect of 2% coconut oil on body weight, dry matter intake, dry matter intake/body weight, water intake and water intake/dry matter intake

Effect of 2% coconut oil supplementation on BW, DMI, DMI/BW, WI and WI/DMI were shown in table 3. There was no significant difference in BW, DMI, DMI/BW, WI and WI/DMI between both diets (P>0.05). The initial BW of control and experimental animals were 31.4 ± 3.0 and 30.0 ± 2.0 kg, respectively. The final BW of control and experimental animals were 31.5 ± 2.4 and 31.1 ± 2.3 kg, respectively. The average BW of control and experimental animals were 31.6 ± 2.5 and 30.5 ± 2.0 kg, respectively. Daily food intake from both control and experimental groups as DMI were 1.22 ± 0.10 and 1.23 ± 0.10 kg DMI/day, respectively. In addition, the calculated DMI/BW from both control and experimental groups were 4.25 ± 0.36 and 4.29 ± 0.34 % BW, respectively. Daily water intake from both control and experimental groups were 4.1 ± 0.6 and 4.3 ± 0.6 L/day, respectively. WI/DMI from both control and experimental groups were 3.37 ± 0.40 and 3.69 ± 0.59 L/kg, respectively.

Table 3 Effect of 2% coconut oil supplementation on body weight, dry matter intake, dry matter intake/body weight, water intake, and water intake/dry matter intake of lactating crossbred Saanen goat (means ± SEM).

Items	Diets		P
	Control	Experimental	
Initial body weight (kg)	31.4 ± 3.0	30.0 ± 2.0	0.71
Average body weight (kg)	31.6 ± 2.5	30.5 ± 2.0	0.74
Final body weight (kg)	31.5 ± 2.4	31.1 ± 2.3	0.92
Dry matter intake (kg DM/day)	1.22 ± 0.10	1.23 ± 0.10	0.94
Dry matter intake/body weight (% BW)	4.25 ± 0.36	4.29 ± 0.34	0.94
Water intake (L/day)	4.1 ± 0.6	4.3 ± 0.6	0.79
Water intake/DMI (L/kg)	3.37 ± 0.40	3.69 ± 0.59	0.66

4.3. Effect of 2% coconut oil supplementation on meal pattern

Effect of 2% coconut oil supplementation on feed intake at day 25 of post-partum during 24h, day time (0600 to 1800h) and night time (1800 to 0600h) from control and experimental groups were shown in figure 3. There was no effect of 2% coconut oil supplementation on total feed intake of lactating crossbred Saanen goat in 24h, day and night time (P>0.05). Feed intake of control and experimental groups were 1.25 ± 0.15 vs. 1.36 ± 0.17 kg DM/day in 24h, 1.05 ± 0.13 vs. 1.08 ± 0.18 kg DM/day in day time and 0.20 ± 0.07 vs. 0.28 ± 0.07 kg DM/day in night time, respectively.

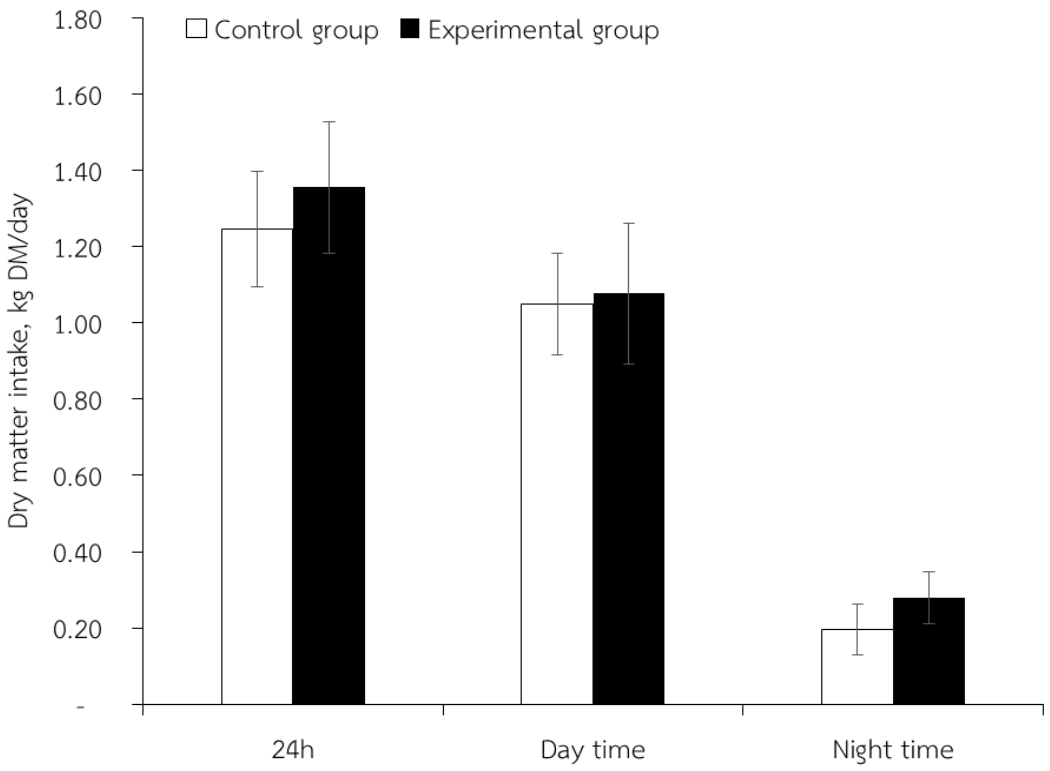


Figure 3 Effect of 2% coconut oil supplementation on total feed intake in 24h, day (0600 to 1800 h) and night time (1800 to 0600 h) of lactating crossbred Saanen goat at day of 25 post-partum.

The data of meal pattern as meal size, meal duration, meal frequency and inter-meal interval during 24h, day time (0600 to 1800h) and night time (1800 to 0600h) from control and experimental groups at day 25 post-partum were shown in table 4. Goats in experimental group had significantly greater meal size and longer meal duration but lower meal frequency than control group ($P<0.05$). Meal size of experimental diet was significantly greater than control diet at 24h (0.12 ± 0.01 vs. 0.07 ± 0.01 kg DM /meal, $P<0.05$), day time (0.15 ± 0.01 vs. 0.09 ± 0.01 kg DM/meal, $P<0.05$), night time (0.07 ± 0.01 vs. 0.03 ± 0.01 kg DM/meal, $P<0.05$), respectively. Meal duration at 24h, day time and night time were significantly longer for experimental group than control, control versus experimental group; 31.20 ± 5.35 vs. 51.06 ± 5.63 min/meal for 24h; 37.33 ± 7.00 vs. 58.67 ± 5.98 min/meal for day time; 22.19 ± 2.98 vs. 35.22 ± 2.80 min/meal for night time, respectively ($P<0.05$). The meal frequency of experimental diet was significantly lower than control at 24h (control vs. experimental group; 18.00 ± 1.72 vs. 11.00 ± 1.95 meals, $P<0.05$), day time (control vs. experimental group; 11.00 ± 0.86 vs. 7.00 ± 1.24 meals, $P<0.05$) and night time (control vs. experimental group; 7.00 ± 1.28 vs. 3.00 ± 1.11 meals, $P<0.05$). The inter-meal interval was no difference between control and experimental groups during 24h (40.18 ± 6.07 vs. 69.59 ± 22.49 min, respectively), day time (28.35 ± 2.20 vs. 64.50 ± 30.10 min, respectively) and night time (65.30 ± 21.24 vs. 87.92 ± 17.41 min, respectively) ($P>0.05$).

Table 4 Effect of 2% coconut oil supplementation on meal pattern as meal size, meal duration, meal frequency and inter-meal interval at 24h, day (0600 to 1800 h) and night time (1800 to 0600 h) of lactating crossbred Saanen goat at day 25 of post-partum (mean ±SEM).

Items		Diets		P
		Control	Experimental	
Meal size (kg DM/meal)	24h	0.07 ± 0.01	0.12 ± 0.01	0.005
	Day time	0.09 ± 0.01	0.15 ± 0.01	0.015
	Night time	0.03 ± 0.01	0.07 ± 0.01	0.013
Meal duration (min/meal)	24h	31.20 ± 5.35	51.06 ± 5.63	0.034
	Day time	37.33 ± 7.00	58.67 ± 5.98	0.049
	Night time	22.19 ± 2.98	35.22 ± 2.80	0.013
Meal frequency (times)	24h	18.00 ± 1.72	11.00 ± 1.95	0.020
	Day time	11.00 ± 0.86	7.00 ± 1.24	0.030
	Night time	7.00 ± 1.28	3.00 ± 1.11	0.030
Inter-meal interval (min)	24h	40.18 ± 6.07	69.59 ± 22.49	0.242
	Day time	28.35 ± 2.20	64.50 ± 30.10	0.265
	Night time	65.30 ± 21.24	87.92 ± 17.41	0.434

Meal size of first morning and afternoon meal from control and experimental groups at day 25 of post-partum were 0.27 ± 0.08 kg DM/meal vs. 0.37 ± 0.07 kg DM/meal and 0.30 ± 0.05 kg DM/meal vs 0.27 ± 0.04 kg DM/meal, respectively (figure 4 a) (P>0.05). Resting morning meal size of control and experimental groups at day 25 of post-partum were 0.05 ± 0.02 and 0.09 ± 0.03 kg DM/meal, respectively (figure 4 b) (P>0.05). For the resting afternoon meal, animal of experimental group consumed 0.17 ± 0.04 kg DM/meal which was significantly greater than control animal (0.06 ± 0.01 kg DM/meal) (P<0.05).

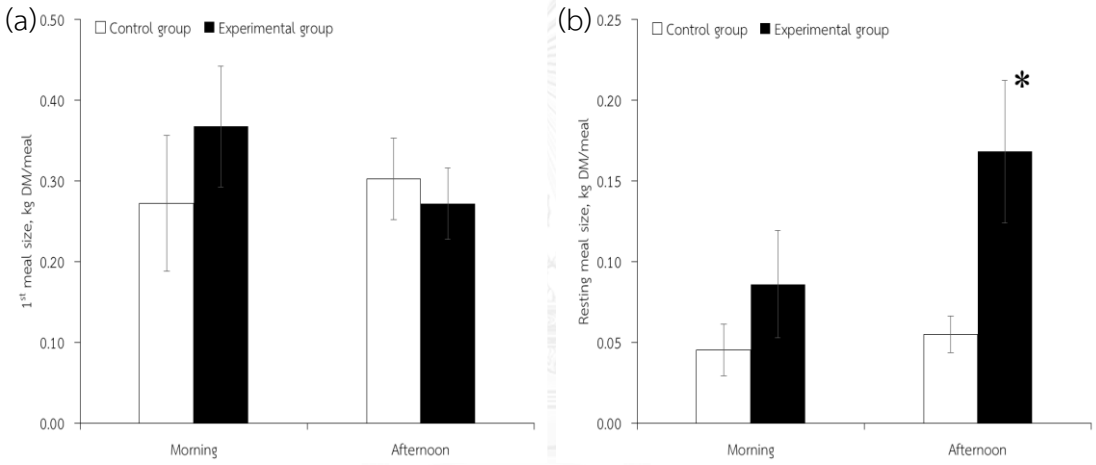


Figure 4 Effect of 2% coconut oil supplementation on first morning and afternoon meal size (a). Effect of 2% coconut oil supplementation on resting morning and afternoon meal size (b). Asterisk show the significant effect, P<0.05.

Meal duration of first morning and afternoon meal form control and experimental groups at day 25 of post-partum were shown in figure 5 a. For the first morning meal, meal duration of experimental group was significantly longer than control group (112.30 ± 17.86 vs. 54.10 ± 12.55 min/meal respectively, P<0.05). For the first afternoon meal, meal duration of both control and experimental groups were 73.98 ± 16.17 and 79.92 ± 13.97 min/meal, respectively (P>0.05). Meal duration of control and experimental groups were 31.74 ± 7.25 vs. 42.02 ± 5.11 min/meal in resting

morning meal, and 35.71 ± 5.85 vs. 63.00 ± 12.00 min/meal in resting afternoon meal, respectively (P>0.05).

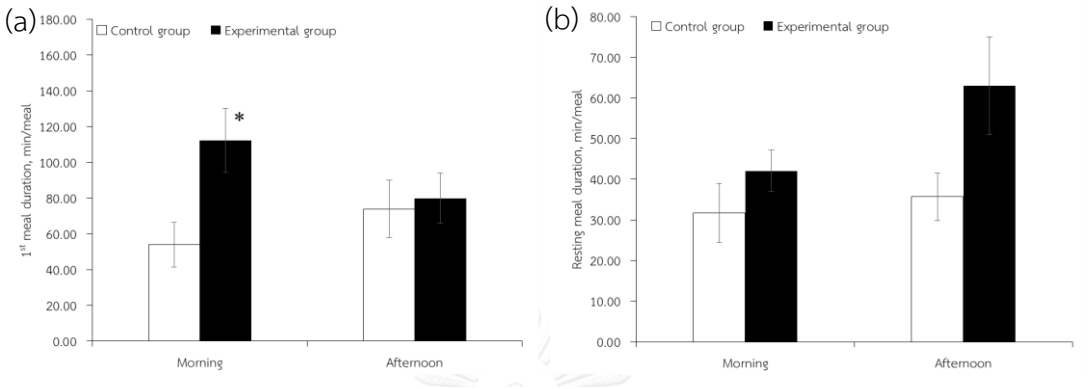


Figure 5 Effect of 2% coconut oil supplementation on first morning and afternoon meal duration (a). Effect of 2% coconut oil supplementation on resting morning and afternoon meal duration (b). Asterisk show the significant effect, P<0.05.

4.4. Effect of 2% coconut oil supplementation on nutrient intake and total tract nutrient apparent digestibility

The nutrient intake and apparent digestibility of control and experimental groups were shown in table 5. There was no difference between control and experimental groups on intake of organic matter (1.13 ± 0.10 vs. 1.14 ± 0.09 kg/day, respectively), crude protein (0.20 ± 0.02 vs. 0.21 ± 0.04 kg/day, respectively), neutral detergent fiber (0.52 ± 0.04 vs. 0.52 ± 0.04 kg/day, respectively), acid detergent fiber (0.31 ± 0.03 vs. 0.32 ± 0.03 kg/day, respectively) (P>0.05). However, fat intake of experimental group with 2% coconut oil supplementation (0.06 ± 0.005 kg DM/day) was significantly higher than control group (0.04 ± 0.003 kg DM/day) (P<0.05). Digestibility of dry matter, organic matter, crude protein (CP), neutral detergent fiber, acid detergent fiber (ADF) and ether extract (EE) were no significant difference between two diets (P>0.05). Nutrient digestibility (%) in control and experimental groups were 74.48 ± 2.43 vs. 70.21 ± 3.65% for DM, 76.31 ± 2.36 vs. 72.95 ± 3.35% for OM, 79.45 ± 1.83 vs. 77.03 ± 2.72% for CP, 63.94 ± 4.01 vs. 57.09 ± 5.47% for NDF, 62.76 ± 4.91 vs. 53.51 ± 6.14% for ADF and 85.96 ± 2.04 vs. 88.57 ± 1.70% for EE.

Table 5 Effect of 2% coconut oil supplementation on nutrient intake and total tract nutrient apparent digestibility in lactating crossbred Saanen goat (mean ± SEM).

Items	Diets		P
	Control	Experimental	
Intake (kg DM/day)			
OM	1.13 ± 0.10	1.14 ± 0.09	0.951
CP	0.20 ± 0.02	0.21 ± 0.04	0.830
NDF	0.52 ± 0.04	0.52 ± 0.04	0.984
ADF	0.31 ± 0.03	0.32 ± 0.03	0.853
EE	0.04 ± 0.003	0.06 ± 0.005	0.004
Apparent digestibility (%)			
DM	74.48 ± 2.43	70.21 ± 3.65	0.358
OM	76.31 ± 2.36	72.95 ± 3.35	0.436
CP	79.45 ± 1.83	77.03 ± 2.72	0.483
NDF	63.94 ± 4.01	57.09 ± 5.47	0.343
ADF	62.76 ± 4.91	53.51 ± 6.14	0.274
EE	85.96 ± 2.04	88.57 ± 1.70	0.355

4.5. Effect of 2% coconut oil supplementation on milk yield

During five weeks of experiment, average daily milk yield of control and experimental groups was 1.55 ± 0.06 vs. 1.05 ± 0.24 L/day for week 1, 1.80 ± 0.19 vs. 1.20 ± 0.25 L/day for week 2, 1.77 ± 0.12 vs. 1.28 ± 0.22 L/day for week 3, 1.76 ± 0.16 vs. 1.37 ± 0.22 L/day for week 4, 1.80 ± 0.19 vs. 1.37 ± 0.19 L/day for week 5, respectively. Mean 4% fat corrected milk production of control and experimental groups were 1.76 ± 0.19 and 1.57 ± 0.23 L/day, respectively. The percent change of milk yield from both control and experimental groups during five weeks of post-partum had no significant difference (P>0.05) (figure 6). Milk yield increased every week start from second week to fifth week in both diets when compared with the first week. Percent change of milk yield in control and experimental groups were 16.36 ± 4.58 vs. 18.02 ± 5.67% for second week; 22.07 ± 5.35 vs. 29.61 ± 10.30% for thirds week; 24.31 ± 6.31 vs. 40.09 ± 11.89% for fourth week; 27.14 ± 8.86 vs. 44.08 ± 15.44% for fifth week, respectively.

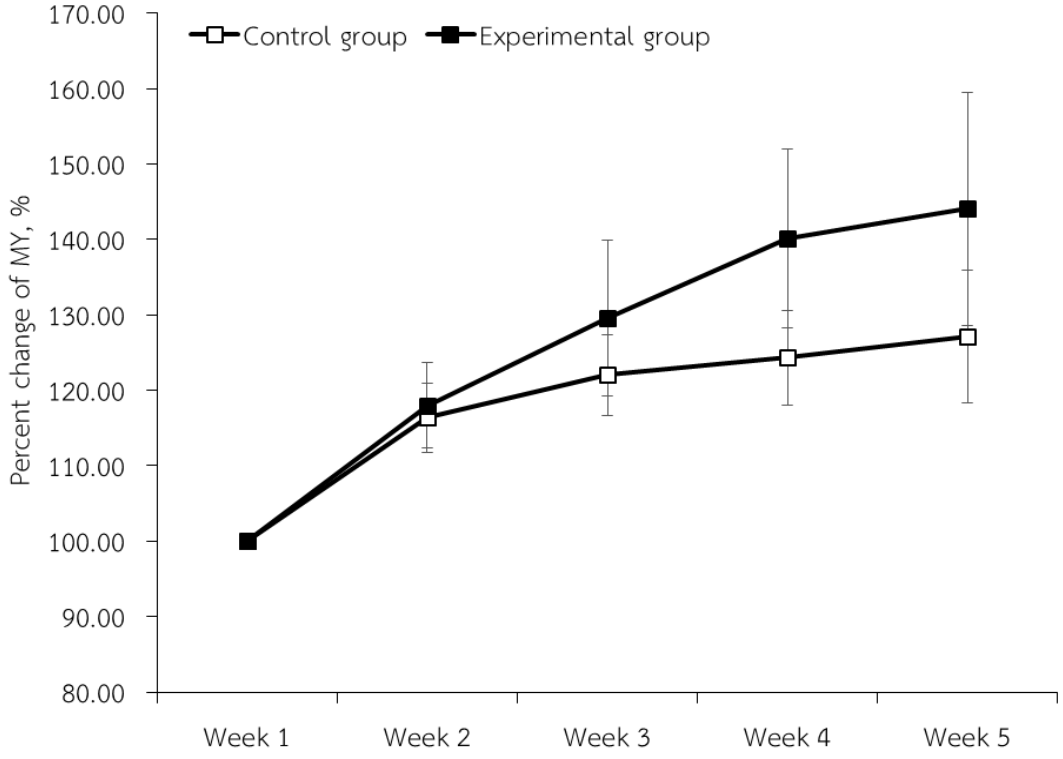


Figure 6 Effect of 2% coconut oil supplementation on percent change of milk yield in lactating crossbred Saanen goat, lines showed percent change of milk yield from week 1 to week 5 of post-partum, baseline value was obtained for milk yield in the first week of post-partum.

4.6. Effect of 2% coconut oil supplementation on milk composition

The effect of 2% coconut oil supplementation on milk composition of control and experimental animals were shown in table 6. Experimental group was significantly higher than control group in milk total solid composition (13.96 ± 0.32 vs. 12.12 ± 0.19% respectively, $P<0.05$), milk protein composition (3.56 ± 0.17 vs. 2.98 ± 0.09% respectively, $P<0.05$), milk fat composition (4.85 ± 0.16 vs. 3.84 ± 0.21% respectively, $P<0.05$) and milk solid not fat composition (9.11 ± 0.23 vs. 8.29 ± 0.23%, respectively, $P<0.05$). However, there was no significant difference in milk lactose composition of control and experimental groups (4.60 ± 0.12 vs. 4.85 ± 0.10%, respectively, $P>0.05$).

Table 6 Effect of 2% coconut oil supplementation on milk composition in lactating crossbred Saanen goat (means ± SEM).

Items (%)	Diets		P
	Control	Experimental	
Total solid	12.12 ± 0.19	13.96 ± 0.32	0.003
Protein	2.98 ± 0.09	3.56 ± 0.17	0.024
Fat	3.84 ± 0.21	4.85 ± 0.16	0.015
Lactose	4.60 ± 0.12	4.85 ± 0.10	0.192
Solid not fat	8.29 ± 0.23	9.11 ± 0.23	0.027

4.7. Effect of 2% coconut oil supplementation on nitrogen intake and nitrogen utilization

Nitrogen intake and utilization in control and experimental animals were shown in table 7. Two percent coconut oil had not significant effect on nitrogen intake, absorption, retention and excretion in milk, feces and urine (P>0.05).

Table 7 Effect of 2% coconut oil supplementation on nitrogen intake and utilization in lactating crossbred Saanen goat (means ± SEM).

Items (g/day)	Diets		P
	Control	Experimental	
Intake	34.4 ± 2.6	35.6 ± 2.9	0.76
Fecal excretion	6.9 ± 0.5	8.2 ± 1.4	0.39
Absorbed	27.5 ± 2.5	27.4 ± 2.0	0.97
Urinary excretion	4.7 ± 0.4	4.8 ± 0.9	0.92
Milk secretion	9.4 ± 0.8	8.0 ± 1.8	0.46
Retained	15.7 ± 1.6	16.0 ± 2.1	0.91

4.8. Effect of 2% coconut oil supplementation on blood glucose, plasma BHBA, NEFA and cortisol hormone

The blood glucose concentration from control and experimental groups at week -1 of pre-partum, week 3 and 5 of post-partum were shown in figure 7 and it was no significant difference between both groups (P>0.05). At week -1 of pre-partum, blood glucose concentration of control and experimental groups were 65.40 ± 2.62 vs. 64.40 ± 6.07 mg/dl, respectively (P>0.05). At post-partum period, blood glucose concentration of control and experimental groups were 69.20 ± 4.16 vs. 73.40 ± 3.12 mg/dl in week 3 and 72.60 ± 3.17 vs. 72.20 ± 3.68 mg/dl in week 5, respectively (P>0.05).

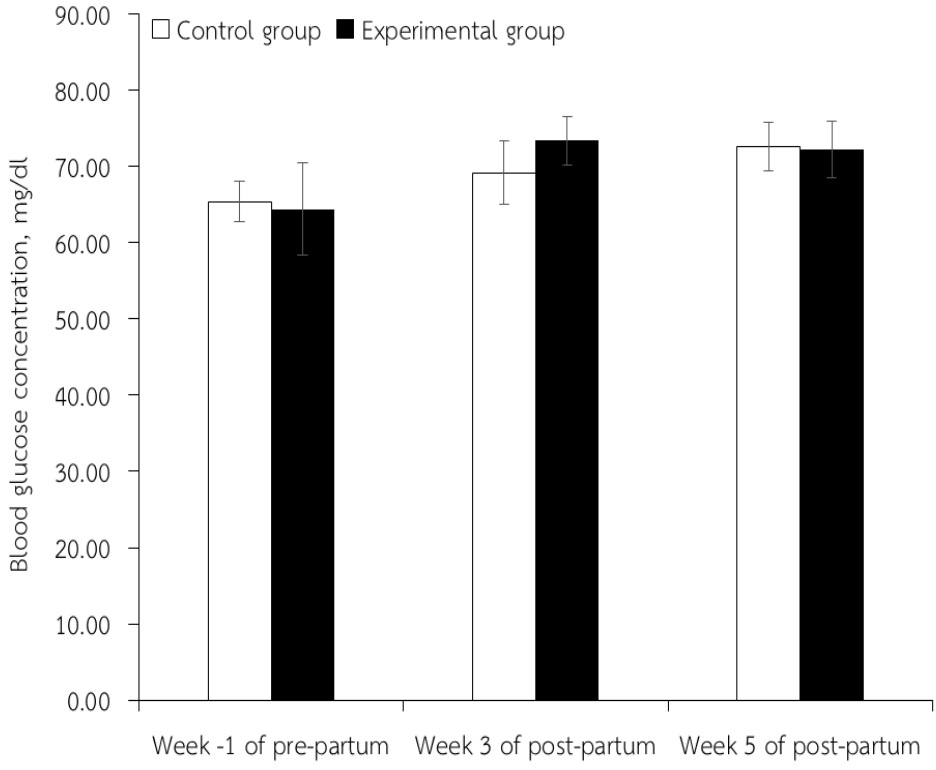


Figure 7 Effect of 2% coconut oil supplementation on blood glucose concentration in lactating crossbred Saanen goat at week -1 of pre-partum, week 3 and 5 of post-partum.

Plasma BHBA concentration from control and experimental groups at week -1 of pre-partum, week 3 and 5 of post-partum were shown in figure 8, and 2% coconut oil supplementation did not influence plasma BHBA concentration (P>0.05). At week -1 of pre-partum, plasma BHBA concentration of control and experimental groups were similar (0.12 ± 0.05 vs. 0.13 ± 0.03 mmol/L respectively, P>0.05). In post-partum period, plasma BHBA concentration of control and experimental groups were 0.21 ± 0.05 vs. 0.23 ± 0.04 mmol/L in week 3 and 0.19 ± 0.05 vs. 0.21 ± 0.03 mmol/L in week 5, respectively.

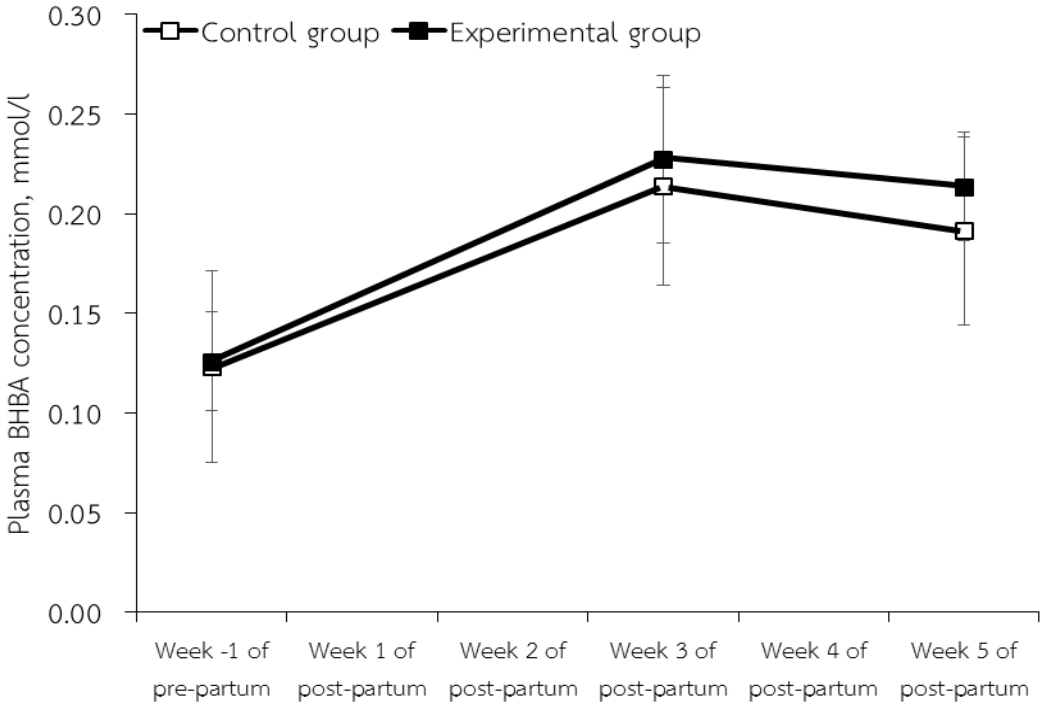


Figure 8 Effect of 2% coconut oil supplementation on plasma BHBA concentration in lactating crossbred Saanen goat at week -1 of pre-partum, week 3 and 5 of post-partum.

The figure 9 showed percent change of plasma NEFA in control and experimental animals at week 3 and 5 of post-partum period based on plasma NEFA concentration at week -1 of pre-partum period and 2% coconut oil supplementation had no effect on percent change of plasma NEFA ($P>0.05$). At week 3 of post-partum, percent change of plasma NEFA in control and experimental groups were 11.02 ± 16.01 vs. 26.50 ± 12.08%, respectively. Percent change of plasma NEFA in control group was similar with experimental group in week 5 of post-partum (30.81 ± 5.62 vs. 30.11 ± 5.12%, respectively).

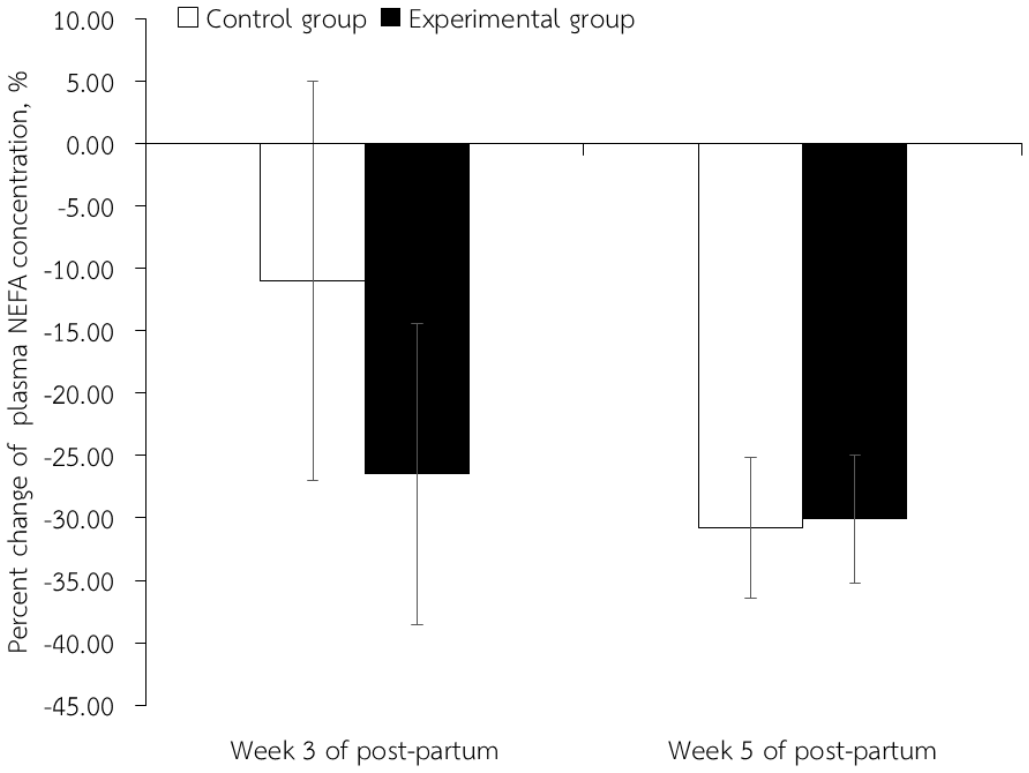


Figure 9 Effect of 2% coconut oil supplementation on percent change of plasma NEFA in lactating crossbred Saanen goat, bars showed percent change of plasma NEFA at week 3 and 5 of post-partum, baseline value was obtained for plasma NEFA at one week before parturition.

The plasma cortisol concentration of control and experimental groups at week -1 of pre-partum, week 3 and 5 of post-partum were shown in figure 10 and 2% coconut oil supplementation had no effect on plasma cortisol concentration (P>0.05). At week -1 of pre-partum, plasma cortisol level of both control and experimental groups were 158.13 ± 38.59 and 106.93 ± 40.70 ng/ml, respectively. In post-partum period, plasma cortisol level of both control and experimental groups were drop down in week 3 (44.32 ± 12.51 vs. 37.33 ± 6.89 ng/ml respectively, P>0.05) and week 5 (63.52 ± 19.99 vs. 42.51 ± 12.42 ng/ml respectively, P>0.05) when compared with week -1 of pre-partum period.

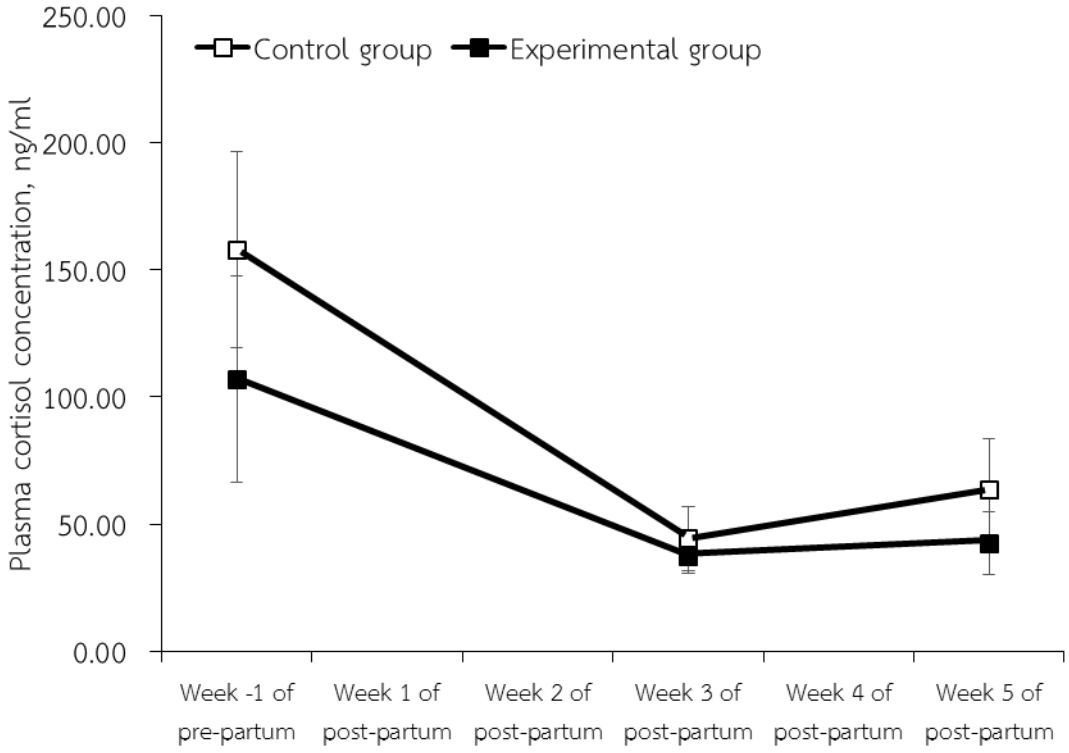


Figure 10 Effect of 2% coconut oil supplementation on plasma cortisol concentration in lactating crossbred Saanen goat at week -1 of pre-partum, week 3 and 5 of post-partum.

CHAPTER 5
DISCUSSIONS

In the current experiment, supplementation with 2% coconut oil had no effect on both DMI and DMI/BW. DMI/BW requirement for dairy goat in early lactation is about 3.4 to 3.8% BW (NRC, 1981). In present experiment, DMI/BW of both diets were about 4.2% BW, so animals were not in the negative energy balance status. The current result was consistent with the previous experiment in dairy goat. There was no negative effect of eating when 2.5 to 4.4% of vegetable oil as soybean oil and sunflower oil supplemented in dairy goat (Martínez Marín et al., 2013). In addition, coconut oil supplemented with 2.1% had no effect in DMI in dairy cattle (Hristov et al., 2009). In present experiment, coconut oil contain 90% saturation fatty acid (Rossell, 1985). In addition, saturation fatty acid had less negative effect on rumen microorganism than unsaturation fatty acid (Palmquist and Jenkins, 1980). The growth of microorganism in the rumen is inhibited due to double bonds of unsaturation fatty acid alters structure membrane of microorganism (Keweloh and Heipieper, 1996). As the result of this accident, lipid synthesis by microorganism was inhibited. The interesting results in the current experiment came from the effect of coconut oil supplementation on eating pattern. Although there was no effect of treatment on the average DMI and the DMI of day time and night time (Fig 3). Coconut oil supplementation did modify eating pattern in the early lactation period (Table 4). In both day time and night time period, meal size and duration were significantly greater for animal consumed experimental diet ($P<0.05$). However, the meal frequency from experimental group was lower than control group. The results suggested that the effect of coconut oil supplementation that increased meal size could not overcome the compensate mechanism of eating pattern. This is the reason why there was no effect of coconut oil supplementation on DMI. It was well known that the reduction of meal frequency is the main mechanism used by laboratory rats fed with high energy diet to induce obesity (Treesukosol and Moran, 2014). It is difficult at this point to provide the specific reason or mechanism for the effect of coconut oil supplementation on meal pattern. Coconut oil

supplementation may increase the palatability of the TMR (Hollmann and Beede, 2012). However, increasing meal size in the current study came together with longer duration of eating time which suggested that the rate of eating was not much changed. Moreover, there had no direct evidences of hedonic effect of coconut oil supplementation in dairy animals (Berridge, 2004). Taken together, the present experiment demonstrated that 2% coconut oil supplementation influenced eating pattern in crossbred Saanen dairy goat by increase meal size and duration with the compensatory reduction of meal frequency. Overall, the 2% coconut oil supplementation had no effect on DMI of crossbred Saanen dairy goat, which probably related to less negative effect of saturation fatty acid in coconut oil on rumen function and high palatability of coconut oil.

There was no significant difference in total tract nutrient apparent digestibility between both diets (P>0.05). Similar with results of present experiment, 2.1% coconut oil supplementation had no effect on nutrient apparent digestibility in dairy cow (Hristov et al., 2009). In sheep, 3.5% coconut oil supplementation did not change nutrient apparent digestibility (Machmüller and Kreuzer, 1999). In contrary, coconut oil supplementation with 5% decreased DM, OM and NDF digestibility of dairy cow (Hollmann and Beede, 2012). However, present experiment supplemented only 2% coconut oil in diet. The unchanged of nutrient digestibility when coconut oil supplementation came from less inhibition on rumen microorganism and fermentation by high content saturation fatty acid of coconut oil (Palmquist and Jenkins, 1980).

There was no significant difference in percent change of milk yield between both groups (P>0.05). Similar with present experiment, dairy cow unchanged in milk yield when supplemented with 2.1% coconut oil (Hristov et al., 2009). When fat supplementation, milk yield was influenced by DMI and nutrient digestibility, especially NDF digestibility (Martínez Marín et al., 2013). In present experiment, the gradually increase in milk yield during early lactation was not difference between both diets It was due to both control and experimental animals consumed almost the same amount of DM, CP as well as all nutrient digestibility. In addition, plasma metabolite in present experiment such as glucose, NEFA and BHBA had no difference and nearly

similar in both diets. It is suggested from this study that animals in this experiment were in the same condition of energy balance.

Two percent coconut oil supplementation significantly increased milk fat and protein composition ($P<0.05$). Similar with present experiment, dairy goat increased milk fat and milk protein composition when supplementation of fat as soybean oil and sunflower oil at 2.5 and 4.4%, respectively (Bouattour et al., 2008; Ollier et al., 2009). Fatty acids for milk fat synthesis are derived from acetate and BHBA and directly from diet (Dils, 1986; Neville and Picciano, 1997). In present experiment, NDF intake and digestibility as well as plasma BHBA concentration were no difference between control and experimental groups. In the other hand, experimental group with 2% coconut oil supplementation was significantly higher fat intake when compared with control group, so the increment of milk fat composition may come from greater fat content in experimental diet. A review of available literature in fat supplementation in dairy goat, Martínez Marín et al. (2013) pointed that milk protein did not reduce with difference fat sources supplementation. Overall, this experiment indicated that coconut oil supplementation in crossbred dairy goat increased milk fat and protein composition, but milk lactose was unchanged.

In the present experiment, blood glucose was not affected by 2% coconut oil supplementation ($P>0.05$). Blood glucose concentration was higher in weeks of early lactation period than in pre-partum period, this pattern was similar with the result in Saanen dairy goat (Sadjadian et al., 2012), cattle (Vazquez-Anon et al., 1994) and sheep (Balıkcı et al., 2007). Similar with present experiment, 2.3% coconut oil supplemented in dairy cow did not affect blood glucose concentration (Lee et al., 2011). Propionate is the main precursor for glucose synthesis of ruminant (Bell and Bauman, 1997). The amount of propionate and another volatile fatty acid are influenced by feed intake and digestibility (France and Dijkstra, 2005). Therefore, concentration of glucose in ruminant is related with DMI and digestibility. In present experiment, the unchanged blood glucose concentration when dairy goat supplemented with coconut oil came from the similar in DMI and diet digestibility between both diets.

Two percent coconut oil did not influence on percent changes of plasma NEFA ($P > 0.05$). In present experiment, plasma concentration of NEFA during post-parturition was lower than from pre-parturition. This pattern was similar to the pattern of plasma NEFA during peri-parturition period reported in Saanen dairy goat (Sadjadian et al., 2012). The concentration of plasma NEFA has been used as the indicator for the fat mobilization from reserve body fat (LeBlanc, 2006). Because the BW and DMI of animals were similar between control and experimental diets and because the concentration of plasma NEFA was not different between groups. The results suggested in part that supplementation of 2% coconut oil could not influence the whole body energy homeostasis and that there was an unchanged in the lipolysis rate from adipose tissue.

Two percent coconut oil supplementation did not affect plasma BHBA concentration. In this experiment, plasma BHBA concentration from pre-partum period was lower than from post-partum period. During peri-parturition, plasma BHBA was synthesized from the gastrointestinal tract using ruminal volatile fatty acid as the substrate and from the liver using both volatile fatty acid and NEFA. An increase in post-partum plasma BHBA came from both increase in portal and hepatic flux of BHBA (VI and Jesse, 1992; Osborne et al., 2009). Since ruminal butyrate is the main substrate for BHBA production and the ruminal butyrate come mainly from the cellulose fermentation and in part convert from acetate (Van Houtert, 1993). The non-difference in pattern of plasma BHBA together with the non-difference in digestibility of NDF suggested that the supplementation with 2% coconut oil could not modify the BHBA metabolism.

Level of plasma cortisol was not affected by 2% coconut oil supplementation during pre and post-partum ($P>0.05$). Level of plasma cortisol was higher in a week before parturition than in week 3 and 5 of post-partum. The pattern of plasma cortisol during peri-parturition is influenced not only by the gestation and parturition but it also come in part from the stress that caused by energy deficiency. Because 2% coconut oil supplementation could not modify both splanchnic BHBA metabolism and adipose tissue fatty acid metabolism, it is reasonable that the plasma cortisol from the current

experiment was influenced mainly by reproductive stage, however, there was no effect from 2% coconut oil supplementation.

In conclusion, the current experiment found that 2% coconut oil supplementation modified meal pattern by increased meal size and duration, but it reduced meal frequency in early lactating crossbred dairy goat. The change in meal pattern may indicate the palatability of coconut oil in early lactating crossbred Saanen goat. So, coconut oil affected eating pattern of crossbred Saanen dairy goat under hot and humid condition. In addition, 2% coconut oil supplementation increased milk fat and protein composition. Supplementation with 2% coconut oil did not affect body weight, DMI, DMI/BW, nutrient digestibility, nitrogen retention as well as the unchanged in blood glucose and plasma NEFA, BHBA and cortisol. However, fat intake from 2% coconut oil supplementation group was higher than from control group. The latter result suggested the idea that the increase in meal size and duration apparently came from the effect of coconut oil on post-absorptive satiation. In addition, the increase in both meal size and duration caused no difference in the eating rate from both groups. This again supports the idea about pre-absorptive effect of coconut oil or the palatability.

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APPENDIX

B	C	D	E	F	G	H	I	J	K	L	M
No.	Weight	Time				MealDuration	MealSize	MealFreq	TotalFI	%TotFI	Intermeal
200	0.79	10/12/2014 8:06	0.000		0.005						
210	0.71	10/12/2014 8:11	0.080								
220	0.655	10/12/2014 8:16	0.055								
230	0.56	10/12/2014 8:21	0.095		0.23						
240	0.555	10/12/2014 8:26	0.005								
250	0.55	10/12/2014 8:31	0.005								
260	0.55	10/12/2014 8:36	0.000		0.010	0:30	0.24	1			
270	0.545	10/12/2014 8:41	0.005								
280	0.56	10/12/2014 8:46	-0.015								0:10
290	0.55	10/12/2014 8:51	0.010		0						
300	0.545	10/12/2014 8:56	0.005								
310	0.54	10/12/2014 9:01	0.005								
320	0.54	10/12/2014 9:06	0.000		0.010						
330	0.54	10/12/2014 9:11	0.000								
340	0.525	10/12/2014 9:16	0.015								
350	0.53	10/12/2014 9:21	-0.005		0.01	0:30	0.02	1			

Figure 1. Meal pattern analysis in excel file

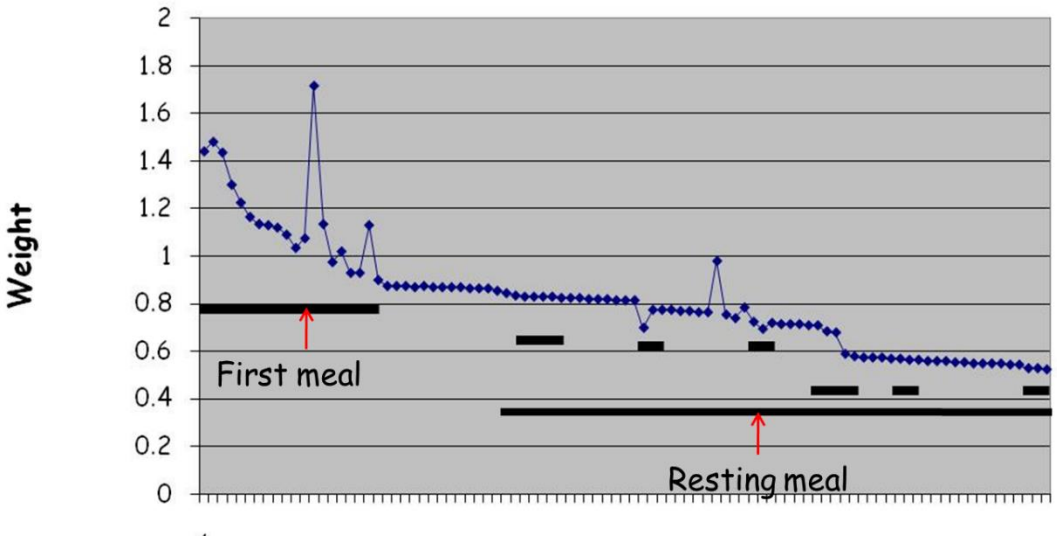

Figure 2. The diagram determined meal pattern

VITA

Mr Ho Thieu Khoi was born on 13 April 1989 in Can Tho city, Vietnam. He attended to Bachelor degree in Animal Husbandry at Can Tho University in 2007 and earned his degree on 2011 by Rector of Can Tho University, Can Tho city, Vietnam. After graduation, Mr Ho Thieu Khoi has been worked at Department of Animal Husbandry, College of Agriculture and Applied Biology, Can Tho University. He has been working there as a researcher and teaching assistant as well as a technician for Department of Animal Husbandry. In 2013, he applied and was awarded a master scholarship from Chulalongkorn University, Thailand in the program of "Scholarship Programs for Neighboring Countries". He studied in the field of Animal Nutrition at Department of Animal Husbandry, Faculty of Veterinary Science, Chulalongkorn University. In order to fulfill requirements for his master degree he carried out the thesis entitled "THE EFFECT OF COCONUT OIL SUPPLEMENTATION ON PLASMA METABOLITE AND LACTATION PERFORMANCE IN EARLY LACTATING CROSSBRED SAANEN GOATS" as a partial need.