EFFECTS OF CASTRATION AND SUPPLEMENTATION OF *Pueraria mirifica* ON GROWTH PERFORMANCE, CARCASS QUALITY AND ODORANT FATTY ACIDS IN GOAT MEAT

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ผลของการตอน และการเสริมกวาวเครือขาวต่อประสิทธิภาพการเจริญเติบโต คุณภาพซาก และกรดไขมันให้กลิ่นในเนื้อแพะ

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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EFFECTS OF CASTRATION AND SUPPLEMENTATION OF *Pueraria mirifica* ON GROWTH PREFORMANCE, CARCASS QUALITY AND ODORANT FATTY ACIDS IN GOAT MEAT

Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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ธนรรษมลวรรณ พลมั่น : ผลของการตอน และการเสริมกวาวเครือขาวต่อประสิทธิภาพการเจริญเติบโต คุณภาพซาก และกรดไขมันให้กลิ่นในเนื้อแพะ (EFFECTS OF CASTRATION AND SUPPLEMENTATION OF *Pueraria mirifica* ON GROWTH PERFORMANCE, CARCASS QUALITY AND ODORANT FATTY ACIDS IN GOAT MEAT)
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การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของการตอน และการเสริมกวาวเครือขาวต่อประสิทธิภาพ, คุณภาพซาก และกรดไขมันให้กลิ่นในเนื้อแพะลูกผสมไทยพื้นเมือง × แองโกลนูเบี้ยน การศึกษาครั้งนี้ประกอบด้วย 3 การทดลอง

การทดลองที่ 1 ศึกษาผลของการตอนแพะที่อายุ 3 และ 8 เดือนโดยวิธีการตอนแบบผ่าตัดและวิธีคีมหนีบ พบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญในน้ำหนักสุดท้าย และอัตราการเติบโตต่อวัน (P>0.05) ระดับของฮอร์โมนเอสตราไดอัลในซีรั่มของกลุ่มควบคุมมีระดับต่ำกว่ากลุ่มที่ได้รับการตอนที่อายุ 8 เดือนทั้งวิธีการตอนแบบผ่าตัดและวิธีคีมหนีบ ผลต่อลักษณะซาก และคุณภาพเนื้อ พบว่าไม่มีความแตกต่างกันระหว่างกลุ่ม อย่างไรก็ตามวิธีการตอนมีผลต่อระดับของ butyric acid (C4 : 0) และปัจจัยระหว่างวิธีการตอนและอายุมีผลต่อระดับของ caproic acid (C6 : 0 (P<0.05) กลุ่มแพะที่ได้รับการตอนโดยวิธีการใช้คีมหนีบมีระดับของ palmitoleic acid (C16 : 1) สูงกว่ากลุ่มที่ไม่ได้ตอน และกลุ่มที่ได้รับการตอนโดยวิธีผ่าตัดตอน (P<0.05) ส่วนของกรดไขมันที่ให้ลักษณะกลิ่นสาบหลักในเนื้อแพะ และระดับของฮอร์โมนเอสตราไดออล และเทสโทสเตอโรน ในการศึกษาครั้งนี้ ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ โดยวิธีการตอน และอายุของแพะไม่มีผลต่อค่าดังกล่าว (P>0.05)

การทดลองที่ 2 ศึกษาผลของการเสริมฮอร์โมนเอสตราไดอัลสังเคราะห์หรือไฟโตเอสโตรเจนจากกวาวเครือขาวในแพะเนื้อพบว่าการเจริญเติบโต ลักษณะเนื้อ ส่วนประกอบซาก สีของเนื้อ %การสูญเสียน้ำ คอเลสเตอรอลรวมในซีรั่ม กรดไขมันอิ่มตัว กรดไขมันไม่อิ่มตัว สัดส่วนกรดไขมันสายสั้น, สายกลาง และสายยาว ไม่มีความแตกต่างเมื่อมีการเสริมฮอร์โมนสังเคราะห์ หรือไฟโตเอสโตรเจนจากกวาวเครือขาว (P>0.05) ขณะที่ค่าความเป็นกรดด่างที่ 24 ชั่วโมงของกลุ่มควบคุมต่ำกว่ากลุ่มอื่น ๆ (P<0.05) อย่างมีนัยสำคัญ แต่ Caprylic acid (C8 : 0) ของกลุ่มควบคุมสูงกว่ากลุ่มอื่น ๆ (P<0.001) กรดไขมันที่ให้กลิ่นสาบในเนื้อแพะ ระดับฮอร์โมนเอสตราไดออล และระดับฮอร์โมนเทสโทสเตอโรนในซีรั่มไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ (P>0.05)

การทดลองที่ 3 ระดับของไฟโตเอสโตรเจนจากกวาวเครือขาว 5 ระดับ 0, 250, 500, 750 และ 1000 ไมโครกรัมต่อวันไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติต่อการกินได้ต่อวัน การเจริญเติบโต ลักษณะซาก องค์ประกอบซาก อัตราการสูญเสียน้ำ และค่าความเป็นกรดด่างของเนื้อแพะ (P>0.05) ขณะที่ไฟโตเอสโจรเจนที่ระดับ 1000 ไมโครกรัมต่อวันมีค่าสีแดง a* value ในเนื้อส่วนขาหน้าสูงกว่า

กลุ่มอื่น ๆ ($P<0.05$), ระดับคอเลสเตอรอลรวมในซีรัมเพิ่มขึ้นแบบ quadratic ในขณะที่กรดไขมันที่ให้กลิ่นสาบลดลงแบบเส้นตรงเมื่อมีการเพิ่มระดับการเสริมกวาวเครือขาว

ในส่วนของการศึกษาทั้ง 3 การทดลองนี้สามารถสรุปได้ว่าอายุ วิธีการตอน และการใช้ฮอร์โมนสังเคราะห์ไม่มีผลต่อประสิทธิภาพการผลิตแพะเนื้อ และกรดไขมันหลักที่ให้กลิ่นสาบในเนื้อแพะ อย่างไรก็ตามในการทดลองที่ 3 แสดงให้เห็นว่าระดับไฟโตเอสโตรเจนจากกวาวเครือขาวที่เสริมมากขึ้น มีผลต่อระดับของกรดไขมันให้กลิ่นสาบในเนื้อแพะที่น้อยลง

THANATSAMONWON PHONMUN : EFFECTS OF CASTRATION AND SUPPLEMENTATION OF *Pueraria mirifica* ON GROWTH PERFORMANCE, CARCASS QUALITY AND ODORANT FATTY ACIDS IN GOAT MEAT
THESIS ADVISOR : ASST. PROF. PRAMOTE PAENGKOUM, Ph.D., 143 PP.

MEAT GOAT/CASTRATION/*Pueraria mirifica*/ODORANT FATTY ACIDS

The objective of this study was to investigate the effects of castration and supplementation phytosetrogen from *Pueraria mirifica* compounds on growth performance, carcass quality and odorant fatty acid in goat meat of Thai native×Anglo-Nubian meat goats. This study was divided into three experiments.

Experiment I : This experiment was to study the interaction effect of age and castration method. The treatments were control (un-castrated), castrated at 3 months and 8 months of ages by surgical and burdizzo method castration. The results showed no significant difference in final weight and average daily gain (ADG). The concentration of estradiol in serum of the control group was lower ($P<0.05$) than castration goat at 8 months of age either surgical and budizzo method. The carcass compositions and meat quality were not significantly different among groups ($P>0.05$). However, castration method had an effect on butyric acid (C4 : 0) and there was highly significant interaction effect between age and castration method on C6 : 0 ($P<0.01$). The main odorant fatty acids and estradiol and testosterone levels in this study were not significantly different among groups ($P>0.05$) as a result of age differences or the use of the castration method.

Experiment II : This experiment was to study the effect of supplementation of synthesis estradiol hormone or phytoestrogen from *Pueraria mirifica* in meat goats. The

results showed the growth performance, carcass characteristics, meat color components, %drip loss, total cholesterol in serum and fatty acid profiles were not significantly different with supplemented synthesis hormone or phytoestrogen from *Pueraria mirifica* ($P>0.05$), while the pH_{24} value of the control group was lower than the other groups ($P<0.05$). The caprylic acid (C8 : 0) of control group was higher than that of the other groups ($P<0.001$). The main odorant fatty acids, estradiol and testosterone values in serum were not significantly different between groups ($P>0.05$).

Experiment III : The treatments consisted of five levels of supplementing phytoestrogen from *Pueraria mirifica* at 0, 250, 500, 750 and 1000 µg/d. There were no significantly different effects on feed intake, growth performance, carcass characteristics, carcass composition, %drip loss or pH value ($P>0.05$). The phytoestrogen from *Pueraria mirifi*ca at 1000 µg/d gave meat with higher a* value at front of the leg than the control group ($P<0.05$). The total cholesterol in serum was increased quadratically while the odorant fatty acids were decreased linearly with increased *Pueraria mirifi*ca supplementation.

Based on the three experiments conducted in this research, it can be concluded that there were no effect of age, castration method and synthesis hormone on animal performances and the main odorant fatty acids in meat. However, results in experiment III suggested that the more phytoestrogen from *Pueraria mirifi*ca was supplemented, the fewer odorant fatty acids in goat meat were formed.

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I would like to express my sincere gratitude to my dedicated supervisor, Assistant Professor Dr. Pramote Paengkoum, and members of my supervisory committee, Associate Professor Dr. Liang Juan Boo and Assistant Dr. Pipat Louanglawan for their invaluable guidance and constant encouragement given throughout this study.

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Thanatsamonwan Phonmun

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CHAPTER I

INTRODUCTION

1.1 Rationale of the study

Goat is a member of the bovine family and is closely related to the sheep. Goat, particularly meat goat production is an important component of small ruminant production in the developing countries. In Thailand, goat production is primarily for meat (Saithanoo and Milton, 1988). Goat meat (chevon or cabrito) is lower in total fat and cholesterol, high in digestibility and protein content and low in saturated fatty acids. Less saturated fats and a relatively high proportion of total unsaturated fats make goat meat a healthy choice. However goat meat is more expensive than poultry.

Preference and consumption pattern for goat meat are dictated by cultural, traditional, religious backgrounds and the socioeconomic status of the community. Since goat meat offers higher nutritional value as lean meat with favorable nutritional qualities it is an ideal choice for the health conscious consumers. However, the consumption of goat meat remains low due to its unique smell which is not acceptable by many consumers.

In addition to the nutrients, individuals consume meat to obtain some satisfactions influenced by psychological and sensory responses such as product appearance, aroma, flavor, tenderness, juiciness and nutritive value. Thus, many consumers do not accept goat meat, even though it has high nutritional quality (Webb et al., 2005). Goat meat is correlated with the presence of branch-chain fatty acids (BCFA) (Wong et al., 1975). Specific fatty acids which contribute to the odor of the buck have been identified

(Sugiyama et al., 1981) and they include 4-ethyloctanoic acids, 4-ethyldecanoic acids, 4-ethyldodecanoic acids and 4-ethyhexadecanoic acids. The 4-ethyloctanoic acid exhibits a strong characteristic goaty odor, even at low concentration (Sugiyama et al., 1981) and this fatty acid is a component of perfumes and has the lowest human odor threshold value of any aliphatic acid tested. Wong et al. (1975) and Brennand (1989) reported that several chemical composition have been implicated in the characteristic aroma of meat especially goat and sheep meat. These include BCFA, especially 4-methyloctanoic, 4-ethyloctanoic, and 4-methylnonanic acids. Branched-chain and unsaturated acids with 8-10 carbon atoms were related with the undesirable flavor. The odor of the meat was found to be mainly due to 4-methyloctanic and 4-methylnonanoic acids.

The source of odor in goat meat comes from activity of testosterone, which can be produced from both, adrenal gland and testis and cholesterol is the precursor for production of testosterone in adrenal gland and active in the dihydrotestosterone form. Moreover, testosterone can also be converted to estradiol by aromatase activity, which resulted in reduction of testosterone in males (Falahati-Nini et al., 2011)

Male goat odor was most apparent in the cornual gland area, less distinct at the mental gland region and faint or absent in the other glandular areas. Surgical removal of the cornual glands decreases buck odor and the persisting scent was ascribed to smaller skin glands dispersed in the cranial body half. Complete absence of buck odor was only observed in castrated bucks. Castration can reduce odor in goat meat (Desta Hamito, 2008) as meat from castrated males has less ‘goaty smell’ or tainted odor compare to meat from intact bucks. Louca et al. (1977) reported a taint of varying intensity in the meat from intact males from 7.5 months of age upward, but not in castrates of similar age. Based on the above information, the impact of castration on odorant fatty acids remains unclear and required further investigations.

The use of products that promote growth through hormonal activity has received much attention in recent years. Estrogens have been used to promote growth performance, carcass characteristics and reduce carcass fatness in livestock. Estrogen hormone is commonly used to improve growth and carcass quality of the animal. The estrogen hormone in animals can increase red meat and stimulate the production of fat in the carcass of sheep. Hormones implanted to animal include diethylstilbrestrol (DES), Zeranol, Trenbolone, and Melengestrol which are synthetic estrogen drugs. The implantation of stilbestrol, a synthetic estrogen hormone I has resulted in increased growth in sheep (Andrews et al., 1956).

Phytoestrogens are weak plant estrogens that are similar in structure and have the ability to mimic the action of female hormone estrogen. Phytoestrogens have been reported in many legumes such as soybean, red clover, subterranean clover, lignans found in seed oils, garbanzo beans, sprouting beans and other legumes, especially White Kwao Krua (*Pueraria mirifica*) which is a native herbal plant in Thailand. Phytoestrogens from *Pueraria mirifica* (miroestrol and deoxymiroestrol) are different from any other phytoestrogen because they possess highest estrogenic activity among the known phytoestrogen due to structural similarity to estradiol (Mahidol et al., 2000). Therefore, the use of *Pueraria mirifica* may be as effective as the use of synthetic estrogen hormone (which will be prohibited in many countries soon) to enhance animal growth and carcass and meat quality.

Reduction in testosterone activity may reduce goaty odor in goat meat. There are two ways to decrease testosterone activity, castration and using of xenoestrogen which the xenoestrogens are consisting of the synthetic and phytoestrogen forms. Castration affects testosterone production differently depending on age and method of castration used. However, the appropriate method and age of castration to decrease testosterone

production remain unclear. Therefore, the aim of this research was to examine the effects of castration and supplementation of phytoestrogen *Pueraria mirifica* on growth performance, carcass quality and reduction of odorant fatty acid in goat meat.

1.2 Research objectives

1.2.1 To investigate the effect of castration on growth performance, carcass quality and reduction of odorant in goat meat.

1.2.2 To study the effect of supplementation of *Pueraria mirifica* on growth performance, carcass quality and reduction of odorant in goat meat.

1.3 Research hypothesis

1.3.1 Difference ages and methods of castration resulting in difference testosterone level and could improve growth performance, carcass quality and reduction of odorant in goat meat

1.3.2 Supplementation of *Pueraria mirifica* as source of phytoestrogen reduces testosterone level and thus improve growth performance, carcass quality and reduction of odorant in goat meat.

1.4 Scope and limitation of this study

This study was focused on the effects of change testosterone level from castration and supplementation of phytoestrogen from *Pueraria mirifica* on growth performance, carcass quality and reduction odorant fatty acid in Thai native×Anglo-Nubian male goat meat.

1.5 Expected results

1.5.1 This study will provide knowledge on the appropriate age and method of castration and their effects on growth performance, carcass quality and reduction odorant in goat meat.

1.5.2 To get better results of supplementation of phytoestrogen from *Pueraria mirifica* on growth performance, carcass quality and reduction odorant in goat meat.

1.6 References

Andrews, F., Stob, M., Perry, T., and Beeson, W. (1956). The effect of oral and subcutaneous estrogen and androgen administration on growth and carcass quality of lambs. **Journal of Animal Science**. 15(2) : 575-588.

Falahati-Nini, A., Riggs, B. L., Atkinson, E. J., O'Fallon, W. M., Eastell, R., and Khosla, S. (2000). Relative contributions of testosterone and estrogen in regulating bone resorption and formation in normal elderly men. **Journal of Clinical Investigation**. 106(12) : 1553.

Iwata, E., Wakabayashi, Y., Kakuma, Y., Kikusui, T., Takeuchi, Y., and Mori, Y. (2000). Testosterone-dependent primer pheromone production in the sebaceous gland of male goat. **Biology of reproduction**. 62(3) : 806-810.

Louca, A., Economides, S., and Hancock, J. (1977). Effects of castration on growth rate, feed conversion efficiency and carcass quality in Damascus goats. **Animal Production**. 24(3) : 387-391.

Mahidol, C., Prawat, H., Prachyawarakorn, V., and Ruchirawat, S. (2002). Investigation of some bioactive Thai medicinal plants. **Phytochemistry Reviews**. 1(3) : 287-297.

Sugiyama, T., Sasada, H., Masaki, J., and Yamashita, K. (1981). Unusual fatty acids with specific odor from mature male goat. **Agricultural and biological chemistry**. 45.

Wong, E., Johnson, C., and Nixon, L. (1975). The contribution of 4-methyloctanoic (hircinoic) acid to mutton and goat meat flavour. **New Zealand Journal of Agricultural Research.** 18 : 261-266.

CHAPTER II

LITERATURE REVIEW

2.1 Introductions

Goat *(Capra aegagrus hircus)* is a member of the bovine family and is closely related to the sheep. According to Haynes and Schanbacher (1983) male goats approach puberty at the age 12 weeks (3 months) and at 30 weeks (7.5 months) they are sexually mature and showing behavior of male effected by testosterone activity. Goat population in Southeast Asia was estimated to be 24.5 million and increased by 11.2% annually to 26.4 million in 2010 with 0.38 million heads were in Thailand (FAO, 2010). Goat production is an important component of livestock rearing in the developing countries. In Thailand, goat production is primarily for meat (Saithanoo and Milton, 1988) and the consumption of goat meat varies with traditional and cultural preferences. Muslims require their meat slaughtered to their religious standards. Most prefer their meat fresh but many accept frozen imported meat. Thai Muslim populations in the southern region are the main consumers of goat meat (Cheven) among the counties and create high demand for live meat goat during religious festivals. Goats weighing 27 kg, either male or female, are desired for Ramadan (Muslim festival), while goats weighting between 20 to 54 kg are also accepted for this Muslim festival.

Meat quality is a combination of chemical and sensory attributes and a carcass with better fat/muscle proportion is normally favored (Madruga et al., 2009). The high nutritional value of goat meat is becoming increasingly important in the health management of people. According to Santos-Cruz et al. (2012) goat meat is lower in total

and saturated fats and cholesterol but high in digestibility and protein content. Less saturated fats and a relatively high proportion of total unsaturated fats make goat meat a very healthy choice. However goat meat is more expensive than poultry meat but the former is a healthier meat.

Preferences and consumption patterns for goat meat are dictated by cultural, traditional, and religious backgrounds, and the socioeconomic status of the community. Goat meat offers more nutritional value as a lean meat with favorable nutritional qualities, and it is an ideal choice for the health conscious consumers. However, due to the unique odor goat meat is not preferred by many consumers.

2.2 Consumer acceptance of goat meat

In many countries around the world, goat meat is a dietary staple and a delicacy served in specialty dishes, particularly at celebratory gatherings. Goat meat is especially popular among Hispanics, Caribbean Islanders and Muslims. Individuals consume meat in order to obtain some satisfaction that is influenced by psychological and sensory responses such as product appearance, price, aroma, flavor, tenderness, juiciness, nutritive value. Hispanics prefer meat from young high quality goat kids, while people of Caribbean heritage and the Muslims prefer meat from older goats, and frequently intact males (Casey et al., 2003). Meat from Anglo-Nubian crossbred goats was reported to be more acceptable, with less “goaty” flavor than Thai native goat meat (Intarapichet et al., 1994).

About 45% of the variation in goat meat from intensive or extensive production systems was based on tenderness, juiciness, stringy, and cohesive sensory attributes, whereas 21% of the variation separated the samples on meaty attributes (odor and flavor) (Carlucci et al., 1998). Sen et al. (2004) reported that goat meat was less tender than sheep meat, although odor, juiciness, and overall palatability were not different. Patties

from sheep were more tender, juicy, greasy, and less chewy than those from goat, with species-related “goaty” and “muttony” flavor being clearly distinguishable (Tshabalala et al., 2003). The “goaty” odor of goat meat has been attributed to presence of 4-methyloctanoic (hircinoic) acid (Wong et al., 1975). Although, many consumers prefer goat meat because it is healthy food, but the odor of the goat meat often deterred consumers from eating it (Webb et al., 2005).

2.3 Precursors of goaty odor

Goat meat has a characteristic odor which is disliked by many consumers. A sweaty flavor noted in goat meat has been correlated with the presence of branch-chain fatty acids (BCFA) (Wong et al., 1975). Specific fatty acids which contribute to the odor of the buck have been identified (Sugiyama et al., 1981); they include 4-ethyloctanoic acids, 4-ethyldecanoic acids, 4-ethyldodecanoic acids and 4-ethyhexadecanoic acids. 4-ethyl-octanoic acid exhibits a strong characteristic goaty odor at low concentration (Sugiyama et al., 1981) and this fatty acid is a component of perfumes and has the lowest human odor threshold value of any aliphatic acid tested. Several chemical components have been implicated in the characteristic aroma of meat especially goat meat. These include BCFA, especially 4-methyloctanoic, 4-ethyloctanoic, and 4-methylnonanic acids which are the main odorant acids in goat and sheep meat (Wong et al., 1975; Brennand, 1989). Branched-chain and unsaturated fatty acids with 8-10 carbon atoms were related with the undesirable flavor.

Branched chain fatty acids are peculiar to ruminants and they are thought to be the result of the use of methyl-malonyl CoA from propionate metabolism which is the main source of liver gluconeogenesis rather than malonyl-CoA, during elongation fatty acid in the liver (Wong et al. 1975). However, branched chain fatty acids are produced when propionate levels exceed the capacity of the liver to normally metabolize it.

Methylmalonate then compensates with malonate for inclusion into fatty acid synthesis (Chanan et al., 2003).

Miller et al. (1986) showed that concentrations of BCFA were higher in subcutaneous fat than intramuscular fat. Subcutaneous fats contain higher odorant fatty acids in meat (Young et al. 1994). Baines and Mlotkiewicz (1984) found that BCFA dominated the fatty acid component in the flavour of cooking meat.

2.4 Factors affecting carcass composition and meat quality

Intact animal has faster growth rate than castrated animal, presumably because of the anabolic hormones produced by the testicles (Lee et al., 2008). Carcass and meat quality of animals are affected by multi- factors.

2.4.1 Age and Sex

A good carcass is one that has a minimum amount of bone, a maximum amount of muscle and an optimum amount of fat. The market demands differ in size of carcass and level of fatness. In most livestock species, age and sex influence meat quality properties. Meat quality is depending on many factors which affect pricing and consumer demand. Goats weighting between 18 to 36 kg are of high demand in the live goat markets than those weighing more than 36 kg (McMillin and Brock, 2005). Dhanda et al. (2003a) reported that slaughtering weight from 16 to 28 kg increased dressing percent and carcass fat thickness with consistent increases in shear force values and lower overall sensory acceptability scores. In contrast, Ruvuna et al. (1992) reported increasing age and weight at slaughter improved carcass dressing percentage and proportions of lean to fat and bone. Carcass weight is a main factor affecting the composition of the carcass and is closely related to age at slaughter. As animals mature, they normally gain weight resulting in a heavier carcass. However, much of the weight gain of a mature animal is

fat rather than muscle. Thus, at heavier live weight, carcass will have lower proportions of muscle and bone and a higher proportion of fat.

Normally, Male kids are10 to 25% heavier at birth and weaning than female kids and higher dressing percentage than females because of richer muscles. Dressing percentage of goats varies between 35 and 53% with the younger animals having higher dressing percentage than the older ones. Fatness refers to quantity of fat in the body because goats first deposit fat in inter-muscular and followed by subcutaneous fat. In general, young goats produce more tender meat than older goats (Rilay et al., 1989), but conformation and breed may influence meat properties (Dawkins et al., 1999).

Fatty acids in meat from goats raised on forage changed with age of the animals. Octadecanoic acid, oleic acid, and cholesterol increased whereas linolenic acid decreased in the lean composite mixtures from carcasses of goats with increased slaughter age from 4 to 6 months to 8 to 10 months (Beserra et al., 2004). However, Dhanda et al. (2003b) reported that oleic and linoleic acids increased in inter-muscular adipose tissue of male goats at 254 d of age compared with younger counter parts at 93 d of age.

Sex is one of the many factors that affect the carcass composition and meat goats, with fat tissue being most affected (Mahgoub et al., 2002). At all weights, females tend to grow fatter than males under similar management. Castrated males had more mesenteric and kidney fat than intact males (Bayraktaroglu et al., 1988). In addition, intact males had higher lean : fat : bone ratio (75 : 10 : 15) than castrated males (68 : 18 : 14) (Ruvuna et al.,1992). Carcasses from females had lower contents of muscle and higher fat than those from intact males (Colomer-Rocher et al., 1992) and carcasses of castrated male kids had higher percentages of lean and lower amounts of carcass and omental fat than carcasses from female kids (Hogg et al., 1992)

Johnson et al. (1995) reported that carcasses of female kid goats had less bone, more fat, and higher amounts of fat-free lean than carcasses of castrated males. There were no differences in moisture, fat, or protein contents of raw goat meat samples from intact male, female, or castrated kid goats of 21 to 28 kg slaughter weight. The tenderness force values of muscles from female carcasses were lower than that from castrated male, which had lower shear force values than those from intact male carcasses. However, Madruga et al., (2000) detected .no differences in sensory attributes of meat from intact and castrated goats at differing slaughter ages.

The unsaturated fatty acid composition of meat from intact male is reported to be higher than that of female or castrated goat (Johnson et al., 1995). However, Santos-Filho et al. (2005) reported no differences in unsaturated fatty acid composition in meat from intact or castrated male goats at 20 kg BW, whereas cholesterol and total saturated fatty acids increased in meat from castrated males.

2.4.2 Diet

The effect of nutrition on carcass composition and meat quality are result of interactions among level of intake, composition of diet and nutrient needs of the animal. High energy intake increased the juiciness, tenderness, and texture of goat meat, but overall acceptability was lower than grazing animals because of higher fat (Mc Millin and Brock, 2005). Intarapichet et al. (1994) also reported that acceptability of goat meat decreased with higher concentrate feeding because of the increased intensity of flavor in the meat. In addition, Carlucci et al. (1998) found that meat from grazing goats supplemented with commercial pellet was tender and juicy, whereas meat from goats fed hay and a commercial pellet was sticky and with high meaty odor and flavor.

Data on the effects of nutrition on the amount and type of fat in meat are inconsistent. Santos-Filho et al. (2005) reported that feeding of cashew nut bran containing high amounts of oil and oleic acid did not alter the fatty acid composition of

meat of intact and castrated male goats compared with control diets. In contrast, deposition of fat among muscle fibers on a high energy ration improves carcass composition and tenderness (Wood et al, 2004). Under nutrition in young intact males did not influence dressing percent, but slaughter, carcass, and prime cut weights were lower than those provided with supplements control goats (Seideman et al., 1982).

2.4.3 Breed

Carcass compositions and meat quality varied among species and breed due to differences in the rate of fat deposition during the later stages of growth. Anglo-Nubian kid goats had heavier carcasses with more muscle and less fat while Boer×Saanen kid goats had carcasses with more fat than carcasses of Saanen kid goats (Gibb et al., 1993). Meat from Anglo-Nubian goats with less goat flavor is more acceptable than meat from Thai native goats (Intarapichet et al., 1994). Dressing percent, fat thickness and sensory acceptability were different among male goats of these genotypes that reported by Dhanda et al. (2003a).

2.5 Castration on performance and meat quality

2.5.1 Castration method

There are several methods to castrate animals; surgical (knife), emasculatome (burdizzo) or elastrator (rubber ring) methods. Castration is the process by which the testes, epididymis and a portion of each spermatic cord are removed from male animals which had effect on testosterone production. Castration should be done at the youngest age possible since the stress of castration can adversely affect growth in older animals.

Surgical method incurred cutting using a scalpel is the most reliable but expensive method because the cost to animal recover. The materials need include a sharp

surgical scalpel, disinfectant, syringes and tetanus antitoxin. Surgical method is cutting testis that effect on decrease testosterone production which normally is produce from testes and adrenal gland in male animal.

On the other hand, burdizzo method involves the use of an instrument which crushes the spermatic cord, thus destroying the blood supply for the testes without this blood supply, the tissues eventually atrophy even though the scrotum will be visible for the rest of animal's lifetime. This method is known as a "bloodless" method since no cutting is done and when is done properly the skin is not even broken**.** Burdizzo method had effect on decreasing testes size in male animal which also had effect on produce testosterone.

Elastrator Method involves cutting off the blood supply to the testes with a heavy rubber band or ring. In 10 to 14 days, the scrotum and testes will slough off. This method is most effective for young animals because their scrotal tissues are not well developed. Although, castration is one way to manage the farm which there are reported to improve animal performance but it was not accepted in the field of animal welfare.

The study of Nsoso et al. (2004).who reported that the dressing percentage of burdizzo and rubber ring method groups were higher significantly than entire males which burdizzo method group promoted development of carcass characteristic with longer diagonal length and deeper height. Meat of entire males also had a tainted smell at 12 months of age. Thus burdizzo castration method was recommended

There is little information on the effect of castration and methodology of castration on growth rate and feed utilization in goats. Differences in the rate of gain

between castrates and intact males are also unclear. Moreover, the castration also has different effect on testosterone production depending on age and method of castration, thus efficient method and appropriated age of castration to decrease testosterone production remain unclear. Therefore, study related to age and method of castration is needed.

Table 2.1 Effects of castration on performance and meat quality of male goats

Parameters	Intact	castrates	%Difference	References
Performances				
Initial body weight (kg)	10.7	10.9	+1.87	El-Hag et al. (2007)
Final body weight (kg)	18.8	19.1	+1.60	
Total feed consumption (kg)	32.0 [b]	37.4 [a]	+16.88	
Daily feed consumption (kg)	0.508 [b]	0.575 [a]	+13.19	
Feed intake (%BW)	3.1	3.9		
Final body weight (kg)	30.8[b]	32.0[a]	+3.70	Sumarmono et al. (2001)
Cold carcass weight (kg)	11.3[b]	14.2[a]	+25.67	
Muscle to bone ratio (M : B)	3.5:1[b]	4.1:1[a]	-	
Slaughter weight (kg)	27.53	24.54	-10.86	McMillin.and Brock (2005)
Hide weight (kg)	3.49	2.81	-19.48	
Carcass weight (kg)	12.47	11.16	-10.51	
Dressing %	45.3	45.5	+0.44	
Backfat thickness (in)	0.003	0.1	+3,233.33	
Ribeye area (in^2)	4.47	3.97	-11.19	
Meat quality				
Juiciness score	1.86	2.19	+17.74	El-Hag et al. (2007)
Tenderness score	1.77	2.18	+23.16	
Flavour score	2.04	2.34	+14.71	

[a, b] means within the row with different superscripts are significantly different ($P<0.05$)

The presence of testicular hormones is related to greater muscle growth capacity in intact male (Arnold et al., 1997), however, El-Hag et al. (2007) reported that castrated goats consumed more feed and had higher feed intake as a percentage of body

weight than intact male goats. Moreover castration had improved sensory properties of meat (Table 2.1).

According to Devendra and McLeroy (1988), advantages of castration include production of less tainted meat especially if kids are slaughtered after more than four months of age and have better performance and meat quality than entire males. Studying the different castration methods, Nsoso et al. (2004) reported that in general, castration method had no effect on growth at the same age and stage of development (Table 2.2). The dressing percentage was significantly higher for goats castrated using the burdizzo and rubber ring methods than entire. Castration using burdizzo also promoted development of carcass (Nsoso et al, 2004).

Table 2.2 Methods of castration on male goat performances

Parameters	Methods of castration				References
	Intact	Burdizzo	Rubber ring	Short scrotum	
Initial weight (kg)	12.50	13.75	12.25	12.00	Nsoso et al. (2004)
Live weight (kg)	27.50	23.33	22.17	22.67	
Dressing (%)	42.50[b]	47.86[a]	43.44[ab]	41.73[b]	
Initial weight (kg)	19.64	19.32	-	19.27	McMillin and Brock (2005)
Gain (kg)	7.30	6.71	-	6.85	
Condition score	3.5	3.9	-	3.9	

[a, b] means within the row with different superscripts are significantly different (P<0.05)

2.5.2 Age of castrating goats

Castration of male goats not suitable for breeding is preferable to be within the first month of age. The testicles at this age are still not developed and the procedure will result in lesser bleeding and stress. In general, castrated males grow faster than

uncastrated males and are free of the goaty male odor. However, Kebede et al. (2008) reported that castration is important for better fat deposition in carcass than for body weight gain improvement but the time of castration did not resulted in better weight gain. Early castration is recommendable as goats castrated at three months of age had better rib eye area and fat thickness than other castrated groups and intact goats. (Table 2.3)

Table 2.3 Period of castration on male goat performances**.**

Parameters	Intact	Castration by burdizzo (months)				References
		3	6	9	12	
Initial body weight (kg)	10.70	9.00	-	-	12.60	
Final body weight (kg)	18.80	17.8	-	-	20.10	El-Hag et al.
Hot carcass weight (kg)	-	6.40[b]	-	-	7.90[a]	(2007)
Dressing (%)	-	38.70[b]	-	-	41.10[a]	
Initial body weight (kg)	10.28	11.28	9.83	10.50	-	
Daily weight gain (g)	64.48	63.67	65.63	62.93	-	
Final body weight (kg)	41.50	40.30	42.00	39.70	-	
Empty live weight (kg)	40.00	38.80	40.70	37.40		
Hot carcass weight (kg)	19.44	18.82	19.32	18.16	-	
Dressing (%)	48.60	48.51	47.47	48.56	-	Kebede et al.
Fat thickness (mm)	0.98[c]	9.20[a]	8.80[a]	6.60[b]	-	(2008)
REA (mm^2)	59.20	61.00	55.60	51.60	-	
Tissue proportion (%) in carcass						
Bone	20.36	19.66	16.75	20.57	-	
Muscle	75.97[a]	66.13[b]	68.45[ab]	65.69[b]	-	
Fat	3.67[b]	14.21[a]	14.80[a]	13.74[a]	-	

[a, b] means within the row with different superscripts are significantly different (P<0.05)

2.5.3 Effect of castration on odor fatty acid composition in muscle

Castration in goats has an advantage of eliminating the strong male odor present in bucks. The specific odorant compounds of the buck have been identified by Sugiyama et al. (1981) as 4-ethyloctanoic acid, 4-ethyldecanoic acid, 4-ethyldodecanoic acid and 4-ethylhexadecanoic acid. The effect of castration on fatty acids in meat male goats affecting specific odor of the buck are shown in Table 2.4

Table 2.4 Effects of castration on odor fatty acid in meat male goats

Fatty acids	Intact	Castrated	%Reduced	References
	---------µg/g of fleece ---------			
4-ethyloctanoic	30.3 ± 12.8	Nd	-	Hillbrick et al. (1995)
4-ethyldecanoic	121 ± 68	20.2 ± 4.6	-83.31	
4-ethyldodecanoic	323 ± 204	68 ± 14.5	-78.95	
4-ethyltetradecanoic	151 ± 85	32.3 ± 5.5	-78.61	
12 week-old (mg/kg adipose tissue)				Sutherland and Ames (1996)
4-methyloctanoic	3.79 ± 1.40	2.85 ± 0.70	-24.80	
4-methylnonanoic	0.35 ± 0.65	0.087 ± 0.97	-75.14	
30 week-old (mg/kg adipose tissue)				
4-methyloctanoic	50.30 ± 1.01 **	3.89 ± 1.00	-92.27	
4-methylnonanoic	1.40 ± 0.90*	0.35 ± 1.20	-75.00	

nd = not detected * = P<0.05 *** = P<0.001

From the above review, it is shown that effects of castration on performance, carcass quality and odor fatty acid in goat meat are inconsistent, in particularly, the appropriate age and method of castration on testosterone level. In has been previously mentioned (Chapter I) that there are two ways to decrease the testosterone activity; firstly by castration and the xenoestrogen is a one of two way of decrease testosterone activity. Thus effects of xenoestrogens on animal production are reviewed below.

2.6 Xenoestrogen

Xenoestrogens are xenohormones that imitates the function of estrogen. They can be either synthetic or natural chemical compounds. Synthetic xenoestrogens are the compound that generally used industrial, natural xenoestrogens include phytoestrogens which present in plants and there are structural similarities to estradiol. Xenoestrogens, like all estrogens can increase growth and pubertal development. Sharpe et al. (2005) indicated that exogenous estrogenic substances are too weak on male reproductive functioning, but indicated that the action appeared to be complex because exogenous chemicals may affect the endogenous testosterone-estrogen balance.

Like other steroid hormones, testosterone is derived from cholesterol. Testosterone is a steroid hormone from the androgen group and is found in mammals, reptiles, birds, and other vertebrates. In mammals, testosterone is primarily secreted in the testicles of males and the ovaries of females, although small amounts are also secreted by the adrenal glands. The largest amounts of testosterone (>95%) are produced by the testes. In addition, the testosterone could change to estradiol by aromatization and binding to estrogen receptors (Carani et al., 1997).

Certain hormones can make young animal gain weight faster. They help to reduce waiting time and the amount of feed by animal before slaughter. While a variety of hormones are produced and essential for normal development of healthy tissue, synthetic steroid hormones used as pharmaceutical drugs, have been found to affect cancer risk. For example, diethylstilbrestrol (DES), Zeranol, Trenbolone, and Melengestrol are a synthetic estrogen drug.

Lifetime exposure to natural steroid hormone estrogen is also associated with an increased risk for breast cancer. Hence, consumers are concerned about whether they are being exposed to hormones residues used in the animal industry. Steroid hormones are

derivatives from cholesterol and contrast only in the ring structure and side chains attached to it (Sih and Whitlock, 1968).

Steroid hormones are lipid soluble and thus are easily permeable to membranes and are not stored in cells and have to be carried in the blood system. Steroid hormones are usually released into the animal from a pellet (ear implant) under the skin of the ear. The ears of the animals are thrown away at slaughter, improper use of pellet implants in other parts of the animal can result in higher levels of hormone residues to remain it the edible meat.

The estrogen hormone is commonly used in implant to improve the growth and carcass of the animal. The estrogen hormone in animals can increase red meat and stimulate the production of fat in the carcass sheep. The implanting stilbestrol that is the estrogen hormone synthesis is resulted increased growth efficiency in sheep (Andrews et al., 1956).

2.7 Function of estrogen and synthesis

The major estrogens in female are estradiol, estriol, and estrone. In the body they are produced from androgen through the action of enzyme. Estradiol is produced from testosterone and estrone from androstenedione. A range of synthetic and natural substances have been identified to possess estrogenic activity. Synthetic substances of this kind are known as xenoestrogen, while natural plant products with estrogenic activity are called phytoestrogen.

Estrogen is produced primarily by developing follicles in the ovaries, the corpus luteum, and the placenta. Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) stimulate the production of estrogen in the ovaries. Some estrogens are also produced by other tissues such as the liver, adrenal glands, and the breasts. While estrogens are present in both males and females, they are usually present at significantly

higher levels in female of reproductive age. They promote the development of female secondary sex characteristics, such as breasts. In males estrogen regulates certain functions of the reproductive system essential to the maturation of sperm and may be required for a healthy libido.

Synthesis of estrogens starts by the synthesis of androstenedione from cholesterol. Androstenedione is a substance of moderate androgenic activity. This compound crosses the basal membrane into the surrounding granulosa cells, where it is converted to estrone or estradiol, either immediately or through testosterone. The conversions of testosterone to estradiol and of androstenedione to estrone are catalyzed by the enzyme aromatase.

Estrogens exert their effects on estrogen responsive cells via activation of estrogen receptor (ERα and ERβ). Endogenous estrogens, synthetic estrogen analogs or phytoestrogens enter the cells, where they bind to the estrogen receptor. The conformation of the bound receptor depends strongly on the nature of the ligand. Binding results in the release of the receptor related proteins. The membrane ER has translocated to a particular location in the membrane. The binding is signals from the membrane are transduce to regulate important functions such as cell growth and survival.

2.8 Effect of phytoestrogen in animal production

The use of products that promote growth through hormonal activity has received much attention in recent years. Estrogens have been used to promote growth performance, carcass characteristics and reduce carcass fatness in livestock. Phytoestrogens are hormone-like compound and a large family of plant derived estrogens possessing significant estrogen agonist/antagonist activity. Because only animal bodies can produce true hormones, these plant chemicals are called phytoestrogens (plant estrogen) include mainly isoflavones, lignans, coumestanes, stilbenes and the flavonoids quercetin and kaempherol.

Many plants contain phytoestrogen compounds that act like estrogens. The amount of estrogen found in plants is insignificant and are not as powerful. Phytoestrogens are compounds found in plants that have similar properties to estrogen produced in the body. The size and shape of phytoestrogen molecules are similar to estrogen and can bind with estrogen beta receptors in the cells. Phytoestrogens are naturally occurring, plant based diphenolic compounds that are similar in structure and function to estradiol (Lissin and Cook, 2000). They are wide spread in nature especially in the legumes. A phytoestrogen must have a chemical structure that brings about effect on animal by binding to the estrogen receptor. The estrogens produced by mammals are steroids, the primary ones being estradiol-17β, estrone and estriol.

The chemical structure of phytoestrogen mimics that of estradiol-17β sufficiently for them to bind weakly to the estrogen receptor (Adams, 1995). The most important estrogenic compounds in legumes are isoflavones and coumestans. Phytoestrogens have been reported in many legumes such as soybean, red clover, subterranean clover, lignans found in seed oils, garbanzo beans, sprouting beans and other legumes, especially White Kwao Krua (*Pueraria mirifica*).

2.9 White Kwao Krua (*Pueraria mirifica*).

Pueraria mirifica (White Kwao Krua) is native herbal plant found mainly in the northern and western part of Thailand and is known locally as “White Kwao Krua”. The enlargement underground tuber accumulates phytoestrogens that are beneficial and can be used for medicinal, food supplementary and cosmetic. Malaivijitnond (2012) reported that root of *Pueraria mirifica* harvested at the age of 6 years gave the highest isoflavonoid compound. Furthermore, root that was younger or older than 6 years old appeared to contain fewer amounts of the active compounds. In Thailand *Pueraria*

mirifica have been used for well over one hundred years, specifically for its rejuvenating quality.

The phytoestrogen containing plants in the Leguminous family comprising of isoflavones (daidzin, daidzein, genistin, genistein and puerarin) while phytoestrogen in *Pueraria mirifica* (miroestrol and deoxymiroestrol) differed from any other phytoestrogen because they possess highest estrogenic activity among the known phytoestrogen due to structural similarity to estradiol. However, it is very likely that the two phytoestrogens coexist in root of this plant. In addition to miroestrol and deoxymiroestrol, *Pueraria mirifica* also contains other chemicals that belong to isoflavones coumestan groups of phytoestrogens such as genistein, daidzein, daidzin, genistin, and coumestrol that are usually found in soybeans. However, the estrogenic activity of miroestrol and deoxymiroestrol is much more potent than that of soy isoflavones. While soy and alfalfa or other legumes contains low amount and low estrogenic of the phytoestrogens (Mahidol et al., 2000).

The concentration of phytoestrogens in *Pueraria mirifica* is much higher than other plant sources such as soy or alfalfa that contains many potent phytoestrogens including miroestrol (Figure 2.2) and deoxymiroestrol. *Pueraria mirifica* contains important chemical compounds, which are divided into several groups such as flavornoids, isoflavonoids, lignans, coumestanes, stilbenes (Figure 2.1). Other compounds in *Pueraria mirifica* is steroids such as β–sitosterol and stigmasterol include alkane, alcohols, fat and sugars. The compounds in *Pueraria mirifica* are show in Table 2.5

Table 2.5 The compounds found in *Pueraria mirifica*

Chromens	**Isoflavones**	**Isoflavones glycosides**	**Coumesta**
Miroestrol	Daidzein	Daidzin	Coumestrol

Deoxymiroestrol	Genistein	Genistin	Mirificoumestan
	Kwakhurin	Mirificin	Mirificoumestan glycol
	Kwakhurin hydrate	Puerarin	Mirificoumestan hydrate

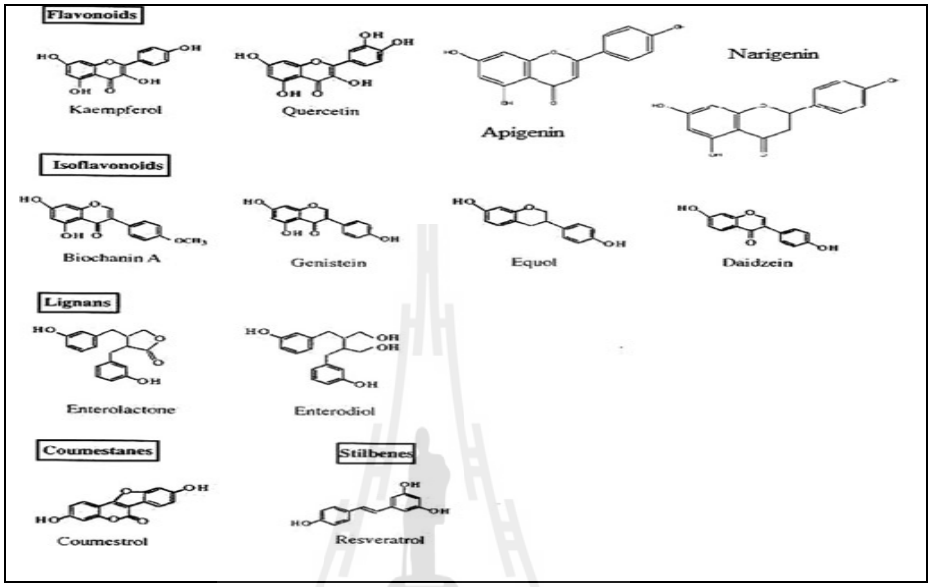

Figure 2.1 The chemical structure of the phytoestrogens. (Moutsatsou 2007)

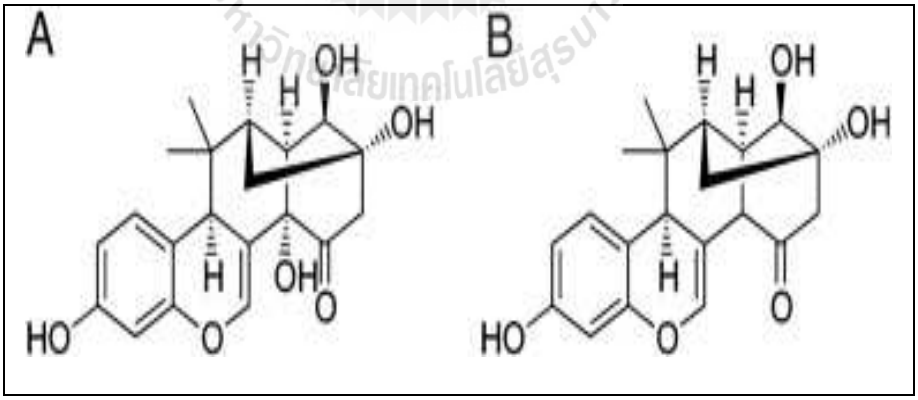

Figure 2.2 structures of miroestrol (A) and deoxymiroestrol (B) (Udomsuk et al., 2012)

2.10 Metabolism of phytoestrogens

Phytoestrogens may be extensively metabolized in the rumen. These compounds have enhanced estrogenicity after demethylation, which permits the hydroxyl groups to

bind to the estrogen receptor. Coumestans appear relatively resistant to microbial degradation in the gut, but the isoflavones are extensively metabolized by gut flora in all species, with substantial effects on the resulting estrogenicity. Mao et al. (2007) reported that isoflavones are group of phytoestrogens found in many plants, and daidzein is one of their major metabolites.

In the rumen of sheep and cattle, genistein and biochanin A are mostly degraded to non-estrogenic phenols but the results in study by Mao et al. (2007) reported that their results indicated potential regulating effects of daidzein on rumen microorganisms could be useful in the rumen function. The estrogenicity of isoflavones is enhanced through demethylation and reduction to the more estrogenic compound, which is absorbed rapidly through the ruminal wall. The estrogen from phytoestrogen seems to have little ability to enhance live weight gain in sheep (Trenkle and Burroughs, 1978). However, estrogenic growth promotants may be additive with phytoestrogen in producing estrogenic effects (Lookhart, 1980).

Metabolic conversions are also extensive in monogastric animals. Formononetin is not common in human diets, but degradation of genistein, daidzein and biochanin A by gut flora is less complete than in ruminants, so these compounds contribute to the estrogenicity. A proportion of daidzein or genistein may be converted to equol, although this may depend on the extent to which the microbial population has adapted to metabolism of the isoflavones. Phytoestrogens can have estrogenic or antiestrogenic effects, depending on the type and amount of phytoestrogen relative to the concentration of endogenous steroid estrogen. Isoflavone and coumestan estrogens bind more weakly to the estrogen receptor than estradiol-17β (Tang and Adams, 1980). Estrogen has a number of minor species-specific effects on metabolism; for example, estrogens stimulate protein deposition and growth in ruminants. Generally, phytoestrogens and

steroidal estrogens act similarly through the estrogen receptor to bring about the classical estrogenic.

2.11 The research of phytoestrogen in animals.

Phytoestrogen has the same features as the hormone estrogen. The estrogen hormone is popularly used in the optimization of the growth of the animal is the synthesis hormone compounds such as diethyl stilbestrol, hexoestrol and estradiol which residues in the meat. Currently, the use of synthetic hormones in animal production has be prohibited. On the other hand, *Pueraria Mirifica* is a plant that contains phytoestrogen has strong action similar to the hormone estrogen. Therefore, the use of *Pueraria mirifica* in animal production may be expected to be effective in animal growth and carcass characteristics and meat quality as synthesized estrogen hormone which will be prohibited in almost all country in the near future.

2.12 The research of *Pueraria mirifica* in animals.

Saardrak et al. (2004) found that levels of phytoestrogen in the *Pueraria mirifica* varied depending on season and age of the plant. Supplementation of Pueraria mirifica powder to replace the synthesis hormone (Hexoestrol) at 2% in native hybrid broiler of 1-18 weeks was found to result in increased breast weight and abdominal fat ($P<0.01$). In additon, the overall satisfaction rate of consumers was higher for chickens fed *Pueraria mirifica* than the control group ($P<0.05$) (Tubcharoen et al., 2007). However, supplemented *Pueraria mirifica* in diet of native chicken increased feed cost by 2

baht/kg diet as shown in Table 2.6.

Table 2.6 The effect of *Pueraria mirifica* on the carcass characteristics in native hybrid broiler (Tubcharoen et al., 2006)

Items	Male		Female	
	1-18 weeks of age		1-18 weeks of age	
	0%	2%	0%	2%
Live weight (g)*	2,472[b]	2,716[a]	2,088	1,972
Carcass (%)	86.33	85.47	84.80	83.37
Breast weight (%)**	16.31[b]	17.73[a]	19.39	20.74
Thigh weight (%)	16.59	16.76	16.39	16.13

[a, b] Means followed by a different letter within the same row are significant difference;
* (P<0.05); ** (P<0.01)

Chumkam et al. (2005) supplemented dry powdered *Pueraria mirifica* at 0, 0.5, 1.0, 2.0, 2.5 and 3.0% in broilers and reported that birds in the 1.0% level had high growth rate and while those in the 0.5-3.0% the blood cholesterol levels were not different compared with the control group (P>0.05). In a separate study, supplementation of *Pueraria mirifica* at 0, 100, 500 and 1000 mg/kg diet in hens did not resulted in differences in yolk cholesterol among treatment groups while hens in the control group had higher(P<0.05) serum cholesterol (Tubcharoen et al., 2003).

Pueraria mirifica inhibits clear expression in male chicken, because exposure to the Phytoestrogen inhibited the activity of male hormones naturally resulting in low secretion of estrogen hormone. Testosterone hormone is production of sperm cells in male animals, thus the use of estrogen hormone will inhibit the secretion of this hormone. Tungtrakoolsub et al. (2002) reported that the using of *Pueraria mirifica* at 200 ppm decreased testosterone hormone but increased feed intake and faster growth rate in pigs.

Supplementation of *Pueraria mirifica* at 200 ppm in diet of finishing pigs showed higher weight gain, ADG than the control group (P<0.01). Tubcharoen et al. (2002) reported that use of *Pueraria mirifica* reduced the stench in the male pigs (Table 2.7) which is consistent with the report of Jintasataporn et al. (2002) who found that *Pueraria mirifica* can prevent the unpleasant odor of male pigs. *Pueraria mirifica* is a legume that acts like the hormone estrogen which can inhibit male hormones (testosterone) thus reduces the odor in the male animals.

Supplementation of coumestrol at 100 ppm did not affect (P>0.05) growth performance in sheep compared with the control (Oldfield et al., 1996). Similarly, Payne et al. (2001) found that the use of isoflavone compounds in soybean did not significantly affect the growth performance in pigs (P>0.05) while isoflavone in diet affect the percentage of red meat (P<0.05), as shown in Table 2.8 and Table 2.9.

Table 2.7 The effect of *Pueraria mirifica* on the growth performance on finishing pigs (Tubcharoen et al., 2007)

Performances	**Treatments**			
	castrate	**Castrate + PM**	**Female**	**Female + PM**
Final weight (kg)	107.44	108.37	98.44	103.81
Weight gain (kg)**	68.44[a]	71.94[a]	59.87[b]	64.56[ab]
Total feed intake (kg)*	216.38[a]	201.27[a]	186.97[b]	189.06[b]
Ave. daily gain (g)**	699.37[a]	713.75[a]	598.75[b]	645.62[ab]
Feed conversion ratio	3.12	2.80	3.12	2.93

[a, b] Means followed by a different letter within the same row are significantly different; PM = *Pueraria mirifica* 200 ppm; * (P<0.05); ** (P<0.01)

Pace et al. (2006) studied the effect of subterranean clover which is a phytoestrogen legume in diet containing 0.8 mg/g of DM found that sheep which received phytoestrogen had higher growth rate and carcass characteristics than those

without phytoestrogen in their diet (P<0.05). Moreover the meat in the phytoestrogen treatment had lower percent drip loss than the control group (P<0.05), while no difference was detected in percent cooking drip loss (P>0.05) (Table 2.10).

Table 2.8 The effects of supplementation of phytoestrogen on growth performance of the animals.

Items	Level of phytoestrogen (Coumestrol)		Level of phytoestrogen (Isoflavone)		References
	0 ppm	100 ppm	Low isoflavone	High isoflavone	
Sheeps					
Initial weigh, kg	47.6	49.4	-	-	Oldfield et al. (1996)
Weight gain, kg	13.2	14.5	-	-	
Average daily gain, kg	0.24	0.26	-	-	
Average daily feed, kg	2.24	2.40	-	-	
Feed/Gain	9.95	9.38	-	-	
Pigs					
Average daily gain, kg	-	-	0.86	0.87	Payne et al. (2001)
Average daily feed, kg	-	-	2.93	2.89	
Feed/Gain	-	-	3.41	3.32	

Table 2.9 Supplementation of phytoestrogen on the carcass quality of the animal

Items	Level of phytoestrogen (Coumestrol)		Level of phytoestrogen (Isoflavone)		References
	0 ppm	**100 ppm**	**Low isoflavone**	**High isoflavone**	
Sheeps					
Dressing, %	53.4	55.0	-	-	
Carcass weight, kg	32.4	35.2	-	-	Oldfield et al.,
Loin eye area, cm^2	14.2	14.8	-	-	(1996)
Fat thickness, mm	15.4	18.0	-	-	
Pigs					
Final weight, kg	-	-	114.23	110.02	
Ave. backfat, cm	-	-	2.92	2.66	
Dressing, %	-	-	75.28	76.06	
%Lean	-	-	44.47^b	48.99^a	Payne et al., (2001)
%Fat	-	-	28.35^a	25.45^b	
Lean : Fat	-	-	1.61^b	1.99^a	

[a, b] Means followed by a different letter within the same row are significantly different ($P<0.05$).

Table 2.10 Effect of supplementation of subterranean clover phytoestrogen on growth, carcass and drip loss in sheep (Pace et al., 2006)

Parameters	Treatments	
	Control	**0.8 mg/g of DM**
Ave. daily gain (g/d), male	111.66 [b]	157.22 [a]
Ave. daily gain (g/d), female	107.19 [b]	145.53 [a]
Slaughtering weight (kg)	47.72 [b]	58.73 [a]
Cold carcass (kg)	25.92 [b]	33.41 [a]
Net dressing (%)	64.00	65.58
Drip loss (Raw)	1.00 [a]	0.78 [b]
Drip loss (Cook)	15.49	14.33

[a, b] Means followed by a different letter within the same row are significantly different ($P<0.05$).

Tubcharoen et al. (2006) supplemented *Pueraria mirifica* powder in castrated lambs at of 0, 400 and 800 ppm found that lambs in the 400 ppm group had highest feed conversion efficiency and growth rates ($P<0.05$) and lower cost of production than the other groups, while no differences ($P>0.05$) were detected between the 800 ppm group and the control group (Table 2.11).

Table 2.11 Effect of *Pueraria mirifica* powder at different levels on growth performance and carcass characteristics in castrated male lamb (Tubcharoen et al., 2006)

Items	Level of *Pueraria mirifica* (ppm)		
	0	**400**	**800**
Initial weight (kg)	20.30	20.75	20.60
Final weight (kg)	29.87	34.37	30.75
Weight gain (kg)	9.57	13.62	10.15
Average daily gain (g)	112.64	160.26	119.41
Feed conversion ratio, roughage (fresh)	17.80[a]	13.34[b]	15.90[ab]
Feed conversion ratio, concentrate	7.45[a]	5.66[b]	6.86[ab]
Feed cost per kg (bath)	62.80[a]	47.65[b]	57.61[ab]
Carcass percentage (%)	46.71	48.74	47.64
Abdominal fat weight (kg)	2.64[a]	1.05[ab]	0.96[b]

[a, b] Means followed by a different letter within the same row are significantly different ($P<0.05$)

2.13 References

Adams, N. R. (1995). Detection of the effects of phytoestrogens on sheep and cattle. **Journal of Animal Science**. 73(5) : 1509-1515.

Andrews, F., Stob, M., Perry, T., and Beeson, W. (1956). The effect of oral and subcutaneous estrogen and androgen administration on growth and carcass quality of lambs. **Journal of Animal Science**. 15(2) : 575-588.

Arnold, A., Peralta, J., and Thonney, M. (1997). Effect of testosterone on differential muscle growth and on protein and nucleic acid concentrations in muscles of growing lambs. **Journal of Animal Science**. 75(6) : 1495-1503.

Bayraktaroğlu, E., Akman, N., and Tuncel, E. (1988). Effects of early on slaughter and carcass characteristics in crossbred Saanen×Kilis goats. **Small Ruminant Research**. 1(2) : 189-194.

Beserra, F., Madruga, M., Leite, A., Da Silva, E., and Maia, E. (2004). Effect of age at slaughter on chemical composition of meat from Moxotó goats and their crosses. **Small Ruminant Research**. 55(1) : 177-181.

Brennand, C. P., HA, J., and Lindsay, R. C. (1989). Aroma properties and thresholds of some branched-chain and other minor volatile fatty acids occurring in milk fat and meat lipids1. **Journal of Sensory Studies**. 4(2) : 105-120.

Carani, C., Qin, K., Simoni, M., Faustini-Fustini, M., Serpente, S., Boyd, J., Simpson, E. R. (1997). Effect of testosterone and estradiol in a man with aromatase deficiency. **New England Journal of Medicine**, 337(2) : 91-95.

Carlucci, A., Girolami, A., Napolitano, F., and Monteleone, E. (1998). Sensory evaluation of young goat meat. **Meat science**. 50(1) : 131-136.

Casey, N., Van Niekerk, W., and Webb, E. (2003). Goat meat. Encyclopedia of Food Sciences and Nutrition. Eds. Caballero. **Academic Press. London**. 2937-2944.

Chumkam, S., Jintasataporn, O., and Triwutanone, O. (2005). Effect of Pueraria mirifica on growth performance, carcass characteristics and some hormone levels in broiler. **Warasan Samnakngan Khana Kammakan Wichai Haeng Chat**. 37.

Colomer-Rocher, F., Kirton, A., Mercer, G., and Duganzich, D. (1992). Carcass composition of New Zealand Saanen goats slaughtered at different weights. **Small Ruminant Research**. 7(2) : 161-173.

Dawkins, N., Phelps, O., McMILLIN, K., and Forrester, I. (1999). Composition and physicochemical properties of chevon patties containing oat bran. **Journal of Food Science**, 64(4) : 597-600.

Devendra, C. (1988). Nutrition and meat production. **Proceedings of the International Workshop on Goat Meat Production in Asia, Tando Jam (Pakistan).** 12-18 Mar 1988.

Dhanda, J., Taylor, D., and Murray, P. (2003a). Part 1. Growth, carcass and meat quality parameters of male goats: effects of genotype and liveweight at slaughter. **Small Ruminant Research**. 50(1) : 57-66.

Dhanda, J., Taylor, D., and Murray, P. (2003b). Part 2. Carcass composition and fatty acid profiles of adipose tissue of male goats: effects of genotype and live weight at slaughter. **Small Ruminant Research**. 50(1) : 67-74.

El-Hag, F., Mudalal, M., Ahmed, M. K., Mohamed, A., Khair, M., Elbushra, O., Fadlalla, B. (2007). Carcass and meat from intact and castrated Desert male goats of different ages. **Tropical Science.** 47(1) : 38-42.

FAOSTAT, F. (2010). Agriculture organization of the United Nations (FAO). **http://faostat fao org/site/567/DesktopDefault aspx: PageID.**

Gibb, M., Cook, J., and Treacher, T. (1993). Performance of British Saanen, Boer×British Saanen and Anglo-Nubian castrated male kids from 8 weeks to slaughter at 28, 33 or 38 kg live weight. **Animal Production**. 57 : 263-271.

Haynes, N., and Schanbacher, B. (1983). The control of reproductive activity in the ram. **Sheep Production**. 431-451.

Hillbrick, G., Tucker, D., and Smith, G. (1995). The lipid composition of cashmere goat fleece. **Crop and Pasture Science**. 46(6) : 1259-1271.

Hogg, B., Mercer, G., Mortimer, B., Kirton, A., and Duganzich, D. (1992). Carcass and meat quality attributes of commercial goats in New Zealand. **Small Ruminant Research**. 8(3) : 243-256.

Intarapichet, K., Pralomkarn, W., and Chinajariyawong, C. (1994). Influence of genotypes and feeding on growth and sensory characteristics of goat meat. **ASEAN Food Journal**. 9 : 151-151.

Jintasataporn, O., Choowatanapakorn, S., and Chumkam, S. (2002). Effect of *Pueraria mirifica* on some specific hormone , boar taint and reproductive organs in boar. **Proceedings of the 40th Kasetsart University Annual Conference, Bangkok (Thailand).** p. 20-26.

Johnson, D., Eastridge, J., Neubauer, D., and McGowan, C. (1995). Effect of sex class on nutrient content of meat from young goat. **Journal of Animal Science**. 73(1) : 296-301.

Kebede, T., Lemma, T., Dinka, H., Guru, M., and Sisay, A. (2008). Growth performance and carcass characteristics of Arsi-Bale goats castrated at different ages. **Journal of Cell and Animal Biology**. 2(11) : 187-194.

Lee, J., Kouakou, B., and Kannan, G. (2008). Chemical composition and quality characteristics of chevon from goats fed three different post-weaning diets. **Small Ruminant Research**. 75(2) : 177-184.

Lissin, L. W., and Cooke, J. P. (2000). Phytoestrogens and cardiovascular health. **Journal of the American College of Cardiology**. 35(6) : 1403-1410.

Lookhart, G. (1980). Analysis of coumestrol, a plant estrogen, in animal feeds by high-performance liquid chromatography. **Journal of Agricultural and Food Chemistry**. 28(3) : 666-667.

Madruga, M., Arruda, S., Narain, N., and Souza, J. (2000). Castration and slaughter age effects on panel assessment and aroma compounds of the “mestiço” goat meat. **Meat science**. 56(2) : 117-125.

Madruga, M. S., Stephen Elmore, J., Dodson, A. T., and Mottram, D. S. (2009). Volatile flavour profile of goat meat extracted by three widely used techniques. **Food Chemistry**. 115(3) : 1081-1087.

Mahgoub, O., Khan, A. J., Al-Maqbaly, R. S., Al-Sabahi, J. N., Annamalai, K., and Al-Sakry, N. M. (2002). Fatty acid composition of muscle and fat tissues of Omani

Jebel Akhdar goats of different sexes and weights. **Meat Science**, 61(4), 381-387.

Mahidol, C., Prawat, H., Prachyawarakorn, V., and Ruchirawat, S. (2002). Investigation of some bioactive Thai medicinal plants. **Phytochemistry Reviews**. 1(3) : 287-297.

Malaivijitnond, S. (2012). Medical applications of phytoestrogens from the Thai herb *Pueraria mirifica*. **Frontiers of medicine**. 6(1) : 8-21.

Mao, Z., Zheng, Y.L., Zhang, Y.Q., Han, B.P., Zhu, X.W., Chang, Q., and Hu, X.B. (2007). The antiapoptosis effects of daidzein in the brain of D-galactose treated mice. **Molecules**. 12(7) : 1455-1470.

McMillin, K., and Brock, A. (2005). Production practices and processing for value-added goat meat. **Journal of Animal Science**. 83(13 suppl) : E57-E68.

Moutsatsou, P. (2007). The spectrum of phytoestrogens in nature: our knowledge is expanding. **Hormones Athens Journal**, 6(3) : 173.

Nsoso, S., Podisi, B., Otsogile, E., Mokhutshwane, B., and Ahmadu, B. (2004). Phenotypic characterization of indigenous Tswana goats and sheep breeds in Botswana : continuous traits. **Tropical Animal Health and Production**. 36(8) : 789-800.

Oldfield, J., Fox, C., Bahn, A., Bickoff, E., and Kohler, G. (1966). Coumestrol in alfalfa as a factor in growth and carcass quality in lambs. **Journal of Animal Science**. 25(1) : 167-174.

Pace, V., Carbone, K., Spirito, F., Iacurto, M., Terzano, M., Verna, M., Settineri, D. (2006). The effects of subterranean clover phytoestrogens on sheep growth, reproduction and carcass characteristics. **Meat science**. 74(4) : 616-622.

Payne, R., Bidner, T., Southern, L., and Geaghan, J. (2001). Effects of dietary soy isoflavones on growth, carcass traits, and meat quality in growing-finishing pigs. **Journal of Animal Science**. 79(5) : 1230-1239.

Riley, R., Savell, J., Johnson, D., Smith, G., and Shelton, M. (1989). Carcass grades, rack composition and tenderness of sheep and goats as influenced by market class and breed. **Small Ruminant Research**. 2(3) : 273-280.

Ruvuna, F., Taylor, J., Okeyo, M., Wanyoike, M., and Ahuya, C. (1992). Effects of breed and castration on slaughter weight and carcass composition of goats. **Small Ruminant Research**. 7(2) : 175-183.

Saardrak, K., Tubcharoen, S., and Chaunchom, S. (2004). Utilization of Kwao Keur in livestock production: Determination of estrogenic substances from *Pueraria mirifica* on with differences cultivation period but harvested in the same time. **Proceedings of 42nd Kasetsart University Annual Conference.** Animals Veterinary Medicine, Bangkok (Thailand). p. 159-166.

Santos-Cruz, C.L.d., Cruz, C.A.C.d., Lima, T.R., Pérez, J.R.O., Junqueira, R.S., and Cruz, B.C.C.d. (2012). Correlation between lipid, cholesterol and fatty acid contents in the shoulder of castrated and non-castrated Santa Inês lambs. **Revista Brasileira de Zootecnia**. 41(7) : 1775-1783.

Santos-Filho, J.M., Morais, S.M., Rondina, D., Beserra, F.J., Neiva, J.N.M., and Magalhães, E.F. (2005). Effect of cashew nut supplemented diet, castration, and time of storage on fatty acid composition and cholesterol content of goat meat. **Small Ruminant Research**. 57(1) : 51-56.

Saithanoo, S. and Milton, J. (1988). Goat meat production in Thailand. In **Proceedings of the International Workshop on Goat Meat Production in Asia, Tando Jam (Pakistan)**. 12-18 Mar 1988.

Sen, A., Santra, A., and Karim, S. (2004). Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. **Meat Science**. 66(4) : 757-763.

Seideman, S.H.R. Cross, R.R Oltjen, and B.D Schanbacher. (1982). Utilization of the intact male for red meat production: A review. **Journal of Animal Science.** 55 : 826.

Sih, C., and Whitlock Jr. H. (1968). Biochemistry of steroids. **Annual Review of Biochemistry**, 37(1) : 661-694.

Sugiyama, T., Sasada, H., Masaki, J., and Yamashita, K. (1981). Unusual fatty acids with specific odor from mature male goat. **Agricultural and biological chemistry**. 45(10) : 313-316.

Sumarmono, J., Pratiwi, N.M.W., Murray, P., and Taylor, D. (2001). Carcass composition of entire and castrated full blood improved Boer bucks. In **Proceedings of the 25th Anniversary Annual Scientific Meeting.**

Sutherland, M.M., and Ames, J.M. (1996). Free fatty acid composition of the adipose tissue of intact and castrated lambs slaughtered at 12 and 30 weeks of age. **Journal of agricultural and food chemistry**. 44(10) : 3113-3116.

Tang, B. and Adams, N. (1980). Effect of equol on oestrogen receptors and on synthesis of DNA and protein in the immature rat uterus. **Journal of Endocrinology**. 85(2) : 291-297.

Trenkle, A. and Burroughs, W. (1978). Physiological effects of estrogens in animal feeds with emphasis on growth ruminants. **Proceedings of the International Symposium on Nutrition and Drug Interrelations.** Iowa State University (USA). 4-6 Aug 1976.

Tshabalala, P.A., Strydom, P.E., Webb, E.C., and de Kock, H.L. (2003). Meat quality of designated South African indigenous goat and sheep breeds. **Meat Science**. 65(1) : 563-570.

Tubcharoen, S., Chomchai, S., Saardrak, K., Pisarnpong, C., Dirokwirat, W., and Ponglumjeak, S. (2007). Effects of dietary turmeric meal supplementation on production performance and carcass quality of growing-finishing pigs. **Proceedings of the 45th Kasetsart University Annual Conference**. Bangkok (Thailand). 30 Jan-2 Feb 2007.

Tubcharoen, S., Triwutanon, O., Sa-nguanphan, S., Songserm, O., Saardrak, K., Yunchalad, M., Ponglumjiak, S. (2006). Effect of Pueraria mirifica in Thai native crossbred chickens. **Proceedings of 44th Kasetsart University Annual Conference.** Animal Veterinary Medicine, Bangkok (Thailand). p. 79-88.

Tubcharoen, S., Tungtakulsub, P., Saardrak, K., and Sanguanphan, S. (2002). Effect of Pueraria mirifica as layer diet on peak-egg production of laying hens. **Proceedings of 41st Kasetsart University Annual Conference**. Animals and Veterinary Medicine.3-7 February, 2002.

Tungtrakoolsub, P., Chomchai, S., Phangkatok, L., Sumon, N., and Tubcharoen, S. (2002). Effect of Pueraria mirifica on estradiol hormone in growing-finishing female pigs. **Proceedings of the 40th Kasetsart University Annual Conference: Animals, Veterinary Medicine, Fisheries, Bangkok (Thailand).** p. 205-211.

Udomsuk, L., Juengwatanatrakul, T., Putalun, W., and Jarukamjorn, K. (2012). Bimodal action of miroestrol and deoxymiroestrol, phytoestrogens from *Pueraria candollei var mirifica*, on hepatic CYP2B9 and CYP1A2 expressions and antilipid peroxidation in mice. **Nutrition Research**. 32(1) : 45-51.

Webb, E., Casey, N., and Simela, L. (2005). Goat meat quality. **Small Ruminant Research**. 60(1-2) : 153-166.

Wong, E., Nixon, L. N., and Johnson, C. B. (1975). Volatile medium chain fatty acids and mutton flavor. **Journal of Agricultural and Food Chemistry**. 23(3) : 495-498.

Wood, J., Nute, G., Richardson, R., Whittington, F., Southwood, O., Plastow, G., Chang, K. (2004). Effects of breed, diet and muscle on fat deposition and eating quality in pigs. **Meat science**, 67(4) : 651-667.

CHAPTER III

EFFECT OF AGE AND CASTRATION METHOD ON PERFORMANCE, CARCASS CHARACTERISTIC, MEAT QUALITY AND ODORENT FATTY ACIDS IN GOAT MEAT

3.1 Abstract

The objective of this study was to evaluate the effects of different ages and castrate methods on performance, carcass characteristics, meat quality and odorant fatty acids in goat meat. There were five treatments Animals were offered *ad-libitum* daily with rice straw and concentrate diet throughout 16 weeks. The result shows that the mean concentration of estradiol in serum of un-castrated goat was lower than castrated goat at 8 months of age either surgical or burdizzo method, while there was not significantly difference with surgical and burdizzo method at 3 months of age. The age of castration had effect on concentration of estradiol in serum, while method of castration was not any effect on concentration of estradiol in serum. The testosterone level and total cholesterol in serum was not significant difference effect with age and castration method. The main odorant fatty acid in this study were not significant difference among groups (P>0.05) while age of castration and castration method were not effect on all the main odor fatty acid in goat meat.

The fatty acid compositions were not significantly difference on amount of total SFA, MUFA, PUFA, conjugated fatty acid isomer, PUFA/SFA, UFA/SFA ratio and (P>0.05) and there were no interaction between castration method and age on amount

of total SFA composition (P>0.05). While, butyric acid (C4 : 0) and caproic acid (C6 : 0) were significantly difference with among groups (P<0.05). Moreover castration method had effect on C4 : 0, there was highly significant interaction effect between age and castration method on C6 : 0 (P<0.01). Moreover, burdizzo method castration group was higher palmitoleic acid (C16 : 1) than un-castration and surgical method castration group (P<0.05). The ratio of (C18 : 0+C18 : 1)/C16 : 0 and DFA is the parameter to describe effects of lipids to health consumer was not difference.

The carcass characteristics, carcass composition, meat quality, growth performance, overall feed intake and feed conversion ratio proportion were not significant difference (P>0.05). The pH_{24} were significantly different among groups with castration by burdizzo method at 3 month of age higher than other group. The had effect form age of castration (P<0.05) while castration method was not effect on cost per gain of goat, the data showed that the age of 3 months has higher cost per gain than other groups. The average cost per gain of goats at 3 months of age by surgery was higher cost per gain than other groups.

Key Words : Castration, Carcass, Meat quality, Odorant, Goat meat

3.2 Introduction

Small ruminant animal production is important in the developing countries with meat goats being the major small ruminant species. Castration of male animals is one of many management practices in animal production system. Although the castration imposes unnecessary pain and stress and may reduce performance but castrating yearling male sheep were shown to achieve higher dressing percentages than intact rams (Kebede et al., 2008). Arnold et al., (1997), however, showed that

intact males have relatively greater muscles in the neck and forequarter than females or castrates. In addition, castration in goats has and advantage of eliminating the strong male odor present in bucks, while un-castrated and sexually mature goats are difficult to sell and fetch low market price because of their strong male taint (Yacob and Kebede, 1993). Wong et al, 1975 had reported that 4-methyloctanic and 4-methylnonanoic acids were the main compounds producing the goaty odor in mutton and goat meat.

Male goat odor due to the presence of testosterone was most apparent in the sweat gland area, less distinct at the mental gland region, and faint or absent in the other glandular areas. Surgical removal of the cornual glands decreased buck odor and persisting scent. Castration can reduce goaty odor was reported by McMillin and Brock (2005) the meat from castrated males has less 'goaty smell' or tainted odor then meat from intact goats.

However, the effect of castration on goat performance, carcass characteristics and meat composition, especially the undesirable odor of meat are limited and unclear.

3.3 Objectives

This study was designed to investigate the effect of difference ages (3 and 8 months) and methods of castration (surgical and burdizzo) on growth performance, carcass characteristics, meat quality and odorant fatty acids in goat meat.

3.4 Materials and Methods

3.4.1 Experimental design and treatment

Thirty 3 months old male crossbred (Thai native×Anglo-Nubian) goats were used in this study. Goats were maintained in quarantine for two weeks after arrival at the experimental farm and were treated for external and internal parasites. Animals were randomly divided into 5 groups with six goats per group (treatment) in a completely randomized design (CRD) (Table 3.1). The experimental period started record after goats in 8 month castration groups were castrated and recovery from castration procedure. Blood samples were collected at the beginning and end of experiment for evaluate determination of testosterone and estradiol hormones.

All animals were offered rice straw *ad libitum* supplemented with concentrate (16% CP) 1.5% (BW). Animals were weighed before feeding, weekly and daily dry matter intake (DMI) was recorded. Six goats from each treatment were randomly selected and slaughtered for carcass evaluation following the procedure of Dhanda et al. (2003a) at the end of experimental period.

Table 3.1 Experimental treatments.

Groups	**Treatments**
T1 (control)	Un-castrated
T2	Castrated at 3 month age by surgical method
T3	Castrated at 8 month age by surgical method
T4	Castrated at 3 month age by burdizzo method
T5	Castrated at 8 month age by burdizzo method

Goats were offered rice straw *ad libitum* and supplemented with concentrate. The chemical composition of the commercial pellet concentrate and rice straw used for the experiment are shown in Table 3.2.

Table 3.2 Chemical composition of the experimental diet (%DM)**.**

Item (%DM)	Concentrate	Roughage (Rice straw)
Crude protein	16.26	3.21
Ether extract	4.01	0.66
Ash	6.89	15.34
Neutral detergent fiber (NDF)	43.89	66.46
Acid detergent fiber (ADF)	27.60	49.95

3.4.2 Slaughtering and carcass evaluation

Animals were weighed and fasted for 18 hrs and weighed again immediately prior to slaughter following the standard procedures of USDA (2005). After skinning, the carcasses were eviscerated and internal organs and tissues were weighed and their percentages with respect to empty live weight of the animals were determined. The kidney fat and the kidneys were then removed. Hot carcass weight (HCW) was measured prior to chilling.

Carcasses were split down the dorsal midline using on a hand saw and the carcass lengths measured using the left side of the carcass which was also used for all other measurements. The carcasses were chilled at 4ºC for 24 h and were weighed again to obtain cold carcass weight (CCW) as prescribed by Fisher and de Boer (1994).

After carcasses were dissected to separated muscles for evaluated carcass composition. The rip eye area (REA) and thickness of fat were evaluated between the longissimus muscle at 12^{th} and 13^{th}. The thickness of fat was determined using digital caliper within 300 mm operating instruction, KEIBA brand, and resolution 0.01–0.0005 inch. REA was evaluated using planimether (N-Series Roller-Type Digital

Planimeter). The muscle samples were analyzed for DM, CP, EE and Ash content following the procedure of AOAC (2000).

3.4.3 Meat quality attributes

Drip loss was determined using the method according by Sen et al. (2004). 20 g of raw meat samples were kept at 4°C for 24 h in a refrigerator under polyethylene sealed covers. The samples were gently dried with paper towels, and reweighed. Percentage of drip loss was estimated as the ratio of weight loss to initial of sample weight.

Muscle pH was determined using a pH meter with a combined electrode by inserted into the *longissimus* muscle between the 12^{th} and 13^{th} rib site, fore and hind legs 45 minutes post slaughter for pH_0 and again at 24 hrs. post-slaughter for pH_{24}. Muscle color was evaluated on the muscle surface using Minolta CR 300 spectrocolorimeter Minolta Italia, Milano, Italy and CIE detecting lightness (L*), red color coordinate (a*), yellow color coordinate (yellowness) with D 65 illumination. Muscle color was subjectively evaluated using a five point scale (Dhanda et al., 2003).

3.4.4 Chemicals analysis and calculation

Moisture content of feed and meat samples was determined by drying in oven at 105^{o}C until constant weight, the ash by burning the material in muffle at 550^{o}C for 5 hrs, crude protein using Kjeldahl procedure and total fat was extracted in Soxhlet Extraction Unit following the procedures of AOAC (2000).

3.4.5 Fatty acids in meat samples

3.4.5.1 Extraction and preparation of sample

Meat sample was extraction from the *Longissimus dorsi* muscle (Enser et al., 1996) and approximately 15 g of the meat sample was homogenize with

90 ml chloroformmethanol (2 : 1 v/v) solution for 2 min and homogenize for 2 min after added 30 chloroform. The mixture solutions of solvent and meat sample were filtrated by using Whatman filter paper No.1 into separate flask and cover with aluminium foil to prevent from direct exposure to sunlight. Deionized water (30 ml) and 5 ml 0.58% NaCl were added to it and leave overnight (Hara and Radin, 1978). The top layer (methanol aqueous fraction) of the solution was discarded while the bottom layer containing fatty acids was transferred into erlenmeyer flask and evaporated to remove chloroform. The extracted fat samples were kept at -20^{o}C for determination of fatty acids using Gas Chromatography (GC).

For fatty acid extraction (Metcalfe and Schmitz, 1961) approximately 25 mg of the extracted fat was transferred into screw capped culture tube and added 1.5 ml of 0.5 methanolic NaOH and then heated for 2 min at 100^{o}C in water bath and flushed with nitrogen gas. 2 ml of Boron trifluoride (BF_3 in 14% methanol) reagent (Morrison and Smith, 1964) was added into cool sample tube and flash with nitrogen gas.

The sample tube was caped tightly and heated for 30 min at 100^{o}C in a water bath. 1 ml of iso-octane was added after cool the mixture to 30-40^{o}C and flash with nitrogen gas, cap and shake vigorously while still warm for 30 sec then added 5 ml saturated NaCl solution. The iso-octane layer was carefully transferred with a pasteur pipette into a screw cap glass vial and stored at -20^{o}C.

3.4.5.2 Determination of fatty acid by GC

Fatty acid composition of the fatty acid methyl esters (FAME) was determined using GC (Hewlett Packard 6890 model Agilent Technologies Inc., Santa Clara, CA) equipped with a flame ionization detector (FID) and fitted with a SP-2560, 100 m × 0.25 mm × 0.20 μm capillary column (Supelco), 7673 controller,

and split injection (Agilent Technologies Inc., Santa Clara, CA). The initial oven temperature was 70^{o}C, held for 4 min. Thereafter, the temperature was increased at a rate of 13^{o}C/min to 175^{o}C. Helium was used as the carrier gas at a flow rate of 1.0 ml/min. Both the injector and the detector were set at 250°C. Fatty acids were identified by comparing their retention times with the fatty acid methyl standards from Supelco, USA.

3.4.6 Statistical Analysis

The data were analyzed according to a completely randomized design (CRD) (Steel and Torrie, 1980). In order to correct for different in initial weight at the start of the experiment, initial body weight was used as a covariate adjustment factor for the analysis of data on live animals (final body weight, weight gain, and feed consumption). Similarly, live weight was used as a covariate adjustment factor for analysis of data on carcass yield (carcass weight, dressing percentage and carcass composition). (Ülker et al., 2002). The initial cholesterol, estradiol and testosterone level in serum were used as covariate adjustment factor for analysis of data on cholesterol, estradiol and testosterone level in serum of animals. Statistical analysis was performed with the general linear model procedure (PROC GLM), A significance level of $P<0.05$ was used to differentiate between means with SPSS 11 program.

3.4.7 Experimental site

The experiment was conducted on the farm of Suranaree University of Technology, The chemical analysis was performed at the Center for Scientific and Technological Equipment (CSTE) of Suranaree University of Technology.

3.4.8 Duration

The experiment on January, 2010–September, 2010

3.5 Results and discussions

3.5.1 The concentration of estradiol, testosterone hormone and cholesterol in serum of meat goat

The effect of different ages and methods of castration in this experiment show the mean of estradiol and testosterone hormone in serum of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or burdizzo method in Table 3.3. The result show the concentration of estradiol in serum of un-castrated goat was lower significant difference (110.50 pmol/L) than castrated goat at 8 months of age either surgical (419.05 pmol/L) or burdizzo method (382.69 pmol/L) ($P<0.05$), while there was not significantly difference with surgical and burdizzo method at 3 months of age (116.58 and 134.20 pmol/L respectively). The age of castration (3 months and 8 months) had effect on concentration of estradiol in serum, while method of castration was not any effect on concentration of estradiol in serum($P>0.05$).

The testosterone level in serum of goat meat was not significant difference effect with age and castration method was range from 0.46 to 1.60 nmol/L. Moreover, the data show that un-castrated goat have had higher testosterone level than castrated goat. The surgical and burdizzo casration are difference on the existence of testes that main source of produce testosterone in male animal. Novara et al., (2009) reported that the surgical castration had reduced concentration of testosterone. Although data shown decrease concentration of testosterone as report by Novara et al., (2009) but the effect of castration was not statically difference either surgical or burdizzo castration method.

The data showed that the total cholesterol in serum was not significantly difference among groups ($P>0.05$) that there was ranged from 67.02 to 70.2 mg/dl that show in Table 3.1. In addition to age and castration method had not effect on total cholesterol in serum ($P>0.05$). The addition estradiol that reported by Liu and

Bachmann (1998) concerned the estradiol reduce cholesterol levels in blood serum. The concentration of cholesterol in this study did not decrease from the increase estradiol effect with castration.

3.5.2 The concentration of odorant fatty acids in goat meat

The evaluated effect of the odorant fatty acid compositions from *Longissimus dorsi* of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or burdizzo method are show in Table 3.4. The data showed were not significantly difference on odorant fatty acid in goat meat ($P>0.05$). The main odorant fatty acid that there are undesired smell to consumer of un-castrated goat was higher 4-methyl-octanoic acid than castration group, however the statistically analysis show were not significant difference among groups ($P<0.05$). In the term of 4-ethyl-octanoic acid and 4-methyl-nonanoic acid those are the main odor in goat meat were not significant different ($P>0.05$) while the data show age of castration and castration method were not effect on all the main odor fatty acid in goat meat.

Different from report by Hillbrick et al. (1995) which the main substance of goaty odor were decreased in castration goat compared with intact goats. Whereas, Sutherland et al. (1996) observed that in castration goats at 12 weeks of age as compared to intact goats were decreased 4-methyoctanoic and 4-methylnonanic acids. While the result of this study shows 4-ethyl-octanoic acid and 4-methyl-nonanoic acid were not significant difference. The castration is a one way decreasing testosterone (Mezey et al., 1980) that there are factor of odor in meat (Falahati-Nini et al., 2011), the result of studies show not significance difference (Table 3.1), although castration data show concentration testosterone lower than un-castrated but the testosterone this level could not effect on clearly reducing odorant fatty acid.

Table 3.3 Effects of age and castration method on estradiol and testosterone level in serum of meat goats**.**

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Estradiol (pmol/L)	110.50[b]	116.58[b]	419.05[a]	134.20[b]	382.69[a]	37.44	**	ns	ns
Testosterone (nmol/L)	1.60	0.50	0.46	0.54	0.47	0.177	ns	ns	ns
Cholesterol, mg/dl	69.92	69.70	70.29	67.17	69.02	2.24	ns	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly; SEM = standard error of the mean; **P<0.01; ns = not significantly different (P>0.05); A = effect of age; M = effect of method; A×M = interaction age and method

Table 3.4 Effects of age and castration method on odor fatty acid as percentage of total fatty acid in goat meat.

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Odorant fatty acid	---------- % of total fatty acid ----------								
4-methyl-octanoic acid	0.008	0.003	0.003	0.003	0.002	0.001	ns	ns	ns
4-ethyl-octanoic acid	0.004	0.004	0.002	0.004	0.003	0.0004	ns	ns	ns
4-methyl-nonanoic acid	0.018	0.025	0.017	0.012	0.013	0.002	ns	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly($P<0.05$); SEM = standard error of the mean; ns = not significantly different ($P>0.05$); A = effect of age; M = effect of method; A×M = interaction age and method

3.5.3 The concentration of fatty acid profile in goat meat

The mean of the fatty acid compositions from *Longissimus dorsi* are show in Table 3.5. The un-castration group or castrated by surgical method or burdizzo method at 3 month or 8 month were not significantly difference on amount of total SFA ($P>0.05$) range from 46.0 to 48.4% of total fatty acid, there were no interaction between castration method and age on amount of total SFA composition ($P>0.05$). In addition Banskalieva et al. (2000) who reviewed about fatty acid in goat muscle that the mean concentration of SFA in goat muscles are varied among from 29 to 54. While, butyric acid (C4 : 0) and caproic acid (C6 : 0) were significantly difference with among groups ($P<0.05$). Moreover castration method had effect on C4 : 0, there was highly significant interaction effect between age and castration method on C6 : 0 ($P<0.01$).

Butyric acid is a fatty acid occurring in the form of esters in animal fats which effect on flavor and unpleasant odor in meat. Butyric acid is the source of the characteristic odor of rancid butter or spoiled meat (Clavero, 2010). The castration with burdizzo method group was higher butyric acid than surgical method group that that may decrease shelf-life of goat meat. Moreover pH_{24} of meat in surgical method was higher than burdizzo method group (Table 3.6). El-Waziry et al. (2011) reported that the high pH value of meat unsuitable of storage because of the favorable development of proteolytic micro-organism.

In the term of amount monounsaturated fatty acid (MUFA), The un-castrated goats or castrated goats at 3 months or 8 months by surgical method or budizzo method were not significantly different on MUFA ($P>0.05$) range from 44.6 to 46.9% of total fatty acid except burdizzo method castration group was higher palmitoleic acid (C16 : 1) than un-castration and surgical method castration group

(P<0.05) while the orthogonal contrast shown the castration method had effect on this fatty acid but interaction between castrated method and ages had no significantly different in MUFA (P>0.05).

Palmitoleic acid or know in the name Omega 7 (Siguel and Maclure, 1987).that present in all tissues but generally found in the liver. In addition the mean concentration of palmitoleic acid in goat muscles is higher compared with lambs (Banskalieva et al., 2000). The palmitoleic acid is biosynthesized from palmitic acid and advantage to increase insulin sensitivity by suppressing inflammation, as well as inhibit the destruction of insulin-secreting pancreatic beta cells (Nestel, et al., 1994). According to Rössner et al., (1989) found that the adipose tissue of obese patients were increase palmitoleic acid, however, but the influence of different method of castration on concentration of palmitoleic acid requires further study.

However, in this study the amount total polyunsaturated fatty acid (PUFA) (range from 6.1 to 7.8% of total fatty acid) and conjugated fatty acid isomer in goat meat were not significantly different either castration method or ages of castration effect (P>0.05) difference from previous study of Teye (2009) reported that age had effect to the lower the concentrations of linoleic acid (18 : 2), linolenic (18 : 3) and total polyunsaturated fatty acids (PUFA) with increasing age (P<0.001). Moreover, the study of Aricetti et al. (2008) that report the castration featured higher depositions of CLA.

Fatty acid ratio between PUFA and SFA was not significant difference among group (P>0.05) the amount of PUFA/SFA ratio which included the sum of desirable fatty acid (DFA) of un-castrated group is 0.17% of total fatty acid higher than castrated group (range from 0.12 to 0.14% of total fatty acid). According to

Madruga et al. (2009) who investigated PUFA/SFA ratio of goat were from 0.08 to 0.09 which below those suggested by Wood et al. (2009) who recommended value of PUFA/SFA ratio above 0.4 to prevent illnesses associated with the consumption of fats. In this study show the PUFA/SFA ratio range from 0.12 to 0.17 whereas, Banskalieva et al. (2000) reported the value of PUFA/SFA ratio around 0.1 is unbalanced consumption of desirable fatty acid which the generally PUFA/SFA ratio of goat meat is lower in ruminant because of ruminal micro-organism activity.

The UFA/SFA ratio of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or burdizzo method were not significantly different ($P>0.05$) range from 1.07 to 1.18% of total fatty acid. The age of castration and castration method had not effect on either PUFA/SFA ratio or UFA/SFA ($P>0.05$).

Bonanome and Grundy (1988) suggested that only C16:0 increases blood cholesterol, whereas C18:0 has no effect and C18:1 decreases blood cholesterol content. Because these fatty acids represent the majority of fatty acids, the ratio of (C18 : 0+C18 : 1)/C16 : 0 could perhaps better describe possible health effects of different types of lipids Banskalieva et al. (2000). Considering the (C18 : 0+C18 : 1)/C16 : 0 ratio in this study was not difference, which the range of (C18 : 0+C18 : 1)/C16 : 0 ratio are from 3.34 to 3.85. According to Banskalieva et al. (2000) and Rhee et al. (2000), mentioned to this ratio is the one the best describes the possible beneficial effects of lipids, which values are from 2.1 to 3.6 for goat meat. In the study showed of Thai native meat goat quite close to meat from Boer and Anglo Nubian crossbred×SPRD goats with values from 3.13 to 3.26 that reported by Madruga et al. (2009).

Banskalieva et al. (2000) mention to possible to express the concentration of desirable fatty acid through the sum of unsaturated fatty acid with stearic acid. Although, the stearic acid is a saturated fatty acid but it can converted into oleic acid in the body. The DFA is indicator benefit of fatty acid in meat that shows risk of obesity, cancer and cardiovascular diseases. In this study shows desirable fatty acid (DFA) range from 74.76 to 76.71% of total fatty acid also show the DFA value of Thai native meat goat excellence close to Boer, Anglo Nubian and crossing with SPRD goat meat.

Table 3.5 Effects of age and castration method on fatty acid profile as percentage of total fatty acid in goat meat.

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Saturated Fatty Acid, SFA	---------- % of total fatty acid ----------								
Butryic (C4 : 0)	0.599[a]	0.354[a]	0.021[b]	0.126[a]	0.708[a]	0.014	ns	*	ns
Caproic (C6 : 0)	0.022[b]	0.019[b]	0.014[b]	0.020[b]	0.040[a]	0.002	**	**	**
Caprylic (C8 : 0)	0.021	0.014	0.024	0.015	0.013	0.001	ns	ns	ns
Capric Acid (C10 : 0)	0.065	0.070	0.062	0.064	0.064	0.003	ns	ns	ns
Lauric Acid (C12 : 0)	0.723	0.703	0.633	0.585	0.634	0.004	ns	ns	ns
Tridecanoic Acid (C13 : 0)	0.015	0.016	0.018	0.014	0.016	0.001	ns	ns	ns
Myristic Acid (C14 : 0)	3.038	3.355	3.093	3.152	3.198	0.049	ns	ns	ns
Pentadecanoic Acid (C15 : 0)	0.377	0.364	0.385	0.372	0.506	0.002	ns	ns	ns
Palmitic Acid (16 : 0)	17.796	17.514	19.114	19.104	19.146	0.391	ns	ns	ns
Heptadecanoic Acid (C17 : 0)	0.790	0.790	0.698	1.098	0.708	0.07	ns	ns	ns
Stearic Acid (C18 : 0)	22.667	23.195	23.461	22.996	22.874	0.383	ns	ns	ns
Arachidic Acid (C20 : 0)	0.193	0.167	0.169	0.216	0.193	0.011	ns	ns	ns
Behenic Acid (C22 : 0)	0.070	0.066	0.083	0.080	0.084	0.003	ns	ns	ns
Tricosanoic Acid (C23 : 0)	0.090	0.061	0.061	0.061	0.069	0.007	ns	ns	ns
Lignoceric Acid (C24 : 0)	0.086	0.078	0.082	0.074	0.073	0.003	ns	ns	ns
Total SFA	46.026	46.450	47.960	48.421	47.764	0.526	ns	ns	ns

Table 3.5 Effects of age and castration method on fatty acid profile as percentage of total fatty acid in goat meat. (Cont.)

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Monounsaturated Fatty Acid, MUFA									
Myristoleic Acid (C14 : 1)	0.797	0.120	0.130	0.097	0.113	0.002	ns	ns	ns
Pantadecenoic Acid (C15 : 1)	0.078	0.041	0.038	0.045	0.043	0.002	ns	ns	ns
Palmitoleic Acid (C16 : 1)	2.392[b]	2.375[b]	2.590[b]	3.068[a]	3.133[a]	0.092	ns	*	ns
Heptadecenoic Acid (C17 : 1)	0.759	0.927	0.764	0.906	0.843	0.052	ns	ns	ns
Elaidic Acid (C18 : 1n9t)	0.288	0.298	0.345	0.344	0.374	0.018	ns	ns	ns
Oleic Acid (C18 : 1n9c)	42.234	42.891	41.680	39.507	40.647	0.505	ns	ns	ns
Eicoenioic Acid (C20 : 1)	0.110	0.104	0.097	0.094	0.109	0.004	ns	ns	ns
Erucic Acid (C22 : 1n9)	0.085	0.085	0.068	0.087	0.079	0.003	ns	ns	ns
Nervonic Acid (C24 : 1)	0.080	0.078	0.067	0.070	0.0721	0.002	ns	ns	ns
Total MUFA	46.069	46.921	45.822	44.646	45.489	0.471	ns	ns	ns
Polyunsaturated Fatty Acid, PUFA	---------- % of total fatty acid ----------								
Linolelaidic Acid (C18 : 2n6t)	0.160	0.151	0.111	0.115	0.156	0.009	ns	ns	ns
Linoleic Acid (C18 : 2n6c)	1.708	1.558	1.495	1.919	1.776	0.009	ns	ns	ns
Gamma-Linolenic Acid (C18 : 3n6)	0.041	0.029	0.028	0.021	0.024	0.004	ns	ns	ns
Alpha-Linolenic Acid (C18 : 3n3)	0.078	0.064	0.079	0.055	0.056	0.006	ns	ns	ns
Eicosedienoic Acid (C20 : 2)	0.093	0.083	0.075	0.098	0.082	0.005	ns	ns	ns
Eicosatrienoic Acid (C20 : 3n6)	0.218	0.221	0.172	0.213	0.182	0.009	ns	ns	ns
Eicosatrienoic Acid (C20 : 3n3)	0.079	0.071	0.064	0.066	0.064	0.004	ns	ns	ns

Table 3.5 Effects of age and castration method on fatty acid profile as percentage of total fatty acid in goat meat. (Cont.)

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Polyunsaturated Fatty Acid, PUFA	---------- % of total fatty acid ----------								
Arachidonic Acid (C20 : 4n6)	3.874	2.901	2.698	2.799	2.977	0.238	ns	ns	ns
Eicosapentaenoic Acid (C20 : 5n3)	0.353	0.406	0.301	0.317	0.297	0.014	ns	ns	ns
Docosadienoic Acid (C22 : 2)	0.382	0.378	0.321	0.334	0.328	0.014	ns	ns	ns
Docosahexaenoic Acid (C22 : 6n3)	0.251	0.132	0.278	0.180	0.193	0.021	ns	ns	ns
Conjugated Linoleic Acid Isomers	---------- % of total fatty acid ----------								
cis-9, trans-11 CLA (C18 : 2)	0.270	0.272	0.254	0.310	0.275	0.011	ns	ns	ns
trans-10 cis-12 CLA (C18 : 2)	0.084	0.076	0.090	0.086	0.081	0.005	ns	ns	ns
cis-9, cis-11 CLA (C18 : 2)	0.101	0.081	0.068	0.139	0.071	0.014	ns	ns	ns
trans-9, trans-11 CLA (C18 : 2)	0.184	0.175	0.155	0.201	0.161	0.009	ns	ns	ns
Total PUFA	7.875	6.597	6.196	6.915	6.729	0.228	ns	ns	ns
PUFA/SFA	0.173	0.143	0.130	0.144	0.141	0.006	ns	ns	ns
UFA/SFA	1.183	1.159	1.088	1.078	1.096	0.023	ns	ns	ns
(C18 : 0+C18 : 1)/C16 : 0	3.748	3.848	3.450	3.399	3.354	0.650	ns	ns	ns
DFA	76.613	76.714	75.501	74.758	75.131	0.466	ns	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly; [1] Fatty acids are presented as g per 100 g of total fatty acid measured from each sample; Means with different superscript letters in the same row differ significantly (P<0.05); SEM = standard error of the mean; *P<0.05; **P<0.01; ns = not significantly different (P>0.05); A = effect of age; M = effect of method; A×M = interaction age and method; DFA = desirable fatty acids = MUFA+PUFA+C18 : 0.

3.5.4 Carcass characteristics and carcass composition

The effects of difference ages and castration methods on carcass characteristics (after adjust covariate data) are presented in Table 3.6. The carcass characteristics of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or burdizzo method were not significant difference (P>0.05). Moreover, the orthogonal contrast among treatment showed that age and castration method were not significant effect on live weight (range from 16.5 to 17.8 kg), cool weight (range from 6.0 to 7.5 kg), %hot dressing (range from 36.3 to 42.6%), backfat (range from 0.8 to 2.0 mm), and rip eye area (REA) (range from 6.7 to 6.8 cm^2) (P>0.05). Support of this finding by Kebede et al. (2008) and El-Waziry et al. (2011). In contrast with Nsoso et al. (2004) reported that castration by burdizzo method at 3 month of age higher dressing percentage than intact goats. In contrast with Shoemaker et al. (2004) reported that significant differences in hot carcass weight and dressing percentage between intact and castrated goats. The carcass characteristics are show in Figure 3.1.

The generally mean dressing percentage for various goat breeds worldwide varied between 38 to 44% (Devendra and Owen, 1983; Kadim et al., 2004). Hot dressing percentage in this study varies from 36.33 to 42.66% while many researchers reported that dressing percentage varies from 39 to 55% (Kebede et al., 2008; Pinkerton et al., 1994; Simela et al., 2008; Acharya, 1998; Daskiran et al., 2006; Hailu et al., 2005). In addition the study of Pralomkarn et al. (1995) found that the mean of dressing percentage of Thai native and Anglo-Nubian×Thai native male goats is 55% while the study about goat meat production in Thailand by Saithanoo and Milton (1988) reported that the dressing percentage of native goat is 45%.

The study of Ciftci and Kor (2010) found that no significant differences in dressing percentage between castrated goat and un-castrated goat with range from 38.72 to 38. 74%. However, dressing percentage might be affected by empty body weight or the amount of rumen, intestine guts, and organs to be included in dressed carcass or removal of some visceral organs in hot carcass measurement might be resulted in different dressing percentages (Bhattacharyya and Khan, 1988; Kebede et al., 2008). Therefore, the lower dressing percentage in this study might be not included kidney and pelvic fat in this determination, unlike with Daskiran et al. (2006) who included kidneys, pelvic fat and testicles in hot carcass measurements which in turn affected dressing percentages.

In the term of mean of carcass composition base on percent live weight of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or budizzo method had not difference ($P>0.05$) except spleen and liver of castrated goat at 3 months of age by burdizzo method were higher than other groups ($P<0.05$). The age and method of castration had effect on liver ($P<0.05$) and spleen ($P<0.01$) of goat. From the data of ADG in Table 3.4 showed that 3 months of age by burdizzo group was high ADG and live weight than other group. Moreover, the castration with burdizzo method at 3 months of age has been un-traumatized to animal, which might be effect on percent of live weight of liver and spleen of animal were significant difference with compare with other groups.

Table 3.6 Effects of age and castration method on carcass characteristics and carcass composition of meat goats.

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Live weight, kg	16.55	16.66	16.96	17.83	16.37	0.40	ns	ns	ns
Carcass weight, kg	6.07	6.19	6.27	7.51	6.07	0.11	ns	ns	ns
Cool weight, kg	5.16	5.59	5.69	6.59	5.34	0.13	ns	ns	ns
HDP (%)	36.77	37.49	37.14	42.66	36.33	0.68	ns	ns	ns
CDP (%)	31.13	33.73	33.69	37.67	31.93	0.74	ns	ns	ns
Backfat, mm	1.71	2.07	1.67	0.92	0.89	0.22	ns	ns	ns
REA, cm^2	6.45	6.83	5.28	6.75	5.85	0.29	ns	ns	ns
----------% Live weight ----------									
Hind leg	10.17	10.63	10.45	11.64	10.07	0.18	ns	ns	ns
Font leg	7.51	7.46	7.26	8.44	7.28	0.18	ns	ns	ns
Loin	1.69	2.08	1.84	2.63	1.64	0.08	ns	ns	ns
Rip	11.59	13.40	11.65	14.39	12.86	0.53	ns	ns	ns
Head	7.99	8.90	8.19	6.98	8.64	0.26	ns	ns	ns
Skin	8.30	7.87	7.50	7.18	8.32	0.18	ns	ns	ns
Leg	2.42	2.24	2.15	2.14	2.26	0.03	ns	ns	ns
Kidney	0.27	0.28	0.25	0.30	0.27	0.01	ns	ns	ns

Table 3.6 Effects of age and castration method on carcass characteristics and carcass composition of meat goats. (Cont.)

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
				% Live weight					
Spleen	0.12[b]	0.13[b]	0.14[b]	0.27[a]	0.10[b]	0.01	**	ns	**
Liver	1.53[ab]	1.07[c]	1.38[bc]	1.82[a]	1.41[bc]	0.05	ns	*	*
Lung	0.89	0.93	0.85	1.02	0.94	0.04	ns	ns	ns
Heart	0.63	0.63	0.67	0.48	0.61	0.04	ns	ns	ns
Fat	1.22	1.64	2.04	1.29	1.10	0.16	ns	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly; SEM = standard error of the mean; *P<0.05; **P<0.01; ns = not significantly different (P>0.05); A = effect of age; M = effect of method; A×M = interaction age and method; HDP = Hot dressing percentage; CDP = Cool dressing percentage; REA = Rip eye area.

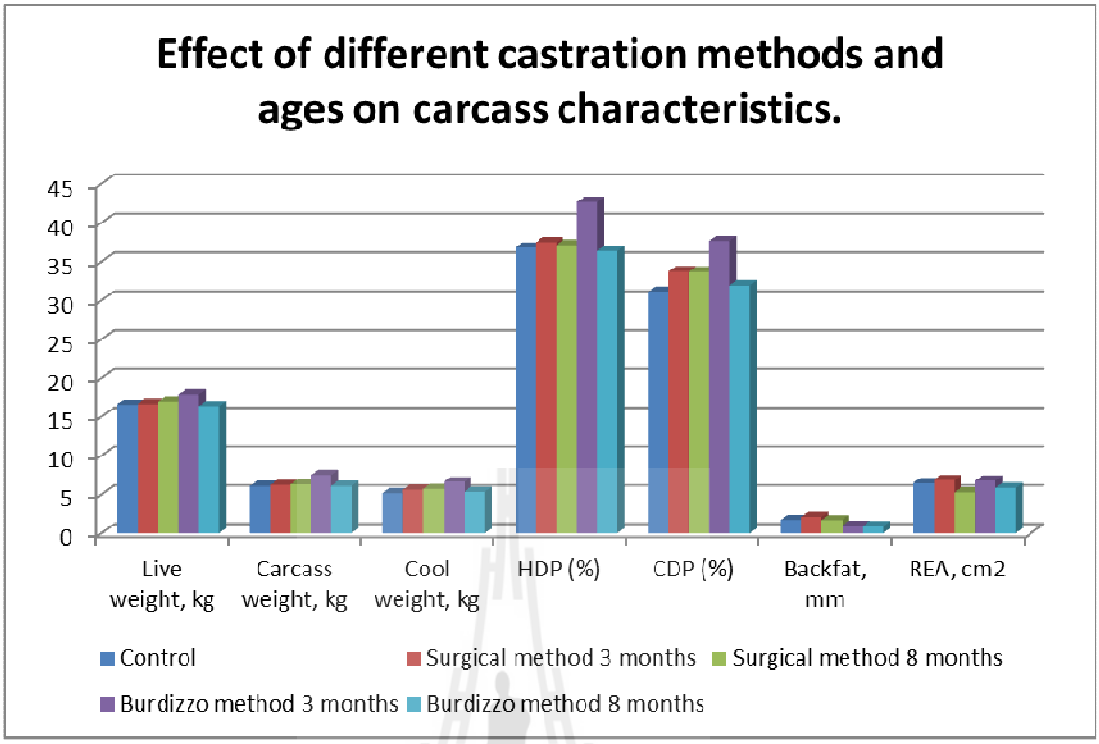

Figure 3.1 The carcass charcteristic of meat goats with difference ages and castration method

3.5.5 Meat quality

The mean of meat quality proportion of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or burdizzo method are show in Table 3.7. Meat color is a main factor that attracts consumer to buy meat. In this study was not difference on meat color components on loin, font of leg or hind of leg ($P>0.05$) while age and castration method were not significant effect on color component ($P>0.05$). Similar to finding study by El-Waziry et al. (2011) who presented that meat color of castration by burdizzo method at 3 months of age were not difference with intact groups. In addition, the study by Solaiman et al., (2011) and Simela et al. (2004) who presented that no significant difference effect on meat color

of castration on Boer cross breed goats and indigenous South African goats respectively.

Conversely, the report by Aricetti et al. (2008) the castration enabled a better carcass quality in term of coloring of meat. The results showed were not significantly difference ($P>0.05$) among groups range from 1.61 to 2.37% of loin, 1.23 to 2.18% of font of leg and 1.13 to 2.13% of hind of leg. In the term of orthogonal analysis also shown age and castration method had not effect on %drip loss of goat meat ($P>0.05$).

The pH value of goat meat was examined and results are presented on Table 3.5 shown that ultimate pH is determined 24 hours post slaughter were significantly different among groups with castration by burdizzo method at 3 month of age approximate value is 6.29 that higher than other group (range from 5.70 to 5.90) ($P<0.05$). In contrast with study of El-Waziry et al. (2011) show data ultimate pH was not significant difference among castrated and intact group. Good quality meat usually has a pH of 5.4 to 5.7 which pH value of meat with above 6 is generally considered unsuitable of storage because of the favorable development of proteolytic micro-organism.

From this study, the effect of pH_{24} in the group with a castration by burdizzo method at 3 months of age is higher than other groups, the results of this study should be clearly again. Because of the injury or traumatized to the animals had might be affect the pH level in the body. Age and castration method had effect on pH_{24} ($P<0.05$), howbeit the initial pH (pH_0) is determined 45 minutes post slaughter were not significantly different among group (range from 6.63 to 6.92) and the age and castration method had not effect on pH_0.

Table 3.7 Effects of age and castration method on meat quality of meat goats**.**

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Color of loin									
L*	52.35	49.05	51.75	54.90	50.83	0.86	ns	ns	ns
a*	10.39	13.60	12.49	12.47	13.51	0.40	ns	ns	ns
b*	3.59	6.58	5.49	4.00	5.25	0.33	ns	ns	ns
Color of fontleg									
L*	52.00	49.10	50.26	50.37	48.62	0.43	ns	ns	ns
a*	9.85	12.14	10.76	12.12	11.58	0.28	ns	ns	ns
b*	3.52	4.98	3.873	4.02	4.54	0.33	ns	ns	ns
Color of hind leg									
L*	46.62	48.30	48.44	46.02	47.37	0.53	ns	ns	ns
a*	12.69	12.22	12.13	13.57	12.78	0.24	ns	ns	ns
b*	7.09	7.78	6.67	5.48	6.83	0.26	ns	ns	ns
%Drip loss									
Loin	2.37	1.61	1.84	2.19	1.81	0.15	ns	ns	ns
Font of leg	1.71	1.54	1.24	2.19	1.56	0.11	ns	ns	ns
Hind of leg	2.11	1.13	1.27	2.14	1.38	0.12	ns	ns	ns

Table 3.7 Effects of age and castration method on meat quality of meat goats. (Cont.)

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
pH_0	6.84	6.88	6.87	6.63	6.92	0.03	ns	ns	ns
pH_{24}	5.84[b]	5.90[b]	5.70[b]	6.29[a]	5.84[b]	0.03	*	**	ns

[a, b] Means with different superscript letters in the same row differ significantly; SEM = standard error of the mean; *P<0.05; **P<0.01; ns = not significantly different (P>0.05); A = effect of age; M = effect of method; A×M = interaction age and method; [1] = total cholesterol in serum; L*, a*, b*: chroma-meter value L* = Lightness, a* = Redness, b* = Yellowness.

3.5.6 The chemical composition of raw goat meat

The results show no difference among treatments. Similar, Lournals (2011) and Pratiwi et al. (2004) reported no significant difference in goat meat composition between castrated and intact animals with 71 to 74% moisture, 19 to 23% CP and 0.9 to 1.1% ash except that the ether extract content in this study was lower. Results of the present study were more similar to those of Adam et al. (2010) who worked with younger goats. The low ether extract content in this study may thus be due to age of goat and in addition, the meat samples from the longissimus muscle which normally contain less fat in Thai native goat meat.

According to Madruga et al. (2000), lipid deposition in goat carcass only occurs when the animal reaches maturity or at a body weight of 40 kg. From the report of Aricetti et al. (2008) showed higher levels of crude protein observed in bull and discussed about protein deposition could be related to the action of male hormone (testosterone) which would contribute to a greater retention of nitrogen in meat.

Table 3.8 Effects of age and castration method on chemical composition of raw goat meat.

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
		----------%----------							
Moisture	71.70	71.62	71.99	74.36	73.54	0.44	ns	ns	ns
Ash	1.62	1.13	1.62	1.25	1.17	0.09	ns	ns	ns
Ether extract	0.72	0.69	0.68	0.58	0.70	0.07	ns	ns	ns
Crude protein	23.75	23.60	22.98	22.27	22.86	0.31	ns	ns	ns

A = effect of age; M = effect of method; A×M = interaction age and method.

3.5.7 Feed intake and Growth performance

The effects of age and castration method on growth performance of goats are in Table 3.9. The results show not significant difference in final weight and ADG among groups (P>0.05). Results of the present study is consistent with that of Kebede et al. (2008) and El-Waziry et al. (2011) who reported that castration by burdizzo method or surgical method at 3 months of age did not affect ADG. Similarly, Solomon et al. (1991) also reported that castration had no significant effect on body weight and ADG in Adal goats.

In contrast Nsoso et al. (2004) reported significantly higher average weight in castrates than the entire male goats. Inconsistency among studies could be due to differences in breed type, feeding management, slaughter age/weight and methods of castration. According to Aricetti et al. (2008) castration resulted in lower weight gain as a result of the reduction in plasma testosterone levels, thus reducing the secretion of growth hormone (IGF-I) and the action of insulin. However, resulted in an averaged overall feed intake ranged from 447.5 to 517.8 g/d which was not statistically different among treatments (P>0.05). Orthogonal contrast analysis showed that feed conversion ratio (FCR) goats castrated at 3 months old had higher FCR than those castrated at 8 months but FCR not affected by castration methods (Figure 3.3).

Cost of production per kg gain was affected age of castration in (P<0.05) with 3 months old using surgical method had higher cost per kg gain (122.95 bath/kgBW) than the other groups. The higher cost per kg gain for the former treatment was partly due to the lower ADG (although not statistically different), presumably because surgery castration was more traumatized to the young animals than burdizzo method.

Table 3.9 Effects of age and castration method on feed intake and growth performances**.**

Item	Control	Surgical method		Burdizzo method		SEM	Effects		
		3 months	8 months	3 months	8 months		A	M	A×M
Initial weight, kg	13.33	13.42	13.79	15.25	14.05	0.29	ns	ns	ns
Final weight, kg	16.21	15.67	16.75	18.75	16.80	0.34	ns	ns	ns
ADG, g/d	22.32	17.86	24.55	31.25	25.00	1.75	ns	ns	ns
Overall Feed intake									
Intake, g/d	447.54	495.17	480.61	517.79	478.99	16.39	ns	ns	ns
%BW	2.75	3.15	2.89	2.76	2.86	0.08	ns	ns	ns
g/kg $BW^{0.75}$	55.11	62.77	58.23	57.41	57.86	1.69	ns	ns	ns
FCR									
Concentrate	9.73^{b}	16.18^{a}	9.56^{b}	7.10^{b}	9.00^{b}	1.01	*	ns	ns
Roughage	10.72^{b}	20.81^{a}	12.13^{b}	10.61^{b}	11.19^{b}	1.17	*	ns	ns
Overall	20.45^{b}	36.99^{a}	21.69^{b}	17.70^{b}	20.19^{b}	6.94	*	ns	ns
Cost/gain, bath/kgBW	73.91^{b}	122.95^{a}	72.61^{b}	53.92^{b}	68.39^{b}	7.7	*	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly; FCR = Feed conversion ratio; SEM = standard error of the mean;

*P<0.05; **P<0.01; ns = not significantly different (P>0.05); A = effect of age; M = effect of method; A×M = interaction age and method.

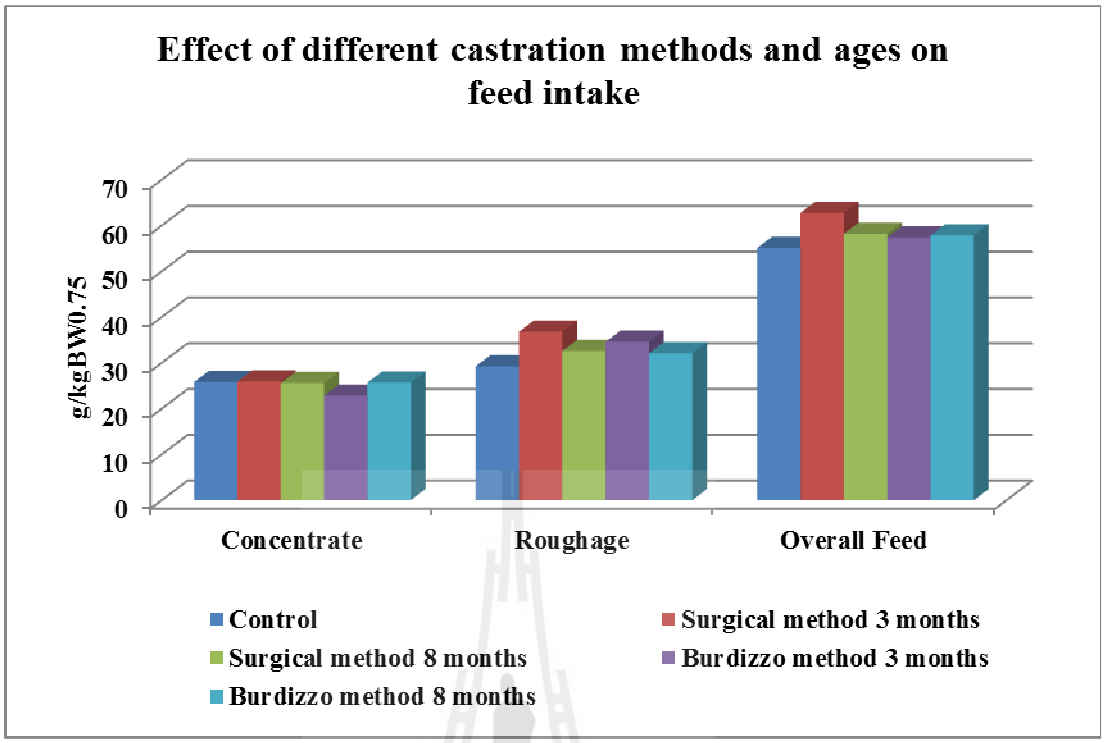

Figure 3.2 The feed intake of meat goats with difference ages and castration method.

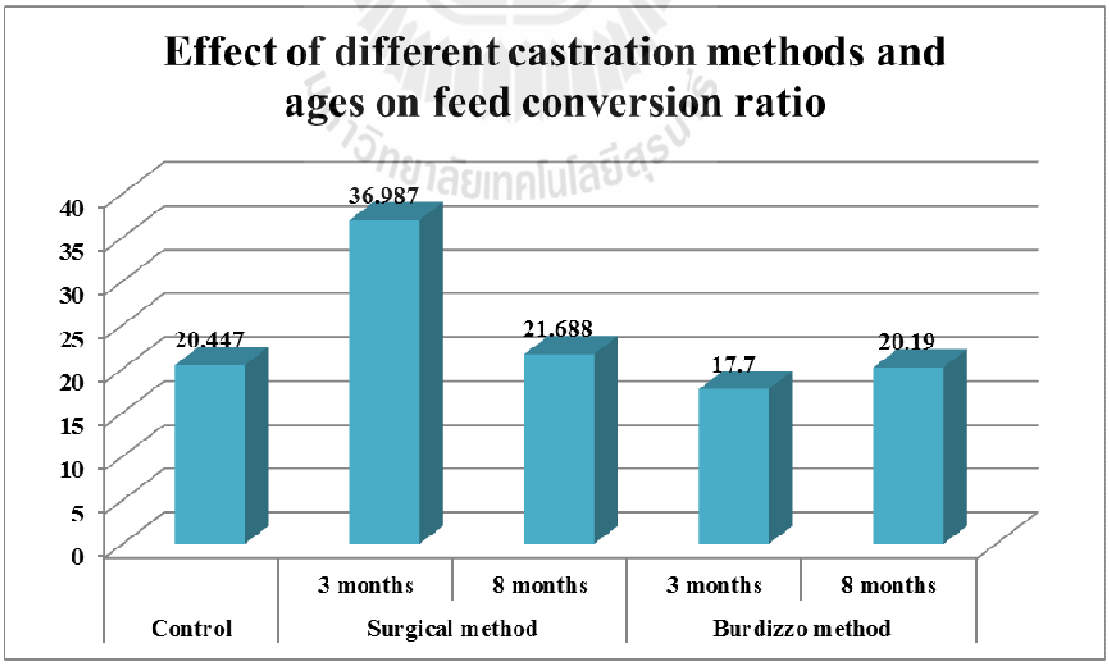

Figure 3.3 The feed conversion ratio of meat goats with difference ages and castration method.

3.6 Conclusions

3.6.1 Effects of age and castration method on concentration of estradiol, testosterone hormone and cholesterol in serum of meat goats

The effect of different ages and methods of castration in this experiment show the concentration of estradiol in serum of un-castrated goat was lower than castrated goat at 8 months of age either surgical or burdizzo method, while there was not significantly difference with surgical and burdizzo method at 3 months of age. The age of castration had effect on concentration of estradiol in serum, while method of castration was not any effect on concentration of estradiol in serum.

The testosterone level in serum of goat meat was not significant difference effect with age and castration method was range from 0.46 to 1.60 nmol/L. Moreover, the data show that un-castrated goat have had higher testosterone level than castrated goat. Although the data of castration shown decrease concentration of testosterone as report by Novara et al., (2009) but the effect of castration was not statically difference either surgical or burdizzo castration method.

In the part of the total cholesterol in serum was not significantly difference among groups ($P>0.05$) In addition to age and castration method had not effect on total cholesterol in serum ($P>0.05$). The addition estradiol that reported by Liu and Bachmann (1998) could reduce cholesterol levels in blood serum but in this study, although the estradiol was significant different between group, but the concentration of cholesterol did not significantly difference by the effect with castration.

3.6.2 Effects of age and castration method on odorant fatty acid in goats meat

The evaluated effect of the odorant fatty acid compositions from *Longissimus dorsi* of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or burdizzo method showed were not significantly difference on odorant fatty acid in goat meat (P>0.05). The main odorant fatty acid that there are undesired smell to consumer of un-castrated goat was higher 4-methyl-octanoic acid than castration group, however the statistically analysis show were not significant difference among groups (P>0.05). In the term of 4-ethyl-octanoic acid and 4-methyl-nonanoic acid those are the main odor in goat meat were not significant different (P>0.05) while the data show age of castration and castration method were not effect on all the main odor fatty acid in goat meat.

The castration is a one way decreasing testosterone (Mezey et al., 1980) that there are factor of odor in meat (Falahati-Nini et al., 2011), the result of studies show not significance difference, although the data of castration group show the concentration of testosterone lower than un-castrated but the testosterone this level was not sufficient to clearly reducing odorant fatty acid.

3.6.3 Effects of age and castration method on fatty acid profile in goats meat

The mean of the fatty acid compositions from *Longissimus dorsi* of the un-castration group or castrated by surgical method or burdizzo method at 3 month or 8 month were not significantly difference on amount of total SFA (P>0.05) and there were no interaction between castration method and age on amount of total SFA composition (P>0.05). While, butyric acid (C4 : 0) and caproic acid (C6 : 0) were significantly difference with among groups (P<0.05). Moreover castration method

had effect on C4 : 0, there was highly significant interaction effect between age and castration method on C6 : 0 ($P<0.01$).

The castration with burdizzo method group was higher butyric acid than surgical method group that that may decrease shelf-life of goat meat. Because butyric acid is a fatty acid show the characteristic odor of rancid butter or spoiled meat (Clavero, 2010). Moreover the pH_{24} value of meat in surgical method was higher than burdizzo method group. El-Waziry et al. (2011) reported that the high pH value of meat unsuitable of storage because of the favorable development of proteolytic micro-organism.

The amount monounsaturated fatty acid (MUFA) of the un-castrated goats or castrated goats at 3 months or 8 months by surgical method or budizzo method were not significantly different on MUFA ($P>0.05$) except burdizzo method castration group was higher palmitoleic acid (C16 : 1) than un-castration and surgical method castration group ($P<0.05$) while the castration method had effect on this fatty acid but interaction between castrated method and ages had no significantly different in MUFA ($P>0.05$). The palmitoleic acid is biosynthesized from palmitic acid and advantage to increase insulin sensitivity by suppressing inflammation, as well as inhibit the destruction of insulin-secreting pancreatic beta cells but the influence of different method of castration on concentration of palmitoleic acid requires further study.

The amount total polyunsaturated fatty acid (PUFA) and conjugated fatty acid isomer in goat meat were not significantly different either castration method or ages of castration effect ($P>0.05$). The concentration of PUFA and SFA were not significant difference among group ($P>0.05$) while the amount of PUFA/SFA ratio of un-castrated group is 0.17% of total fatty acid higher than castrated group. The

UFA/SFA ratio of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or burdizzo method were not significantly different (P>0.05). The age of castration and castration method had not effect on either PUFA/SFA ratio or UFA/SFA (P>0.05).

The ratio of (C18 : 0+C18 : 1)/C16 : 0 is the parameter to describe effects of lipids to health consumer in this study was not difference, which the range from 3.34 to 3.85. that show the meat of Thai native goat in this study higher than Boer and Anglo Nubian crossbred × SPRD goats with values from 3.13 to 3.26 that reported by Madruga et al. (2009).

The DFA is indicator benefit of fatty acid in meat that shows risk of obesity, cancer and cardiovascular diseases. In this study shows desirable fatty acid (DFA) range from 74.76 to 76.71% of total fatty acid also show the DFA value of Thai native meat goat excellence close to Boer, Anglo Nubian and crossing with SPRD goat meat.

3.6.4 Effects of age and castration method on carcass characteristic and carcass composition in meat goats

The effects of difference ages and castration methods on carcass characteristics were not significant difference (P>0.05). Moreover, the age and castration method were not significant effect on live weight, cool weight, %hot dressing, backfat, and rip eye area (REA) (P>0.05).

In the term of mean of carcass composition base on percent live weight of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or budizzo method had not difference (P>0.05) except spleen and liver of castrated goat at 3 months of age by burdizzo method were higher than other groups (P<0.05).

The age and method of castration had effect on liver ($P<0.05$) and spleen ($P<0.01$) of goat. From the data of ADG showed that 3 months of age by burdizzo group was high ADG and live weight than other group. Moreover, the castration with burdizzo method at 3 months of age has been un-traumatized to animal, which might be effect on percent of live weight of liver and spleen of animal were significant difference with compare with other groups.

3.6.5 Effects of age and castration method on meat quality in meat goats.

The mean of meat quality proportion of un-castrated goats or castrated goats at 3 months or 8 months by surgical method or budizzo method were not significantly difference on chemical composition of raw meat, meat color components and % drip loss on loin, font of leg or hind of leg ($P>0.05$) while age and castration method were not significant effect on color component and %drip loss ($P>0.05$).

The pH_{24} were significantly different among groups with castration by burdizzo method at 3 month of age higher than other group. In this study, the effect of pH_{24} in the group with a castration by burdizzo method at 3 months of age is higher than other groups, the results of this study should be clearly again. Because of the injury or traumatized to the animals had might be affect the pH level in the body. Age and castration method had effect on pH_{24} ($P<0.05$), howbeit the pH_0 were not significantly different among group and the age and castration method had not effect on pH_0. The total cholesterol in serum was not significantly difference among groups ($P>0.05$). In addition to age and castration method had not effect on total cholesterol in serum ($P>0.05$).

3.6.6 Effects of age and castration method on performance in meat goats

The effect of the growth performance of goats castrated at 3 months or 8 months by surgical method or burdizzo method were not significant difference in final weight and ADG among groups (P>0.05). Although ADG in all treatment were not significant difference but the data shown the burdizzo castration goats at 3 months of age had rather higher ADG than other groups. This might be effect on behavior in castrate goats that very docile and friendly to managing when compare with the intact one. While the surgical method goats at 3 months of age have been traumatized more than other one group thus they might be effect on ADG lower than other groups. In the term of overall feed intake were not significance difference to each other (P>0.05)

Feed conversion ratio (FCR) in each group was showed orthogonal contrast analysis that age affects the FCR of concentrate, roughage and overall (P<0.05), the castrated goats at the age of 3 months were higher FCR than goats at the age of 8 months but not depending on the castration method.

The cost per gain in this study is the cost of feed during the study had effect form age of castration (P<0.05) while castration method was not effect on cost per gain of goat, the data showed that the age of 3 months has higher cost per gain than other groups. The data shows that the average cost per gain of goats at 3 months of age by surgery was higher cost per gain than other groups. This makes the cost of production per kilogram of body weight higher than the other groups, because of the surgery are over traumatized to the animals more than burdizzo method. Moreover, the castration with the young animal is hurt even more that has effect on the growth or feed efficiency.

3.7 Implication

From the result show that no statistically difference between surgical and burdizzo method that difference of the existence of the testes which source of production of male hormones. The effect of concentrate of odorant fatty acid in meat and testosterone in serum in goat meat were not significant decrease with castration. Although, castration was decrease testosterone but the level was not sufficient to clearly decrease odor fatty acid in goat meat. The study of effect decrease odorant fatty acid in goat meat in another way need to further study. From the effect of castration in this experiment, the author design the experiment II is investigate to effect of xenoestrogen which is one of two way to decrease odorant fatty acid that come from the testosterone activity and associate study to effect of performance and meat quality on meat goat.

3.8 Reference

Acharya, R. (1988). Goat breeding and meat production. **Paper presented at the International Workshop on Goat Meat Production in Asia, Tando Jam (Pakistan).** 12-18 Mar 1988.

Adam, A.A.G., Atta, M., and Ismail, S.H.A. (2010). Quality and sensory evaluation of meat from nilotic male kids fed on two different diets. **Journal of Animal and Veterinary Advances**. 9(15) : 2008-2012.

AOAC. 2000. Meat and Meat products. In: Official Methods of Analysis. **Association of Official Analytical Chemists Inc.** Gaithersburg, USA.

Arain, M.A., Khaskheli, M., Rajput, I., Faraz, S., Rao, S., Umer, M., and Devrajani, K. (2010). Effect of slaughtering age on chemical composition of goat meat. **Pakistan Journal of Nutrition**. 9(4) : 404-408.

Aricetti, J.A., Rotta, P.P., Prado, R.,Perotto, D., Moletta, J.L., Matsushita, M., and Prado, I. (2008). Carcass characteristics, chemical composition and fatty acid profile of Longissimus muscle of bulls and steers finished in a pasture system. **Asian-Australasian Journal of Animal Science**. 21(10) : 1441-1448.

Arnold, A., Peralta, J., and Thonney, M. (1997). Effect of testosterone on differential muscle growth and on protein and nucleic acid concentrations in muscles of growing lambs. **Journal of animal science**. 75(6) : 1495-1503.

Banskalieva, V., Sahlu, T., and Goetsch, A.L. (2000). Fatty acid composition of goat muscles and fat depots: a review. **Small Ruminant Research**. 37(3) : 255-268.

Bhattacharyya, N. and Khan, B. (1988). Goat meat production in India. **Proceeding of the International Workshop on Goat Meat Production in Asia, Tando Jam (Pakistan).** 12-18 Mar 1988.

Ciftci, M.R. and Kor, A. (2010). The Effects of Early Castration on Slaughter and Carcass Characteristics of Norduz Male Kids. **Journal of Animal and Veterinary Advances**. 9(18) : 2382-2385.

Clavero, R. (2010). Solving Microbial Spoilage Problems in Processed Foods. **Principles of Microbiological Troubleshooting in the Industrial Food Processing Environment.** 63-78.

Dadi, H., Woldu, T., and Lema, T. (2005). Comparison of carcass characteristics of Borana and Arsi-Bale goats under different durations of feedlot management. **Livestock Research for Rural Development**. 17(12) : 2005.

Daskiran, I., Askin, K., and Mehmet, B. (2006). Slaughter and carcass characteristics of Norduz male kids raised in either intensive or pasture conditions. **Pakistan Journal of Nutrition**. 5(3) : 274-277.

Devendra, C. and Owen, J. (1983). Quantitative and qualitative aspects of meat production from goats. **World Animal Review**.

Dhanda, J., Taylor, D., and Murray, P. (2003). Part 1. Growth, carcass and meat quality parameters of male goats: effects of genotype and liveweight at slaughter. **Small Ruminant Research**. 50(1) : 57-66.

Enser, M., Hallett, K., Hewitt, B., Fursey, G., and Wood, J. (1996). Fatty acid content and composition of English beef, lamb and pork at retail. **Meat Science**. 42(4) : 443-456.

Hillbrick, G., Tucker, D., and Smith, G. (1995). The lipid composition of cashmere goat fleece. **Crop and Pasture Science**. 46(6) : 1259-1271.

Fisher, A., and De Boer, H. (1994). The EAAP standard method of sheep carcass assessment. Carcass measurements and dissection procedures report of the EAAP working group on carcass evaluation, in cooperation with the CIHEAM instituto agronomico Mediterraneo of Zaragoza and the CEC directorate general for agriculture in Brussels. **Livestock Production Science**. 38(3) : 149-159.

Kadim, I., Mahgoub, O., Al-Ajmi, D., Al-Maqbaly, R., Al-Saqri, N., and Ritchie, A. (2004). An evaluation of the growth, carcass and meat quality characteristics of Omani goat breeds. **Meat science**. 66(1) : 203-210.

Kebede, T., Lemma, T., Dinka, H., Guru, M., and Sisay, A. (2008). Growth performance and carcass characteristics of Arsi-Bale goats castrated at different ages. **Journal of Cell and Animal Biology**. 2(11) : 187-194.

Liu, D., and Bachmann, K. A. (1998). An investigation of the relationship between estrogen, estrogen metabolites and blood cholesterol levels in ovariectomized rats. **Journal of Pharmacology and Experimental Therapeutics**, 286(1) : 561-568.

Lournals, M. (2011). Performance, Carcass Characteristics and Meat Quality of Intact and Castrated Ardhi Goat Kids Fed High Energy Diet. **Journal of Animal and Veterinary Advances**. 10(16) : 2157-2162.

Madruga, M., Arruda, S., Narain, N., and Souza, J. (2000). Castration and slaughter age effects on panel assessment and aroma compounds of the “mestiço” goat meat. **Meat science**. 56(2) : 117-125.

Madruga, M. S., Stephen Elmore, J., Dodson, A. T., and Mottram, D. S. (2009). Vola-tile flavour profile of goat meat extracted by three widely used techniques. **Food Chemistry**. 115(3) : 1081-1087.

McMillin, K. and Brock, A. (2005). Production practices and processing for value-added goat meat. **Journal of animal science**. 83(13 suppl) : E57-E68.

Metcalfe, L. and Schmitz, A. (1961). The rapid preparation of fatty acid esters for gas chromatographic analysis. **Analytical Chemistry**. 33(3) : 363-364.

Mezey, E., Potter, J. J., Harmon, S. M., and Tsitouras, P. D. (1980). Effects of castration and testosterone administration on rat liver alcohol dehydrogenase activity. **Biochemical pharmacology**, 29(23) : 3175-3180.

Morrison, W.R. and Smith, L.M. (1964). Preparation of fatty acid methyl esters and dimethylacetals from lipids with boron fluoride–methanol. **Journal of Lipid Research**. 5(4) : 600-608.

Nestel, P., Clifton, P., and Noakes, M. (1994). Effects of increasing dietary palmitoleic acid compared with palmitic and oleic acids on plasma lipids of hypercholesterolemic men. **Journal of lipid research**, 35(4) : 656-662.

Novara, G., Galfano, A., Secco, S., Ficarra, V., and Artibani, W. (2009). Impact of surgical and medical castration on serum testosterone level in prostate cancer patients. **Urologia internationalis**, 82(3) : 249-255.

Nsoso, S., Podisi, B., Otsogile, E., Mokhutshwane, B., and Ahmadu, B. (2004). Phenotypic characterization of indigenous Tswana goats and sheep breeds in Botswana: continuous traits. **Tropical Animal Health and Production**. 36(8) : 789-800.

Pinkerton, F. (1994). A survey of prevalent production and marketing practices in meat goats of southern origin. **SRDC publication**.

Pralomkarn, W., Saithanoo, S., Kochapakdee, S., and Norton, B. (1995). Effect of genotype and plane of nutrition on carcass characteristics of Thai native and Anglo-Nubian×Thai native male goats. **Small Ruminant Research**. 16(1) : 21-25.

Pratiwi, N.W., Murray, P., and Taylor, D. (2004). The fatty acid composition of muscle and adipose tissues from entire and castrated male Boer goats raised in Australia. **Animal Science**. 79(2) : 221-229.

Rhee, K., Waldron, D., Ziprin, Y., and Rhee, K. (2000). Fatty acid composition of goat diets vs intramuscular fat. **Meat science**. 54(4) : 313-318.

Rössner, S., Walldius, G., and Björvell, H. (1989). Fatty acid composition in serum lipids and adipose tissue in severe obesity before and after six weeks of weight loss. **International journal of obesity**, 13(5) : 603.

Saithanoo, S. and Milton, J. (1988). Goat meat production in Thailand. **Proceeding of the International Workshop on Goat Meat Production in Asia, Tando Jam (Pakistan)**. 12-18 Mar 1988.

Sen, A., Santra, A., and Karim, S. (2004). Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. **Meat science**, 66(4) : 757-763.

Simela, L., Webb, E.C., and Bosman, M. (2008). Acceptability of chevon from kids, yearling goats and mature does of indigenous South African goats: **A case study.**

Simela, L., Webb, E., and Frylinck, L. (2004). Effect of sex, age, and pre-slaughter conditioning on pH, temperature, tenderness and colour of indigenous South African goats. **South African Journal of Animal Science**. 34 : 208-211.

Solaiman, S., Kerth, C., Willian, K., Min, B., Shoemaker, C., Jones, W., and Bransby, D. (2011). Growth Performance, Carcass Characteristics and Meat Quality of Boer-Cross Wether and Buck Goats Grazing Marshall Ryegrass. **Asian Australasian Journal of Animal Science**. 24(3) : 351.

Steel, R. and Torrie, J. (1980). Prnciples and Procedures of Statistics: **A Biometrical Approach : McGraw-Hill. New York.**

Sutherland, M.M., and Ames, J.M. (1996). Free fatty acid composition of the adipose tissue of intact and castrated lambs slaughtered at 12 and 30 weeks of age. **Journal of agricultural and food chemistry**. 44(10) : 3113-3116.

Teye, G. (2009). Effects of age/weight and castration on fatty acids composition in pork fat and the qualities of pork and pork fat in meishn×large white pigs. **African Journal of Food, Agriculture, Nutrition and Development**. 9(8).

Ülker, H., Gökdal, Ö., Temur, C., Budağ, C., Oto, M., deavila, D., and Reeves, J. (2002). The effect of immunization against LHRH on body growth and carcass characteristics in Karakaş ram lambs. **Small Ruminant Research**. 45(3) : 273-278.

USDA. (2005). Dietary guidelines for Americans. Available from **http://www.health.gov/dietaryguidelines/dga2005/document/**, accessed at 16 June 2005.

Wong, E., Johnson, C., and Nixon, L. (1975). The contribution of 4-methyloctanoic (hircinoic) acid to mutton and goat meat flavour. **New Zealand Journal of Agricultural Research.** 18 : 261-266.

Woods, V. B., and Fearon, A. M. (2009). Dietary sources of unsaturated fatty acids for animals and their transfer into meat, milk and eggs: A review. **Livestock Science**. 126(1) : 1-20.

Yacob, Y., Fletcher, I., and Kebede, G. (1993). Effect of Castration on Growth, Fattening and Market Value of Black-Head Somali Rams. **Proceeding of the 4th National Livestock Improvement Conference.** Addis Abeba (Eth-iopia). 13-15 Nov 1991.

CHAPTER IV

EFFECTS OF SUPPLEMENTATION OF HORMONE OR PHYTOESTROGEN FROM *Pueraria mirifica* ON PERFORMANCE, CARCASS CHARACTERISTIC, MEAT QUALITY AND ODORANT FATTY ACIDS IN GOAT MEAT

4.1 Abstract

The objective of this study was to evaluate the effects of supplementation of hormone or phytoestrogen from *Pueraria mirifica* on growth performance, carcass characteristics and meat quality and odorant fatty acids in goat meat. The animals were fully offered rice straw and concentrate diet was feed at 1.5% of BW throughout 16 weeks. The result shows that the concentrations of estradiol and testosterone hormone with supplementation hormone or phytoestrogen from *Pueraria mirifica* were not significant difference among groups (P>0.05). Although the concentration of testosterone in supplemented hormone was higher than control group, but there are not effect on increase the concentration of main odorant fatty acid. The supplementations of hormone or phytoestrogen were not effect on the main odorant fatty acid (4-methyl-octanoic acid, 4-ethyl-octanoic acid and 4-methyl-nonanoic acid) and not effect on decrease cholesterol in serum (P>0.05).

There was no difference in total SFA (P>0.05) between the treatment groups

and the control while caprylic acid (C8 : 0) of control group was higher than those supplemented with synthesis estradiol and phytoestrogen from *Pueraria mirifica* groups ($P<0.001$). The supplementation of hormone or phytoestrogen had effect on decrease caprylic acid in goat meat, although it is not main odor fatty acid mention in goat meat. The amounts of total MUFA, PUFA, PUFA/SFA, UFA/SFA ratio and conjugated fatty acid isomer were not significantly different among group ($P>0.05$). In addition the (C18 : 0+C18 : 1)/C16 : 0 ratio and DFA value that presented the value of possible beneficial effects of lipid were not significantly difference ($P>0.05$).

The result shows that no significant differences among groups on raw meat chemical composition, growth performance and carcass characteristics. In the term of meat quality were not significant difference on meat components, %drip loss in loin, front and hind legs ($P>0.05$). The pH_{24} value of control group was lower than the other groups but pH0 was not significantly difference among groups ($P>0.05$).

The supplementation of hormone or phytoestrogen from *Pueraria mirifica* feed were not significantly different on intake and growth performance ($P>0.05$). Although, the supplementation of estradiol either synthesis or phytoestrogen form had not negative result on performance in meat goat, but the cost/gain of control group was lowest compare with other group. It can be concluded that using xenoestrogen either synthesis estrogen or phytoestrogen from *Pueraria mirifica* were not decrease odorant fatty acid in goat meat and there are not effect on performance in meat goats.

Key words : Hormone, phytoestrogen, *Pueraria mirifica*, Performance, Carcass, Odorant, Goat meat

4.2 Introduction

Growth rates of animals are influenced by many factors including genetic and nutrition. Genetic selections as well as improvements in nutrition and management have contributed significantly to improve productivity in meat and other animal products. The use of products that promote growth through hormonal activity has received much attention in recent years. Estrogens have been used to stimulate growth performance, carcass characteristics and reduce carcass fatness in livestock (Ogilvie et al., 1960; Johnson et al., 1996; Nichols et al., 2002; Kellermeier et al., 2009;). Estrogens are steroid hormones with a complex mode of action, characterized by high tissue specificity and dose-dependent activity. (Moutsatsou, 2007).

Phytoestrogens are plant derived (most common in legume) that are similar in structure and have the ability to mimic the action of female hormone estrogen. Because only animal bodies can produce true hormones, these plant chemicals are called phytoestrogens (plant estrogen) include mainly isoflavones, lignans, coumestanes, stilbenes and the flavonoids quercetin and kaempherol.

Phytoestrogens have similar properties to estrogen produced in the body because of their similar molecular structure which can bind with estrogen beta receptors in cells. Many plants contain phytoestrogen that act like estrogens and the amount of estrogen found in plants is insignificant but those are weak estrogenic activity (Vaya and Tamir, 2004).

Phytoestrogens have been reported in many legumes such as soybean, red clover, subterranean clover, lignans found in seed oils, garbanzo beans, sprouting beans and other legumes, especially White Kwao Krua (*Pueraria mirifica*), a Thai native herbal plant. The phytoestrogens in most of the leguminous plants comprise of

isoflavones (daidzin, daidzein, genistin, genistein and puerarin) while phytoestrogens in *Pueraria mirifica* are much higher in concentration and potency which include miroestrol and deoxymiroestrol. Thus, phytoestrogen from *Pueraria mirifica* may be used to promote growth in animal instead of synthetic estrogen hormone.

4.3 Objectives

The objective of this experiment was to examine the effects of supplementing hormone or phytoestrogen from *Pueraria mirifica* on growth performance, carcass characteristics and meat quality and odorant fatty acids in goat meat.

4.4 Materials and Methods

4.4.1 Experimental design and treatment

Eighteen 8 months old male goats (Thai native×Anglo-Nubian) were used for this study. All goats were maintained in quarantine for two weeks after their arrival to the university farm and were treated for external and internal parasites. The goats were randomly allocated into 3 groups of six goats per treatment (Table 4.1) in a completely randomized design (CRD). Blood samples were collected at the beginning and end of experiment to determine concentration of testosterone and estradiol hormones.

Table 4.1 Experimental treatments

Groups	Treatments
T1 (Control)	No hormone
T2	Injected with synthesis estradiol (200 µg/d)
T3	Supplemented with phytoestrogen from *Pueraria mirifica* at 200 µg/d

Goats were offered rice straw *ad libitum* and supplemented with concentrate. The concentrate, roughage (rice straw) and *Puraria mirifica* chemical composition of are presented in Table 4.2. All animals were offered rice straw *ad libitum* supplemented with concentrate (16% CP) 1.5% (BW). Animals were weighed before feeding, weekly and daily dry matter intake (DMI) of individual goat was recorded. Six goats from each treatment were randomly selected and slaughtered for carcass evaluation following the procedure of Dhanda et al. (2003a) at the end of 16 weeks experiment.

Table 4.2 Chemical composition of experimental diet (%DM)

Item	**Concentrate**	**Roughage (Rice straw)**	***Pueraria mirifica***
	---------- **%DM** ----------		
Crude protein	16.05	2.81	10.45
Ether extract	4.21	0.66	0.45
Ash	6.78	14.84	23.31
Neutral detergent fiber (NDF)	45.66	65.48	38.92
Acid detergent fiber (ADF)	29.04	49.65	13.01

Goats were weighed before feeding and weekly and daily dry matter intake (DMI) of individual goat was recorded. Six goats from each treatment group were slaughtered for carcass evaluation following procedure of Dhanda et al. (2003a) at the end of 16 weeks experiment.

4.4.2 Slaughtering and carcass evaluation

The slaughtering and carcass evaluation were managed and measured in the same way as described in chapter III.

4.4.3 Meat quality attributes

All the parameter of meat quality was analyses in the same way as described in chapter III.

4.4.4 Chemicals analysis and calculation

The chemical compositions of experiment diet and meat sample were determined in the same way as described in chapter III.

4.4.5 Fatty acids in meat samples

The analysis process of fatty acid in meat sample was description in the chapter III.

4.4.6 Statistical Analysis

The data were analysis as completely randomized design (CRD) (Steel and Torrie, 1980). In order to compensate for differences in live weight at the start of the experiment, initial body weight was used as a covariate adjustment factor for the analysis of data on live animals (final body weight, weight gain, feed consumption). Similarly, live weight was used as a covariate adjustment factor for analysis of data on carcass yield (carcass weight, dressing percentage and carcass composition). (Ülker et al., 2002). The initial cholesterol, estradiol and testosterone level in serum were used as covariate adjustment factor for analysis of data on cholesterol, estradiol and testosterone level in serum of animals. Statistical analysis was performed with the general linear model procedure (PROC GLM). A significance level of $P<0.05$ was used to differentiate between means with SPSS 11 program.

4.4.7 Experimental site

The experiment was conducted on the farm of Suranaree University of Technology. The chemical analysis was performed at the Center for Scientific and Technological Equipment (CSTE) of Suranaree University of Technology.

4.4.8 Duration

The experiment on May, 2010 – September, 2010

4.5 Results and discussions

4.5.1 The concentration of estradiol, testosterone hormone and cholesterol in serum of meat goat

The mean concentrations of estradiol and testosterone hormone with supplementation hormone or phytoestrogen from *Pueraria mirifica* are show in Table 4.3. The result show the concentration of estradiol and testosterone in serum was not significant difference among groups (P>0.05) (range from 160.89 to 217.33 pmol/L) while the concentration of testosterone in serum were varied from 1.05 nmol/L in control group and 14.97 nmol/L in supplemented synthesis estradiol and 22.03 nmol/L in supplemented estradiol from *Pueraria mirifica*. The data of concentration of estradiol and testosterone that data after adjust covariance with their initial concentration show lowest of the testosterone compare with supplemented hormone and phytoestrogen from *Pueraria mirifica*, whereas concentration of estradiol either synthesis estradiol or phytoestrogen were not decrease testosterone in serum that opposite to the studies by Ronde and Jong (2011) and Weber et al., (2001) who reported that phytoestrogen decrease testosterone level in male.

The result of the total cholesterol in serum was not significantly difference among groups (P>0.05) ranged from 59.57 to 71.75 mg/dl that supplementation of hormone or phytoestrogen were not effect on decrease cholesterol in serum that contrast with Bachmann (1998) who concerned the estradiol reduce cholesterol levels in blood serum.

Table 4.3 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* estradiol and testosterone level in serum of meat goats

Item	Treatment*			SEM	P-value
	T1	T2	T3		
Estradiol (pmol/L)	160.89	197.04	217.33	24.61	0.67
Testosterone (nmol/L)	1.05	14.97	22.03	4.84	0.50
Cholesterol, mg/dl	66.04	71.76	59.58	3.09	0.33

*T1 = no hormone (control), T2 = injected synthesis estradiol (released rate 200 µg/d), T3 = supplemented phytoestrogen from *Pueraria mirifica* 200 µg/d

4.5.2 The concentration of odorant fatty acids in goat meat

The evaluated effect of supplementation hormone or phytoestrogen from *Pueraria mirifica* were not significantly difference on odorant fatty acid in goat meat (P>0.05) (Table 4.4). The result shown that the main odorant fatty acid in this study are 4-methyl-octanoic acid, 4-ethyl-octanoic acid and 4-methyl-nonanoic acid were not significant different (P>0.05) while the data show supplemented either synthesis estradiol or phytoestrogen from *Pueraria mirifica* at 200 µg/d had lower than control group but this concentrate are not yet clearly statistic significantly difference although concentration of testosterone in supplemented hormone was higher than control group (Table 4.3), but there are not effect on increase the concentration of main odorant fatty acid as the report of Chemineau, (1987) who commented the factor of odor in goat meat come from testosterone activity.

Table 4.4 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on odorant fatty acid as percentage of total fatty acid in goat meat

Fatty acid	Treatment*			SEM	P-value
	T1	T2	T3		
Odorant fatty acid	-- % of total fatty acid --				
4-methyl-octanoic acid	0.027	0.005	0.005	0.010	0.157
4-ethyl-octanoic acid	0.007	0.004	0.008	0.001	0.224
4-methyl-nonanoic acid	0.040	0.032	0.021	0.005	0.293

*T1 = no hormone (control), T2 = injected synthesis estradiol (released rate 200 µg/d), T3 = supplemented phytoestrogen from *Pueraria mirifica* 200 µg/d

4.5.3 The concentration of fatty acid profile in goat meat

The mean of the fatty acid compositions from the study effect of supplementation hormone or phytoestrogen from *Pueraria mirifica* are show in Table 3.5. The supplemented synthesis estradiol groups and supplemented phytoestrogen from *Pueraria mirifica* were not significantly difference on amount of total SFA ($P>0.05$) compare with control group varied from 60.23 to 62.58% of total fatty acid while caprylic acid (C8 : 0) of control group (1.508% of total fatty acid) was higher than supplemented synthesis estradiol groups (0.043% of total fatty acid) and supplemented phytoestrogen from *Pueraria mirifica* groups (0.044% of total fatty acid) ($P<0.001$). The caprylic acid is one of many odor fatty acid that are mention by Tranquilan (2009) there are effect in the development of goaty odor and flavor in goat meat. Thus, supplementation of hormone or phytoestrogen from *Pueraria mirifica* had effect on decrease caprylic acid in goat meat, although it is not main odor fatty acid mention in goat meat.

The amount monounsaturated fatty acid (MUFA) was not significantly different among group (P>0.05). The MUFA are range from 31.7 to 33.16% of total fatty acid, however, in this study the amount total polyunsaturated fatty acid (PUFA) (range from 5.64 to 6.63% of total fatty acid) and conjugated fatty acid isomer in goat meat were not significantly different either supplemented synthesis estradiol or supplemented phytoestrogen from *Pueraria mirifica* (P>0.05).

Fatty acid ratio between PUFA and SFA was not significant difference among group (P>0.05) the amount of PUFA/SFA ratio of supplemented synthesis estradiol group is 0.092% of total fatty acid was lower than control group (0.108% of total fatty acid) and supplemented phytoestrogen from *Pueraria mirifica* group (0.109% of total fatty acid). In this study show the PUFA/SFA ratio range from 0.09 to 0.10 was quite close to study of Madruga et al. (2009) who investigated PUFA/SFA ratio of goat were from 0.08 to 0.09, however this value are below the suggestion by Wood et al. (2003) who recommended value of PUFA/SFA ratio above 0.4 to prevent illnesses associated with the consumption of fats. In addition, the study of Williams (2000) reported the value of PUFA/SFA ratio around 0.1 is unbalanced consumption of desirable fatty acid. While UFA/SFA ratio of all treatments were not significantly different (P>0.05) range from 0.606 to 0.662% of total fatty acid.

In term of the (C18 : 0+C18 : 1)/C16 : 0 ratio that presented the value of possible beneficial effects of lipid which values are from 2.1 to 3.6 for goat meat (Banskalieva et al., 2000 and Rhee et al., 2000) and it is strongly recommended that ratio least 0.2 (Wood et al., 2003) or 0.12 as the upper limit (Hoffman et al., 2003). Moreover the lower ratio was described by Banskalieva et al. (2000) in sheep meat which varies from 0.07-0.26. While in this study was not significantly difference on (C18 : 0+C18 : 1)/C16 : 0 ratio range from 2.31 to 2.67 that is data of Thai native

meat goat quite close to meat from Boer and Anglo Nubian crossbred×SPRD goats with values from 3.13 to 3.26 that reported by Madruga et al. (2009). Whereas, the desirable fatty acid (DFA) value is index rick factor from food, in this study range from 67.42 to 69.98% of total fatty acid also show the DFA value of Thai native meat goat excellence close to Boer, Anglo Nubian and crossing with SPRD goat meat that mention by Banskalieva et al. (2000) and Rhee et al. (2000).

Table 4.5 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on fatty acid profile as percentage of total fatty acid in goat meat

Fatty acid	Treatment*			SEM	P-value
	T1	T2	T3		
Saturated Fatty Acid, SFA	--- % of total fatty acid ---				
Butryic (C4 : 0)	0.134	0.194	0.211	0.020	0.205
Caproic (C6 : 0)	0.031	0.026	0.035	0.004	0.664
Caprylic (C8 : 0)	1.508[a]	0.043[b]	0.044[b]	0.014	<0.001
Capric Acid (C10 : 0)	0.075	0.075	0.086	0.009	0.866
Lauric Acid (C12 : 0)	0.251	0.430	0.524	0.006	0.155
Tridecanoic Acid (C13 : 0)	0.172	0.135	0.042	0.057	0.625
Myristic Acid (C14 : 0)	3.562	4.436	4.455	0.332	0.481
Pentadecanoic Acid (C15 : 0)	0.397	0.436	0.480	0.038	0.663
Palmitic Acid (16 : 0)	23.101	24.847	22.234	0.625	0.053
Heptadecanoic Acid (C17 : 0)	1.205	0.974	1.244	0.125	0.576
Stearic Acid (C18 : 0)	31.160	29.542	29.833	0.750	0.660
Arachidic Acid (C20 : 0)	0.230	0.326	0.315	0.035	0.542
Behenic Acid (C22 : 0)	0.093	0.139	0.124	0.013	0.389
Tricosanoic Acid (C23 : 0)	0.114	0.107	0.279	0.04	0.117
Lignoceric Acid (C24 : 0)	0.115	0.147	0.138	0.008	0.297
Total SFA	61.422	62.580	60.232	0.765	0.337
Monounsaturated Fatty Acid, MUFA	--- % of total fatty acid ---				
Myristoleic Acid (C14 : 1)	0.124	0.116	0.141	0.015	0.708
Pantadecenoic Acid (C15 : 1)	0.043	0.178	0.078	0.026	0.107

Table 4.5 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on fatty acid profile as percentage of total fatty acid in goat meat (Cont.)

Fatty acid	Treatment*			SEM	P-value
	T1	T2	T3		
Monounsaturated Fatty Acid, PUFA	--- % of total fatty acid ---				
Palmitoleic Acid (C16 : 1)	2.810	2.446	2.176	0.196	0.053
Heptadecenoic Acid (C17 : 1)	0.982	1.401	2.165	0.345	0.072
Elaidic Acid (C18 : 1n9t)	0.271	0.254	0.195	0.029	0.571
Oleic Acid (C18 : 1n9c)	27.063	26.420	27.949	0.867	0.550
Eicoenioic Acid (C20 : 1)	0.081	0.120	0.076	0.011	0.158
Erucic Acid (C22 : 1n9)	0.113	0.166	0.142	0.013	0.245
Nervonic Acid (C24 : 1)	0.1117	0.131	0.130	0.010	0.710
Total MUFA	31.8710	31.739	33.160	0.774	0.581
Polyunsaturated Fatty Acid, PUFA	--- % of total fatty acid ---				
Linolelaidic Acid (C18 : 2n6t)	0.236	0.190	0.182	0.016	0.385
Linoleic Acid (C18 : 2n6c)	1.528	1.584	1.909	0.100	0.258
Gamma-Linolenic Acid (C18 : 3n6)	0.039	0.053	0.042	0.008	0.741
Alpha-Linolenic Acid (C18 : 3n3)	0.138	0.062	0.255	0.051	0.338
Eicosedienoic Acid (C20 : 2)	0.756	0.127	0.475	0.196	0.427
Eicosatrienoic Acid (C20 : 3n6)	0.160	0.249	0.129	0.026	0.065
Eicosatrienoic Acid (C20 : 3n3)	0.106	0.127	0.116	0.013	0.806
Arachidonic Acid (C20 : 4n6)	1.619	1.250	0.823	0.313	0.606
Eicosapentaenoic Acid (C20 : 5n3)	0.357	0.345	0.320	0.047	0.945
Docosadienoic Acid (C22 : 2)	0.528	0.093	0.652	0.049	0.639
Docosahexaenoic Acid (C22 : 6n3)	0.450	0.192	0.249	0.067	0.117
Conjugated Linoleic Acid Isomers, CLA	--- % of total fatty acid ---				
cis-9, trans-11 CLA (C18 : 2)	0.250	0.236	0.555	0.074	0.166
trans-10 cis-12 CLA (C18 : 2)	0.135	0.287	0.437	0.093	0.404
cis-9, cis-11 CLA (C18 : 2)	0.114	0.128	0.268	0.045	0.305
trans-9, trans-11 CLA (C18 : 2)	0.123	0.148	0.284	0.039	0.064
Total PUFA	6.632	5.640	6.574	0.482	0.662

Table 4.5 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on fatty acid profile as percentage of total fatty acid in goat meat (Cont.)

Fatty acid	Treatment*			SEM	P-value
	T1	T2	T3		
PUFA/SFA	0.108	0.092	0.109	0.008	0.639
UFA/SFA	0.629	0.606	0.662	0.020	0.543
(C18 : 0+C18 : 1)/C16 : 0	2.550	2.310	2.670	0.099	0.354
DFA	69.979	67.417	69.667	0.612	0.180

[a, b] Means with different superscript letters in the same row differ significantly; *T1 = no hormone (control), T2 = injected synthesis estradiol (released rate 200 µg/d), T3 = supplemented phytoestrogen from *Pueraria mirifica* 200 µg/d; DFA = desirable fatty acids = MUFA+PUFA+C18 : 0.

4.5.4 Carcass characteristics and carcass composition

The investigation of effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on carcass characteristics and carcass composition are presented in Table 4.6. The carcass characteristics of supplemented synthesis estradiol hormone and phytoestrogen from *Pueraria mirifica* were not significant difference (P>0.05) with control group. The generally mean dressing percentage for various goat breeds worldwide varied between 38 to 44% (Devendra and Owen, 1983; Kadim et al., 2004). Hot dressing percentage in this study varies from 35.34 to 44.83% while many researchers reported that dressing percentage varies from 39 to 55% (Kebede et al., 2008; Pinkerton et al., 1994; Simela et al., 2008; Acharya, 1998; Daskiran et al., 2006; Hailu et al., 2005).

However, dressing percentage might be affected by empty body weight or

the amount of rumen, intestine guts, and organs to be included in dressed carcass or removal of some visceral organs in hot carcass measurement might be resulted in different dressing percentages (Bhattacharyya and Khan, 1988; Kebede et al., 2008). Therefore, the lower dressing percentage in this study might be not included kidney and pelvic fat in this determination, unlike with Daskiran et al. (2006) who included kidneys, pelvic fat and testicles in hot carcass measurements which in turn affected dressing percentages. In the term of mean of carcass composition base on percent live weight of all treatments were not difference (P>0.05).

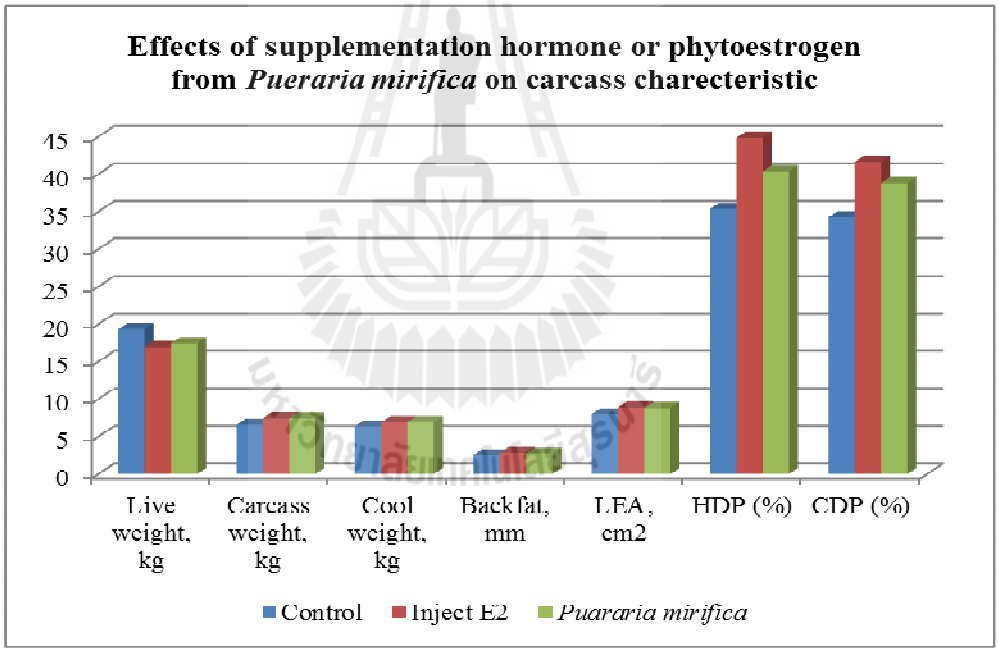

Figure 4.1 The carcass characteristics of meat goats with supplemented hormone or phytoestrogen from *Pueraria mirifica*

Table 4.6 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on carcass characteristics and carcass composition of meat goats

Item	Treatment			SEM	P-value
	T1	T2	T3		
Live weight, kg	19.30	16.96	17.43	0.65	0.13
Carcass weight, kg	6.58	7.45	7.44	0.22	0.26
Cool weight, kg	6.38	6.92	6.95	0.22	0.53
Backfat, mm	2.49	2.82	2.73	0.25	0.87
REA, cm^2	7.97	8.89	8.79	0.16	0.11
HDP (%)	35.35	44.84	40.35	1.31	0.19
CDP (%)	34.26	41.63	38.82	1.18	1.31
	----------% Live weight----------				
Hind leg	11.13	12.94	13.06	0.45	0.20
Font leg	7.93	8.81	8.45	0.42	0.70
Loin	2.16	2.43	2.47	0.15	0.68
Rip	13.53	14.93	13.73	0.76	0.73
Head	6.92	7.89	7.63	0.27	0.36
Skin	7.33	8.72	8.44	0.45	0.44
Leg	2.20	2.48	2.37	0.07	0.27
Kidney	0.27	0.29	0.28	0.01	0.69
Spleen	0.12	0.14	0.15	0.02	0.66
Liver	1.57	1.68	1.63	0.05	0.73
Lung	0.93	0.78	1.02	0.07	0.41
Heart	0.33	0.36	0.37	0.02	0.70
Fat	1.25	1.01	1.34	0.13	0.57

*T1 = no hormone (control), T2 = injected synthesis estradiol (released rate 200 µg/d), T3 = supplemented phytoestrogen from *Pueraria mirifica* 200 µg/d in diet; HDP = Hot dressing percentage; CDP = Cool dressing percentage; REA = Rip eye area

4.5.5 Meat quality

The mean of meat quality proportion of supplementation hormone or phytoestrogen from *Pueraria mirifica* are show in Table 4.7. There was no difference on meat color components on loin, font of leg or hind of leg ($P>0.05$). The %drip loss of loin, font of leg and hind of leg were not significantly difference ($P>0.05$). The ultimate pH is determined 24 hours post slaughter were significantly different among groups with control group (5.72) that lower than supplemented synthesis estradiol group (5.87) and supplemented phytoestrogen from *Pueraria mirifica* group (5.86) ($P<0.05$). The pH_{24} of this study is still in the range of normal pH value of meat which the good quality meat usually has a pH of 5.4 to 5.7 which pH value of meat with above 6 is generally considered unsuitable of storage because of the favorable development of proteolytic microorganism. The initial pH (pH_0) is determined 45 minutes post slaughter were not significantly different among group (varied from 6.83 to 6.87) ($P>0.05$).

4.5.6 Chemical composition of raw goat meat

The results show that supplementation of hormone or phytoestrogen from *Pueraria mirifica* at 200 µg/d did not affect the chemical composition of raw goat meat ($P>0.05$) mean of moisture percentage 76.47%, ash of 1.11%, crude protein of 20.14%, and fat of 0.57%. Madruga et al. (2000) reported that lipid deposition in goat carcass only occurs when the animal reaches maturity or a body weight of about 40 kg. Thus, the lower values for ether extract in this study could be related due to the younger goats. Moreover, meat samples were analyzed as part of the longissimus muscle which a relatively slim fat content in Thai native goat meat.

Table 4.7 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on meat quality of meat goats

Item	Treatment*			SEM	P-value
	T1	T2	T3		
Color of loin					
L*	53.56	54.52	50.23	0.89	0.17
a*	13.26	12.73	13.44	0.38	0.74
b*	4.86	4.94	4.78	0.32	0.98
Color of font leg					
L*	53.40	52.56	51.59	0.81	0.67
a*	10.52	10.80	10.86	0.33	0.90
b*	3.37	2.57	2.39	0.24	0.26
Color of hind leg					
L*	48.85	51.02	47.75	0.75	0.25
a*	12.17	11.30	11.91	0.36	0.62
b*	4.72	3.27	4.08	0.31	0.21
%Drip loss					
Loin	2.45	2.12	1.86	0.11	0.14
Font of leg	1.90	1.77	1.66	0.10	0.64
Hind of leg	2.58	2.05	2.43	0.19	0.54
pH_0	6.83	6.88	6.83	0.02	0.55
pH_{24}	5.72^b	5.88^a	5.87^a	0.02	0.01

[a, b] Means with different superscript letters in the same row differ significantly; *T1 = no hormone (control), T2 = injected synthesis estradiol (released rate 200 µg/d), T3 = supplemented phytoestrogen from *Pueraria mirifica* 200 µg/d in diet; L*, a*, b* : chroma-meter value L* = Lightness, a* = Redness, b* = Yellowness

Results of the moisture and crude protein contents in the raw goat meat fall within the range reported by Marichal et al. (2003), i.e. 76 to 78% moisture and 18 to 20% CP. Ash contents of goat meat recorded in this study was similar to those (1.1 to 1.2%) reporte by Babider et al. (1990) and Johnson et al. (1995). Thus results from this study suggest that supplementation of estradiol either synthesis estradiol or phytoestrogen from *Pueraria mirifica* at 200 mcg/d did not affect chemical composition of goat meat. Although Aricetti, et al. (2008) reported that protein deposition is related to concentration of testosterone, but the result of this study did not agree with their report.

Table 4.8 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on chemical composition of raw goat meat

Item	Treatment*			SEM	P-value
	T1	T2	T3		
Moisture (%)	77.05	76.81	75.55	0.34	0.22
Dry mater (%)	22.95	23.19	24.45	0.34	0.22
Ash (%)	1.08	1.12	1.12	0.01	0.33
Ether extract (%)	0.58	0.51	0.62	0.06	0.75
Crude protein (%)	19.40	20.07	20.97	0.33	0.14

*T1 = no hormone (control), T2 = injected synthesis estradiol (200 µg/d), T3 = supplemented phytoestrogen from *Pueraria mirifica* at 200 µg/d in diet

4.5.7 Feed intake and Growth performance

The effects of supplementation of hormone or phytoestrogen from *Pueraria mirifica* on feed intake and growth performance are shown in Table 4.9. Daily total intake, expressed in terms of g/d, g/kg BW and g/kg $BW^{0.75}$ were not significantly different (P>0.05) among treatments. The average of total daily feed intake of between 50.27 to 52.71 g/kg$BW^{0.75}$.

Although the ADG of goats from the control group appeared to be higher than those from the treatment groups, these values (averaged 25.05 g/d) were not statistically significant. However, the data of supplemented synthesis hormone showed lower gain (19.34 g/d) than other group, that might cause injection of the hormone causes the animal stress and can result in the feed intake and gain of the animal. Torres and Nowson (2007) reported that stress appears to alter overall food intake in two ways, resulting in under- or over-eating, which may be influenced by stressor severity. Feed conversion ratio (FCR) of goats was not affected by either supplementation of synthesis estradiol or phytoestrogen from *Pueraria mirifica.* (Table 4.9 and Figure 4.3). The mean of overall FCR ranged from 19.2 to 24.8. Although supplementation of estradiol has resulted in addition cost, results of this study show that the cost per BW gain was not significantly different (P>0.05) among treatment (Table 4.9). Although supplementation of estradiol either synthesis or phytoestrogen was not negative result on performance in meat goat, but the data show lowest cost/gain in control group (79.56 bath/kgBW).

Table 4.9 Effects of supplementation hormone or phytoestrogen from *Pueraria mirifica* on feed intake and growth performances in meat goats

Item	Treatment*			SEM	P-value
	T1	T2	T3		
Initial weight, kg	17.04	16.50	17.88	0.55	0.60
Final weight, kg	20.33	18.67	20.83	0.46	0.17
ADG, g/d	29.39	19.34	26.41	1.99	0.14
Overall Feed					
Intake, g/d	503.54	451.23	512.51	21.41	0.47
%BW	2.49	2.42	2.47	0.10	0.97
g/kg $BW^{0.75}$	52.72	50.27	52.64	2.13	0.87
FCR					
Concentrate	10.47	13.62	12.12	1.03	0.48
Roughage	8.79	11.22	10.04	1.36	0.77
Overall	19.26	24.83	22.17	2.26	0.61
Cost/gain, bath/kgBW	79.56	103.51	92.14	7.82	0.48

*T1 = no hormone (control), T2 = injected synthesis estradiol (200 µg/d), T3 = supplemented phytoestrogen from *Pueraria mirifica* at200 µg/d

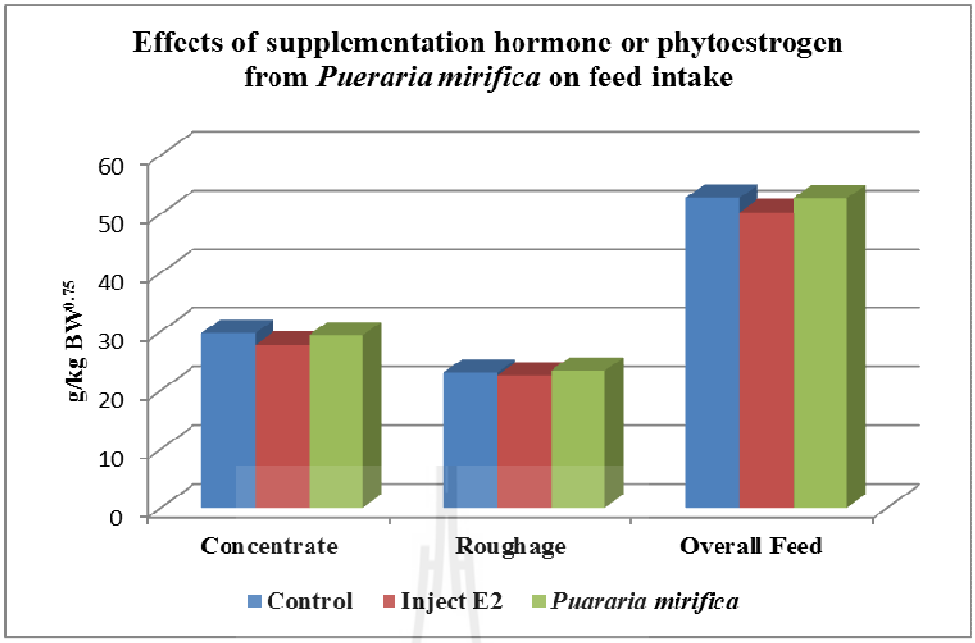

Figure 4.2 The feed intake of meat goats with supplemented hormone or phytoestrogen from *Pueraria mirifica*

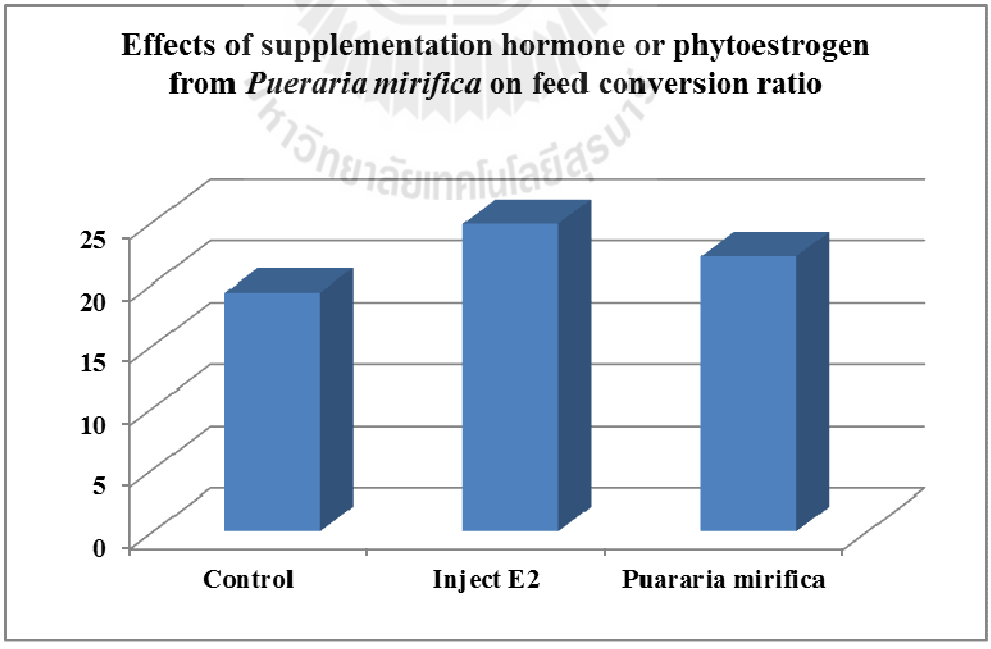

Figure 4.3 The feed conversion ratio of meat goats with supplemented hormone or phytoestrogen from *Pueraria mirifica*

4.6 Conclusions

The concentrations of estradiol and testosterone hormone with supplementation hormone or phytoestrogen from *Pueraria mirifica* were not significant difference among groups (P>0.05) while the concentration of testosterone in serum in control group was lowest compare with supplemented hormone and phytoestrogen from *Pueraria mirifica* group. In addition the concentration of estradiol either synthesis estradiol or phytoestrogen were not decrease testosterone in serum. The total cholesterol in serum was not significantly difference among groups (P>0.05) that supplementation of hormone or phytoestrogen were not effect on decrease cholesterol in serum.

The odorant fatty acid in this study are 4-methyl-octanoic acid, 4-ethyl-octanoic acid and 4-methyl-nonanoic acid were not significant different (P>0.05) while the data show supplemented either synthesis estradiol or phytoestrogen from *Pueraria mirifica* at 200 µg/d had lower than control group but this concentrate are not yet clearly statistic significantly difference. Although the concentration of testosterone in supplemented hormone was higher than control group, but there are not effect on increase the concentration of main odorant fatty acid

The fatty acid compositions of supplemented synthesis estradiol groups and supplemented phytoestrogen from *Pueraria mirifica* were not significantly difference on amount of total SFA (P>0.05) compare with control group. While caprylic acid (C8 : 0) of control group was higher than supplemented synthesis estradiol groups and phytoestrogen from *Pueraria mirifica* groups (P<0.001). The caprylic acid is one of many odors fatty acid are mention to effect in the development of goaty odor and flavor in goat meat. Thus, supplementation of hormone or phytoestrogen from

Pueraria mirifica had effect on decrease caprylic acid in goat meat, although it is not main odor fatty acid mention in goat meat.

The amount MUFA, PUFA and conjugated fatty acid isomer were not significantly different among group (P>0.05).Moreover the fatty acid ratio between PUFA and SFA was not significant difference among group (P>0.05), while UFA/SFA ratio of all treatments were not significantly different (P>0.05). In addition the (C18 : 0+C18 : 1)/C16 : 0 ratio and DFA value that presented the value of possible beneficial effects of lipid were not significantly difference. The carcass characteristics and carcass composition were not significant difference (P>0.05) among group.

Supplementation hormone or phytoestrogen from *Pueraria mirifica* was no difference on meat color components, %drip loss (P>0.05). The pH_{24} were significantly different among groups with control group that lower than supplemented synthesis estradiol group and supplemented phytoestrogen from *Pueraria mirifica* group (P<0.05). However the pH_{24} of this study is still in the range of normal pH value of meat. The pH_0 and the composition of raw goat meat were not significantly different among group (P>0.05).

The feed intake and growth performance were not significantly different (P>0.05) among treatments. Feed conversion ratio (FCR) and cost/gain were not affected by either supplementation of synthesis estradiol or phytoestrogen from *Pueraria mirifica.* Although, the supplementation of estradiol either synthesis or phytoestrogen form had not negative result on performance in meat goat, but the cost/gain of control group was lowest compare with other group.

4.7 Implication

The study of xenoestrogen (synthesis estradiol and phytoestrogen from *Pueraria mirifica*) in this experiment which is one of two way to decrease odorant fatty acid that come from the testosterone activity. The result shown the xenoestrogen was not effect on odorant fatty acid, although the concentration of testosterone was increase in supplemented xenoestrogen. In the opinion of author, cause of the result not clearly decrease odorant fatty acid might the level of xenoestrogen was not sufficient to significant difference. Moreover the synthesis estradiol was not different effect on odorant compare with phytoestrogen from *Pueraria mirifica*. Therefore the increasing levels of phytoestrogen from *Puraria mirifica* in the experiment III need to study further.

4.8 References

Acharya, R. (1988). Goat breeding and meat production. In **Preceeding of the International Workshop on Goat Meat Production in Asia,** Tando Jam (Pakistan). 12-18 Mar 1988.

Adams, N. R. (1995). Detection of the effects of phytoestrogens on sheep and cattle. **Journal of animal science**, 73:5 : 1509-1515.

AOAC. (2000). Meat and Meat products. In: Official Methods of Analysis. **Association of Official Analytical Chemists Inc.** Gaithersburg, USA.

Aricetti, J.A., Rotta, P.P., Prado, R., Perotto, D., Moletta, J.L., Matsushita, M., and Prado, I. (2008). Carcass characteristics, chemical composition and fatty acid profile of Longissimus muscle of bulls and steers finished in a pasture system. **Asian-Australasian Journal of Animal Science**. 21(10) : 1441-1448.

Babiker, S., El Khider, I., and Shafie, S. (1990). Chemical composition and quality attributes of goat meat and lamb. **Meat science**, 28(4) : 273-277.

Banskalieva, V., Sahlu, T., and Goetsch, A.L. (2000). Fatty acid composition of goat muscles and fat depots: a review. **Small Ruminant Research**. 37(3) : 255-268.

Bhattacharyya, N. and Khan, B. (1988). Goat meat production in India. In **Preceeding of the International Workshop on Goat Meat Production in Asia,** Tando Jam (Pakistan). 12-18 Mar 1988.

Chemineau, P. (1987). Possibilities for using bucks to stimulate ovarian and oestrous cycles in anovulatory goats-a review. **Livestock Production Science**, 17 : 135-147.

Daskiran, I., Askin, K., and Mehmet, B. (2006). Slaughter and carcass characteristics of Norduz male kids raised in either intensive or pasture conditions. **Pakistan Journal of Nutrition**. 5(3) :274-277.

de Ronde, W., and de Jong, F. H. (2011). Aromatase inhibitors in men: effects and therapeutic options. **Reproductive Biology and Endocrinology**, 9(1) : 93-100.

Devendra, C., and Owen, J. (1983). Quantitative and qualitative aspects of meat production from goats. **World Animal Review**, 47(2) : 19-29

Dhanda, J., Taylor, D., and Murray, P. (2003). Part 1. Growth, carcass and meat quality parameters of male goats: effects of genotype and liveweight at slaughter. **Small Ruminant Research**. 50(1) : 57-66.

Enser, M., Hallett, K., Hewitt, B., Fursey, G., and Wood, J. (1996). Fatty acid content and composition of English beef, lamb and pork at retail. **Meat Science**. 42(4) : 443-456.

Fisher, A. and De Boer, H. (1994). The EAAP standard method of sheep carcass assessment. Carcass measurements and dissection procedures report of the EAAP working group on carcass evaluation, in cooperation with the CIHEAM instituto agronomico Mediterraneo of Zaragoza and the CEC directorate general for agriculture in Brussels. **Livestock Production Science**. 38(3) : 149-159.

Hara, A. and Radin, N.S. (1978). Lipid extraction of tissues with a low-toxicity solvent. **Analytical Biochemistry**, 90(1) : 420-426.

Johnson, B., Anderson, P., Meiske, J., and Dayton, W. (1996). Effect of a combined trenbolone acetate and estradiol implant on feedlot performance, carcass characteristics, and carcass composition of feedlot steers. **Journal of animal science**, 74(2) : 363-371.

Johnson, D., Eastridge, J., Neubauer, D., and McGowan, C. (1995). Effect of sex class on nutrient content of meat from young goat. **Journal of animal science**, 73(1) : 296-301.

Kadim, I., Mahgoub, O., Al-Ajmi, D., Al-Maqbaly, R., Al-Saqri, N., and Ritchie, A. (2004). An evaluation of the growth, carcass and meat quality characteristics of Omani goat breeds. **Meat science**. 66(1) : 203-210.

Kebede, T., Lemma, T., Dinka, H., Guru, M., and Sisay, A. (2008). Growth performance and carcass characteristics of Arsi-Bale goats castrated at different ages. **Journal of Cell and Animal Biology**. 2(11) : 187-194.

Kellermeier, J., Tittor, A., Brooks, J., Galyean, M., Yates, D., Hutcheson, J., Miller, M. (2009). Effects of zilpaterol hydrochloride with or without an estrogen trenbolone acetate terminal implant on carcass traits, retail cutout, tenderness,

and muscle fiber diameter in finishing steers. **Journal of animal science**, 87(11) : 3702-3711.

Madruga, M., Arruda, S., Narain, N., and Souza, J. (2000). Castration and slaughter-age effects on panel assessment and aroma compounds of the “mestiço” goat meat. **Meat science**. 56(2) : 117-125.

Madruga, M.S., Stephen Elmore, J., Dodson, A.T., and Mottram, D.S. (2009). Volatile flavour profile of goat meat extracted by three widely used techniques. **Food Chemistry**. 115(3) : 1081-1087.

Marichal, A., Castro, N., Capote, J., Zamorano, M., and Argüello, A. (2003). Effects of live weight at slaughter (6, 10 and 25 kg) on kid carcass and meat quality. **Livestock Production Science**, 83(2) : 247-256.

Metcalfe, L. and Schmitz, A. (1961). The rapid preparation of fatty acid esters for gas chromatographic analysis. **Analytical Chemistry**. 33(3) : 363-364.

Morrison, W.R. and Smith, L.M. (1964). Preparation of fatty acid methyl esters and dimethylacetals from lipids with boron fluoride–methanol. **Journal of Lipid Research**. 5(4) : 600-608.

Moutsatsou, P. (2007). The spectrum of phytoestrogens in nature: our knowledge is expanding. **Hormones Athens Journal**, 6(3) : 173.

Nichols, W., Galyean, M., Thomson, D., and Hutcheson, J. (2002). Review: Effects of steroid implants on the tenderness of beef. **The Professional Animal Scientist**, 18(3) : 202-210.

Ogilvie, M., Faltin, E., Hauser, E., Bray, R., and Hoekstra, W. (1960). Effects of stilbestrol in altering carcass composition and feed lot performance of beef steers. **Journal of animal science**, 19(4) : 991-1001.

Pinkerton, F. (1994). A survey of prevalent production and marketing practices in

meat goats of southern origin. **SRDC publication**.

Rhee, K., Waldron, D., Ziprin, Y., and Rhee, K. (2000). Fatty acid composition of goat diets vs intramuscular fat. **Meat science**. 54(4) : 313-318.

Sen, A., Santra, A., and Karim, S. (2004). Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. **Meat science**, 66(4) : 757-763.

Simela, L., Webb, E.C., and Bosman, M. (2008). Acceptability of chevon from kids, yearling goats and mature does of indigenous South African goats: **A case study.**

Steel, R. and Torrie, J. (1980). Prnciples and Procedures of Statistics: **A Biometrical Approach: McGraw-Hill. New York.**

Torres, S. J., and Nowson, C. A. (2007). Relationship between stress, eating behavior, and obesity. **Nutrition**, 23(11) : 887-894.

Ülker, H., Gökdal, Ö., Temur, C., Budağ, C., Oto, M., deavila, D., and Reeves, J. (2002). The effect of immunization against LHRH on body growth and carcass characteristics in Karakaş ram lambs. **Small Ruminant Research**. 45(3) : 273-278.

USDA. (2005). Dietary guidelines for Americans. Available from **http://www. health.gov/dietaryguidelines/dga2005/document/**, accessed at 16 June 2005.

Vaya, J., and Tamir, S. (2004). The relation between the chemical structure of flavonoids and their estrogen-like activities. **Current medicinal chemistry**, 11(10) : 1333-1343.

Weber, K., Setchell, K., Stocco, D., and Lephart, E. (2001). Dietary soy-phytoestrogens decrease testosterone levels and prostate weight without

altering LH, prostate 5alpha-reductase or testicular steroidogenic acute regulatory peptide levels in adult male Sprague-Dawley rats. **Journal of Endocrinology**, 170(3) : 591-599.

Woods, V.B. and Fearon, A.M. (2009). Dietary sources of unsaturated fatty acids for animals and their transfer into meat, milk and eggs: A review. **Livestock Science**. 126(1) : 1-20.

CHAPTER V

EFFECTS OF DIFFERENT LEVEL OF PHYTOESTROGEN FROM *Pueraria mirifica* ON PERFORMANCE, CARCASS CHARECTERISTIC, MEAT QUALITY AND ODORANT FATTY ACIDS IN GOAT MEAT

5.1 Abstract

The objective of this study was to evaluate the effects of different levels of phytoestrogen from *Pueraria mirifica* on performance, carcass quality and odorant fatty acids in goat meat. The experiment consisted of five treatments; that is goats were offered rice straw *ad-libitum* as roughage source and commercial concentrate pellet plus different levels (0, 250, 500, 750 and 1000 µg/d) of phytoestrogen from *Pueraria mirifi*ca in the diets. The supplementation phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1000 µg/d in diet were not significantly difference on concentration of estradiol and testosterone hormone in serum of meat goat among groups (P>0.05). Total cholesterol in serum was significant different with increased quadratically with increasing phytoestrogen in the diet (P>0.05).

The effect of supplemented phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1,000 µg/d in diet were linear decrease odorant fatty acid in goat meat with increase phytoestrogen from *Pueraria mirifi*ca (P<0.05). The main of odorant

fatty acid was higher 4-methyl-octanoic acid than other groups while the supplemented phytoestrogen from *Pueraria mirifi*ca at 1,000 µg/d in diet was lowest 4-methyl-octanoic acid than other group. The supplemented phytoestrogen from *Pueraria mirifi*ca at 1,000 µg/d in diet was lowest 4-ethyl-octanoic acid than other groups. The 4-methyl-nonanoic acid of the control group was highest 4-methyl-nonanoic acid than other group, while the supplemented phytoestrogen from *Pueraria mirifi*ca at 1,000 µg/d in diet was lowest 4-methyl-nonanoic acid than other groups.

The fatty acid compositions were not significantly difference on amount of total SFA, MUFA and PUFA (P>0.05). While, lauric acid (C12 : 0) and tridecanoic acid (C13 : 0) were significantly difference among groups (P<0.05). (P>0.05). The supplemented phytoestrogen from *Pueraria mirifi*ca in diet were difference on alpha-linolenic acid (C18 : 3n3) with decreased cubic, while the conjugated fatty acid isomer (cis-9, cis-11 CLA) also was difference with increased linear and quadratic as increase supplemented phytoestrogen from *Pueraria mirifi*ca in diet.

In the term of the possible beneficial effects of lipids ratio are the (C18 : 0+C18 : 1)/C16 : 0 value in this study was not difference, while the desirable fatty acid (DFA) in this study shows the excellence level close to Boer, Anglo Nubian and crossing with SPRD goat meat. The PUFA/SFA and UFA/SFA ratio and of supplemented were not significant difference among group (P>0.05) with increasing phytoestrogen from *Pueraria mirifi*ca in diet. The increasing level of phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1000 µg/d in diet were not significant difference (P>0.05) on either carcass characteristics or carcass composition.

Supplementation of 1000 µg/d phytoestrogen had higher a* value for front of leg meat than control group (P<0.05) gut not the other treatment groups. While L* and b* values, %drip loss of meat at loin, front of leg and hind of leg, pH_0 and pH_{24}

were not significantly different among groups (P>0.05).

Daily feed intake and growth performance (P>0.05) were not affected by the different treatment groups but result showed that cost per kg gain in treatment supplemented with phytoestrogen at 1000 µg/d was higher than the other groups. No difference (P>0.05) were detected among treatments in carcass and carcass composition.

Key words : *Pueraria mirifica*, phytoestrogen, Performance, Carcass, Meat quality, Goat meat

5.2 Introduction

Pueraria mirifica (White Kwao Krua) is Thai native herbal plant common species found mainly in the northern and western part of Thailand. The tuber accumulates “phytoestrogens” (Hormone from Plant) that are beneficial and can be used for medicinal, food supplementary and cosmetic.

The phytoestrogen in *Pueraria mirifica* differs from other phytoestrogens because the miroestrol and deoxymiroestrol in the *Pueraria mirifica* possess high estrogenic activity due to structural similarity to estradiol. It was found that supplementation of phytoestrogen from *Pueraria mirifica* at 200 µg/d of goat (Experiment II) did not significantly affecting the goats, presumably due to the low concentration of phytoestrogen from *Pueraria mirifica* used. The objective of this experiment is to investigate the effect of supplementing higher level of phytoestrogen from *Pueraria mirifica* on performance, carcass quality and odorant fatty acids in goat meat.

5.3 Objectives

This experiment was carried out to examine the effects of different level of phytoestrogen from *Pueraria mirifica* on performance, carcass quality and odorant fatty acids in goat meat.

5.4 Materials and Methods

5.4.1 Experimental design and treatment

Thirty 8 months old male crossbred (Thai native×Anglo-Nubian) goats were used in this study. Goats were maintained in quarantine for two weeks after arrival at the experimental farm and were treated for external and internal parasites. Animals were randomly divided into 5 groups with six goats per group (treatment) in a completely randomized design (CRD) (Table 5.1). Each treatment was consisting of six goats and the treatment varied to level of phytoestrogen from *Pueraria mirifica.* Blood samples were collected at the beginning and end of experiment for evaluate determination of testosterone and estradiol hormones.

All animals were offered rice straw *ad libitum* supplemented with concentrate (16% CP) 1.5% (BW). Animals were weighed before feeding, weekly and daily dry matter intake (DMI) was recorded. Six goats from each treatment were randomly selected and slaughtered for carcass evaluation following the procedure of Dhanda et al. (2003a) at the end of experimental period.

Table 5.1 Experimental treatments.

Groups	Treatments
T1 (control)	Without phytoestrogen
T2	Supplemented with phytoestrogen from *Pueraria mirifica* at 250 µg/d
T3	Supplemented with phytoestrogen from *Pueraria mirifica* at 500 µg/d
T4	Supplemented with phytoestrogen from *Pueraria mirifica* at 750 µg/d
T5	Supplemented with phytoestrogen from *Pueraria mirifica* at 1000 µg/d

Goats were offered rice straw *ad libitum* and supplemented with concentrate. The chemical composition of the commercial pellet concentrate, rice straw and *Pueraria mirifica* used for the experiment are shown in Table 5.2.

Table 5.2 Chemical composition of experimental diet (%DM)

Item	Concentrate	Roughage (Rice straw)	*Pueraria mirifica*
	---------- %DM ----------		
Crude protein	16.43	2.48	10.45
Ether extract	4.03	0.58	0.45
Ash	6.08	14.14	23.31
Neutral detergent fiber (NDF)	46.71	66.52	38.92
Acid detergent fiber (ADF)	29.81	47.25	13.01

5.4.2 Slaughtering and carcass evaluation

The slaughtering and carcass evaluation were managed and measured in the same way as described in chapter III.

5.4.3 Meat quality attributes

All the parameter of meat quality was analyses in the same as described in chapter III.

5.4.4 Chemicals analysis and calculation

The chemical compositions of experiment diet and meat sample were determined in the same way as described in chapter III.

5.4.5 Muscle fatty acid evaluation by Gas chromatography (GC)

The analysis process of fatty acid in meat sample was description in the chapter III.

5.4.6 Statistical Analysis

The data were analysis as completely randomized design (CRD) (Steel and Torrie 1980) In order to compensate for differences in live weight at the start of the experiment, initial body weight was used as a covariate adjustment factor for the analysis of data on live animals (final body weight, weight gain, feed consumption).

Similarly live weight was used as a covariate adjustment factor for analysis of data on carcass yield (carcass weight, dressing percentage and carcass composition). (Ülker et al., 2002) The initial cholesterol, estradiol and testosterone level in serum were used as covariate adjustment factor for analysis of data on cholesterol, estradiol and testosterone level in serum of animals. Statistical analysis was performed with the general linear model procedure (PROC GLM), difference among treatments means were used to examine the responses (linear, quadratic, cubic and quartic) to increased supplement level of phytoestrogen from *Pueraria mirifi*ca in the diets. A significance level of $P<0.05$ was used to differentiate between means with SPSS11 program.

5.4.7 Experimental site

The experiment was conducted on the farm of Suranaree University of Technology. The chemical analysis was performed at the Center for Scientific and Technological Equipment (CSTE) of Suranaree University of Technology.

5.4.8 Duration

The experiment on January, 2011 – May, 2011

5.5 Results and discussions

5.5.1 The concentration of estradiol, testosterone hormone and cholesterol in serum of meat goat

The mean of estradiol and testosterone hormone of supplementation phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1000 µg/d are show in Table 5.3. The result show the concentration of estradiol in serum with increasing phytoestrogen were not significantly difference among groups (P>0.05).

The concentration of testosterone in serum of meat goat were not significant difference effect with increasing phytoestrogen (P>0.05). The orthogonal polynomial contrast analysis show the level of phytoestrogen has not effect on either concentration of estradiol or testosterone in meat goat serum (P>0.05).

The total cholesterol in serum were significantly difference (P<0.05) with increasing phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1000 µg/d in diet. The phytoestrogen at 500 µg/d was higher total cholesterol than other group but not difference with the supplemented phytoestrogen at 0, 250 and 750 µg/d. Whereas, the supplemented phytoestrogen at 1000 µg/d was lower total cholesterol than other group but not difference with control group and the supplemented phytoestrogen at 750 µg/d. In addition, the orthogonal polynomial contrast analysis was showed the total cholesterol in serum was significant quadratic increase with increased phytoestrogen

Table 5.3 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on estradiol, testosterone level and cholesterol in serum of meat goats

Item	Treatment*					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Estradiol (pmol/L)	186.50	144.52	151.47	153.61	179.84	11.44	ns	ns	ns	ns
Testosterone (nmol/L)	1.01	1.65	0.78	1.96	1.59	1.76	ns	ns	ns	ns
Cholesterol, mg/dl	56.21^{b}	76.66^{a}	85.89^{a}	60.61^{ab}	46.26^{b}	3.67	ns	*	ns	ns

*T1 = Control; T2 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 250 µg/d; T3 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 500 µg/d; T4 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 750 µg/d; T5 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 1000 µg/d; L = linear; Q = quadratic; C = cubic; O_4 = quartic.

5.5.2 The concentration of odorant fatty acids in goat meat

Table 5.4 shown that the evaluated effect of supplemented phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1,000 µg/d were significantly difference on odorant fatty acid in goat meat ($P<0.05$). The 4-methyl-octanoic acid which the one of three main odorant fatty acid in this studies was linear decrease with increase phytoestrogen from *Pueraria mirifica* ($P<0.05$), the phytoestrogen at 250 µg/d in diet group was higher (0.086% of total fatty acid) than other groups, but not difference with control group (0.126% of total fatty acid) and supplemented phytoestrogen at 500 µg/d group (0.038% of total fatty acid). While the supplemented phytoestrogen at 1,000 µg/d was lowest 4-methyl-octanoic acid (0.008% of total fatty acid) than other group, but not significantly difference with supplemented phytoestrogen at 500 and 750 µg/d group.

In the term of 4-ethyl-octanoic acid and 4-methyl-nonanoic acid also were linear decrease with increase phytoestrogen. The data showed the supplemented phytoestrogen at 1,000 µg/d was lowest 4-ethyl-octanoic acid (0.015% of total fatty acid) than other groups ($P<0.05$) but not difference with supplemented phytoestrogen at 750 µg/d (0.020% of total fatty acid). The control group was highest 4-methyl-nonanoic acid (0.036% of total fatty acid) than other group ($P<0.01$), while the supplemented phytoestrogen at 1,000 µg/d was lowest 4-methyl-nonanoic acid (0.009% of total fatty acid) than other groups.

Table 5.4 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on odorant fatty acid as percentage of total fatty acid in goat meat

Item	Treatment*					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Odorant fatty acid	---------- % of total fatty acid ----------									
4-methyl-octanoic acid	0.086[a]	0.126[a]	0.038[ab]	0.022[b]	0.008[b]	0.001	**	ns	ns	ns
4-ethyl-octanoic acid	0.033[a]	0.033[a]	0.032[a]	0.020[ab]	0.015[b]	0.003	*	ns	ns	ns
4-methyl-nonanoic acid	0.036[a]	0.025[ab]	0.016[b]	0.015[b]	0.009[b]	0.003	**	ns	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly; *T1 = Control; T2 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 250 µg/d; T3 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 500 µg/d; T4 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 750 µg/d; T5 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 1000 µg/d; L = linear; Q = quadratic; C = cubic; O_4 = quartic

5.5.3 The concentration of fatty acid profile in meat goat

The mean of the fatty acid compositions from *Longissimus dorsi* of supplementation phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1000 µg/d are present in Table 5.5. The increasing phytoestrogen were not significantly difference on amount of total SFA (P>0.05) range from 52.96 to 56.94% of total fatty acid. While, lauric acid (C12 : 0) and tridecanoic acid (C13 : 0) were significantly difference among groups (P<0.05). The orthogonal polynomial contrast analysis was significant difference on lauric acid (C12 : 0) with increased phytoestrogen with quadratic and cubic (range from 0.34 to 0.73% of total fatty acid). The tridecanoic acid (C13 : 0) was significant difference with decreased quadratic (range from 0.03 to 0.05% of total fatty acid).

In the term of amount monounsaturated fatty acid (MUFA), the increasing phytoestrogen were not significantly different on MUFA (P>0.05). However, in this study the amount total poly unsaturated fatty acid (PUFA) were not significantly different among groups (P>0.05). Consideration each fatty acid in PUFA group, supplemented phytoestrogen were difference on alpha-linolenic acid (C18 : 3n3) (range from 0.18 to 0.33% of total fatty acid) with decreased cubic, while the conjugated fatty acid isomer (cis-9, cis-11 CLA) also was difference with increased linear and quadratic as increase supplemented phytoestrogen (range from 0.08 to 0.17% of total fatty acid).

Fatty acid ratio between PUFA and SFA of supplemented phytoestrogen was not significant difference among group (P>0.05**.** In this study show the PUFA/SFA ratio range from 0.25 to 0.31 while study of Madruga et al. (2009) who investigated PUFA/SFA ratio of goat were from 0.08 to 0.09, however this value are

below the suggestion by Wood et al. (2004) who recommended value of PUFA/SFA ratio above 0.4 to prevent illnesses associated with the consumption of fats. In addition, the study of Williams (2000) reported the value of PUFA/SFA ratio around 0.1 is unbalanced consumption of desirable fatty acid. In the term of UFA/SFA ratio of supplemented phytoestrogen also were quite close to among group (P>0.05) (range from 0.80 to 0.89%).

In the term of the possible beneficial effects of lipids ratio are the (C18 : 0+C18 : 1)/C16 : 0 value (Table 5.5) in this study was not difference are range from 2.20 to 2.39. According to Banskalieva et al. (2000) and Rhee et al. (2000), mentioned to this ratio is the one the best describes the possible beneficial effects of lipids, which values are from 2.1 to 3.6 for goat meat. In the study showed of Thai native meat goat still on range of goat meat and but lower (C18 : 0+C18 : 1)/C16 : 0 value than Boer and Anglo Nubian crossbred×SPRD goats with values from 3.13 to 3.26 that reported by Madruga et al. (2009). Whereas, the desirable fatty acid (DFA) in this study shows range from 67.59 to 70.15% of total fatty acid show the DFA value of Thai native meat goat excellence close to Boer, Anglo Nubian and crossing with SPRD goat meat.

Table 5.5 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on fatty acid profile as percentage of total fatty acid in goat meat

Item	Treatment*					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Saturated Fatty Acid (SFA)	---------- % of total fatty acid ----------									
Butryic (C4 : 0)	0.043	0.041	0.097	0.028	0.316	0.004	ns	ns	ns	ns
Caproic (C6 : 0)	0.034	0.040	0.024	0.040	0.053	0.003	ns	ns	ns	ns
Caprylic (C8 : 0)	0.029	0.023	0.019	0.023	0.023	0.002	ns	ns	ns	ns
Capric Acid (C10 : 0)	0.132	0.132	0.122	0.135	0.144	0.010	ns	ns	ns	ns
Lauric Acid (C12 : 0)	0.592^{ab}	0.739^{a}	0.341^{b}	0.545^{ab}	0.964^{a}	0.055	ns	*	*	ns
Tridecanoic Acid (C13 : 0)	0.043^{a}	0.030^{ab}	0.021^{b}	0.021^{b}	0.050^{a}	0.005	ns	*	ns	ns
Myristic Acid (C14 : 0)	3.878	4.048	2.837	3.709	4.295	0.242	ns	ns	ns	ns
Pentadecanoic Acid (C15 : 0)	0.913	0.838	0.621	0.909	0.964	0.055	ns	ns	ns	ns
Palmitic Acid (16 : 0)	21.824	23.321	22.767	23.901	23.256	0.669	ns	ns	ns	ns
Heptadecanoic Acid (C17 : 0)	1.503	1.317	1.272	1.427	1.237	0.069	ns	ns	ns	ns
Stearic Acid (C18 : 0)	23.394	25.262	23.870	22.542	22.216	0.626	ns	ns	ns	ns
Arachidic Acid (C20 : 0)	0.283	0.283	0.206	0.262	0.309	0.016	ns	ns	ns	ns
Behenic Acid (C22 : 0)	0.259	0.244	0.231	0.259	0.292	0.012	ns	ns	ns	ns
Tricosanoic Acid (C23 : 0)	0.398	0.362	0.393	0.393	0.396	0.025	ns	ns	ns	ns

Table 5.5 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on fatty acid profile as percentage of total fatty acid in goat meat (Cont.)

Item	Treatment*					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Saturated Fatty Acid (SFA)	---------- % of total fatty acid ----------									
Lignoceric Acid (C24 : 0)	0.244	0.263	0.215	0.158	0.360	0.025	ns	ns	ns	ns
Total SFA	53.568	56.942	52.967	53.197	54.588	2.143	ns	ns	ns	ns
Monounsaturated Fatty Acid (MUFA)	---------- % of total fatty acid ----------									
Myristoleic Acid (C14 : 1)	0.107	0.065	0.081	0.078	0.096	0.011	ns	ns	ns	ns
Pantadecenoic Acid (C15 : 1)	0.371	0.232	0.329	0.365	0.316	0.038	ns	ns	ns	ns
Palmitoleic Acid (C16 : 1)	2.510	2.134	2.222	2.289	1.927	0.153	ns	ns	ns	ns
Heptadecenoic Acid (C17 : 1)	0.373	0.300	0.337	0.328	0.419	0.04	ns	ns	ns	ns
Elaidic Acid (C18 : 1n9t)	0.236	0.308	0.350	0.258	0.327	0.03	ns	ns	ns	ns
Oleic Acid (C18 : 1n9c)	27.591	26.108	28.507	27.143	26.978	0.376	ns	ns	ns	ns
Eicoenioic Acid (C20 : 1)	0.163	0.170	0.164	0.210	0.239	0.013	ns	ns	ns	ns
Erucic Acid (C22 : 1n9)	0.256	0.249	0.220	0.162	0.219	0.02	ns	ns	ns	ns
Nervonic Acid (C24 : 1)	0.179	0.190	0.193	0.177	0.236	0.018	ns	ns	ns	ns
Total MUFA	31.784	29.704	32.515	30.893	30.756	0.423	ns	ns	ns	ns

Table 5.5 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on fatty acid profile as percentage of total fatty acid in goat meat (Cont.)

Item	Treatment*					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Polyunsaturated Fatty Acid (PUFA)	---------- % of total fatty acid ----------									
Linolelaidic Acid (C18 : 2n6t)	0.219	0.225	0.254	0.141	0.218	0.019	ns	ns	ns	ns
Linoleic Acid (C18 : 2n6c)	5.372	5.645	4.333	6.348	4.427	0.403	ns	ns	ns	ns
Gamma-Linolenic Acid (C18 : 3n6)	0.082	0.078	0.064	0.099	0.075	0.015	ns	ns	ns	ns
Alpha-Linolenic Acid (C18 : 3n3)	0.329^{a}	0.227^{ab}	0.180^{b}	0.180^{b}	0.258^{ab}	0.031	ns	ns	*	ns
Eicosatrienoic Acid (C20 : 3n6)	0.540	0.502	0.440	0.494	0.587	0.045	ns	ns	ns	ns
Eicosedienoic Acid (C20 : 2)	0.143	0.116	0.372	0.146	0.192	0.054	ns	ns	ns	ns
Eicosatrienoic Acid (C20 : 3n3)	0.235	0.225	0.233	0.195	0.290	0.016	ns	ns	ns	ns
Arachidonic Acid (C20 : 4n6)	5.378	5.647	5.205	6.140	6.157	0.47	ns	ns	ns	ns
Eicosapentaenoic Acid (C20 : 5n3)	0.978	0.715	0.710	0.939	0.981	0.101	ns	ns	ns	ns
Docosadienoic Acid (C22 : 2)	0.135	0.080	0.122	0.116	0.132	0.021	ns	ns	ns	ns
Docosahexaenoic Acid (C22 : 6n3)	0.356	0.311	0.321	0.392	0.392	0.037	ns	ns	ns	ns
Conjugated Linoleic Acid Isomers	---------- % of total fatty acid ----------									
cis-9, trans-11 CLA (C18 : 2)	0.307	0.420	0.302	0.417	0.399	0.035	ns	ns	ns	ns
trans-10 cis-12 CLA (C18 : 2)	0.119	0.100	0.121	0.119	0.136	0.01	ns	ns	ns	ns

Table 5.5 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on fatty acid profile as percentage of total fatty acid in goat meat (Cont.)

Item	Treatment*					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Conjugated Linoleic Acid Isomers	---------- % of total fatty acid ----------									
cis-9, cis-11 CLA (C18 : 2)	0.097[ab]	0.098[ab]	0.0814[b]	0.111[a]	0.173[a]	0.011	*	**	ns	ns
trans-9, trans-11 CLA (C18 : 2)	0.205	0.183	0.184	0.168	0.207	0.013	ns	ns	ns	ns
Total PUFA	14.494	14.387	13.270	15.855	14.624	0.799	ns	ns	ns	ns
PUFA/SFA	0.277	0.264	0.249	0.308	0.278	0.018	ns	ns	ns	ns
UFA/SFA	0.878	0.801	0.853	0.899	0.850	0.028	ns	ns	ns	ns
(C18 : 0+C18 : 1)/C16 : 0	2.398	2.299	2.311	2.201	2.214	0.007	ns	ns	ns	ns
DFA	69.671	68.818	70.153	69.29	67.596	0.591	ns	ns	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly; *T1 = Control; T2 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 250 µg/d; T3 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 500 µg/d; T4 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 750 µg/d; T5 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 1000 µg/d; L = linear; Q = quadratic; C = cubic; O_4 = quartic; DFA = desirable fatty acids = MUFA+PUFA+C18 : 0.

5.5.4 Carcass characteristics and carcass composition

The effects of supplemented different level of phytoestrogen from *Pueraria mirifi*ca at 0, 250, 500, 750 and 1000 µg/d on carcass characteristics and carcass composition are report in Table 5.6. The increasing level of phytoestrogen were not significant difference (P>0.05) on carcass characteristics. Moreover, the orthogonal polynomial contrast among treatment showed that the level of phytoestrogen also were not effect on carcass characteristics (P>0.05). The carcass characteristics are show in Figure 5.1.

The generally mean dressing percentage for various goat breeds worldwide varied between 38 to 44% (Devendra and Owen, 1983; Kadim et al., 2004). Hot dressing percentage in this study varies from 34.51 to 39.06% while many researchers reported that dressing percentage varies from 39 to 55% (Kebede et al., 2008; Pinkerton et al., 1994; Simela et al., 2000; Acharya, 1998; Daskiran et al., 2006).

However, dressing percentage might be affected by empty body weight or the amount of rumen, intestine guts, and organs to be included in dressed carcass or removal of some visceral organs in hot carcass measurement might be resulted in different dressing percentages (Bhattacharyya and Khan, 1988; Kebede et al., 2008). Therefore, the lower dressing percentage in this study might be not included kidney and pelvic fat in this determination, unlike with Daskiran et al., (2006) who included kidneys, pelvic fat and testicles in hot carcass measurements which in turn affected dressing percentages. The mean of carcass composition base on percent live weight of each increased level of phytoestrogen had not difference (P>0.05). The term of the orthogonal polynomial contrast analysis among treatment showed that the increasing level of phytoestrogen also were not effect on carcass compositions (P>0.05).

Table 5.6 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on carcass characteristics and carcass composition in meat goats

Item	Treatment					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Live weight	22.06	18.34	21.05	21.84	19.47	0.907	ns	ns	ns	ns
Carcass weight, kg	7.39	7.80	7.32	7.58	6.84	0.229	ns	ns	ns	ns
Cool weight, kg	6.72	6.74	6.53	6.67	5.99	0.176	ns	ns	ns	ns
Backfat, mm	2.51	2.24	2.02	2.34	1.66	0.315	ns	ns	ns	ns
LEA, cm^2	6.62	6.93	7.43	6.38	6.66	0.554	ns	ns	ns	ns
HDP (%)	35.62	39.06	35.33	35.79	34.51	0.925	ns	ns	ns	ns
CDP (%)	32.08	33.90	31.52	31.39	30.54	0.757	ns	ns	ns	ns
----------% Live weight----------										
Hind leg	9.26	10.37	9.45	8.88	8.905	0.374	ns	ns	ns	ns
Font leg	6.76	7.84	6.67	6.81	6.68	0.22	ns	ns	ns	ns
Loin	1.71	1.77	1.76	1.62	1.63	0.127	ns	ns	ns	ns
Rip	13.02	12.48	12.49	12.58	11.81	0.262	ns	ns	ns	ns
Head	6.98	8.47	7.76	8.09	7.48	0.215	ns	ns	ns	ns
Skin	6.70	6.48	6.63	7.77	5.98	0.412	ns	ns	ns	ns

Table 5.6 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on carcass characteristics and carcass composition in meat goats (Cont.)

Item	Treatment					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
	----------% Live weight----------									
Leg	2.07	2.42	2.24	2.17	2.33	0.067	ns	ns	ns	ns
Kidney	0.26	0.29	0.26	0.26	0.25	0.017	ns	ns	ns	ns
Spleen	0.10	0.12	0.20	0.13	0.13	0.010	ns	ns	ns	ns
Liver	1.27	1.805	1.49	1.44	1.46	0.076	ns	ns	ns	ns
Lung	0.90	0.96	1.01	0.88	1.06	0.041	ns	ns	ns	ns
Heart	0.37	0.48	0.34	0.39	0.43	0.014	ns	ns	ns	ns
Fat	0.60	0.79	0.87	0.96	0.75	0.102	ns	ns	ns	ns

*T1 = Control; T2 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 250 µg/d; T3 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 500 µg/d; T4 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 750 µg/d; T5 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 1000 µg/d; L = linear; Q = quadratic; C = cubic; O_4 = quartic.

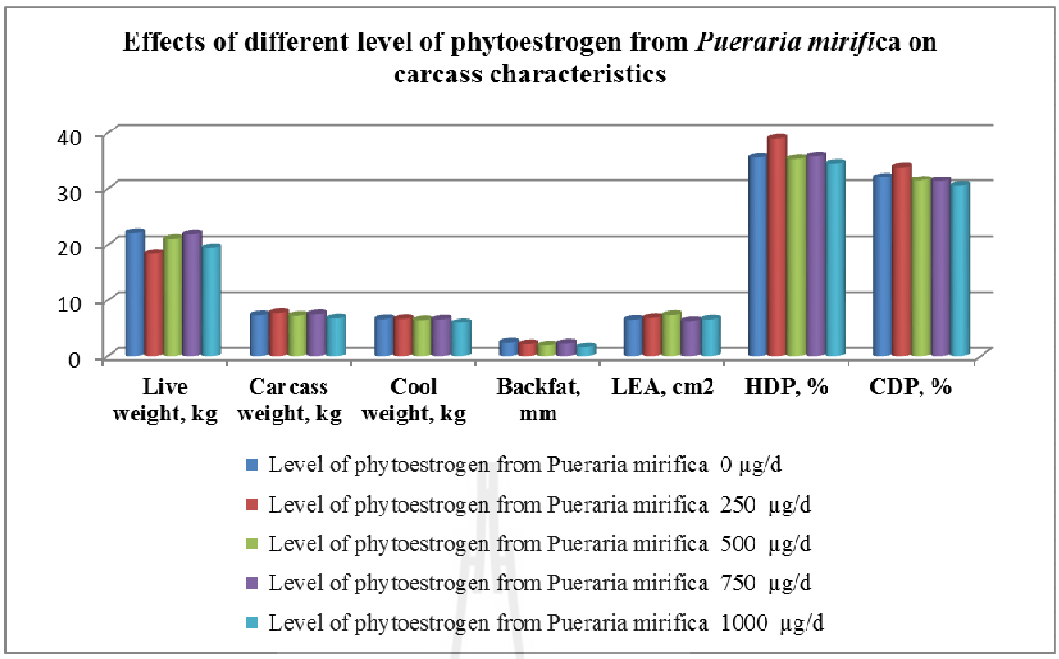

Figure 5.1 The carcass characterisics of meat goats with different level of phytoestrogen from *Pueraria mirifi*ca

5.5.5 Meat quality

The investigation of meat quality proportion of supplementation different level of phytoestrogen at 0, 250, 500, 750 and 1000 µg/d are show in Table 5.7. There was higher a* value at font of leg in 1000 µg/d of phytoestrogen (15.965) than control group (13.585) ($P<0.05$), the orthogonal polynomial contrast analysis was showed highly significant difference increased phytoestrogen with linear. On the contrary, the increasing level of phytoestrogen at 250, 500 and 750 µg/d (14.975, 14.855 and 15.610, respectively) were similar a* value with 1000 µg/d. On the other hand, increasing level of phytoestrogen at 0, 250, 500, 750 and 1000 µg/d were not significantly difference on L* value and b* value of meat at loin, front of leg and hind of leg ($P>0.05$) while the result of orthogonal polynomial contrast test were not show any effect on meat color component.

The %drip loss of loin, front of leg and hind of leg were not significantly difference with increasing level of phytoestrogen ($P>0.05$). The pH value are presented on Table 5.7 shown that ultimate pH is determined 24 hours post slaughter and initial pH (pH_0) is determined 45 minutes post slaughter were not significantly different among groups with increasing level of phytoestrogen ($P>0.05$). Good quality meat usually has a pH_{24} of 5.4 to 5.7 which pH_{24} value of meat with above 6 is generally considered unsuitable of storage because of the favorable development of proteolytic micro-organism.

Table 5.7 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on meat quality in goat meat

Item	Treatment					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Color of Loin										
L*	55.715	47.220	55.955	52.885	53.215	1.575	ns	ns	ns	ns
a*	12.255	15.015	13.395	12.720	12.735	0.783	ns	ns	ns	ns
b*	3.265	2.480	3.580	5.570	5.690	0.575	ns	ns	ns	ns
Color of front leg										
L*	54.275	51.945	52.380	49.800	51.215	0.787	ns	ns	ns	ns
a*	13.585[b]	14.975[a]	14.855[a]	15.610[a]	15.965[a]	0.133	**	ns	ns	ns
b*	6.075	8.755	8.365	8.110	11.220	0.592	ns	ns	ns	ns
Color of hind leg										
L*	51.125	51.670	51.050	49.130	50.495	0.887	ns	ns	ns	ns
a*	12.895	14.030	12.185	12.780	13.360	0.310	ns	ns	ns	ns
b*	9.140	8.935	7.235	9.005	10.610	0.604	ns	ns	ns	ns
%Drip loss										
Loin	3.161	3.345	3.210	4.026	3.623	0.182	ns	ns	ns	ns
Front of leg	3.079	2.696	2.497	2.606	2.677	0.166	ns	ns	ns	ns
Hind of leg	2.997	2.430	3.155	2.779	2.960	0.239	ns	ns	ns	ns

Table 5.7 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on meat quality in goat meat (Cont.)

Item	Treatment					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
pH_0	7.200	7.325	7.055	6.915	7.230	0.054	ns	ns	ns	ns
pH_{24}	6.090	5.995	6.015	6.195	6.030	0.032	ns	ns	ns	ns

[a, b] Means with different superscript letters in the same row differ significantly; *T1 = Control; T2 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 250 µg/d; T3 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 500 µg/d; T4 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 750 µg/d; T5 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 1000 µg/d; L = linear; Q = quadratic; C = cubic; O_4 = quartic; L*, a*, b*: chroma-meter value L* = Lightness, a* = Redness, b* = Yellowness

5.5.6 The chemical composition of raw goat meat

The results show the different level of phytoestrogen from *Pueraria mirifi*ca did not affect %moisture, %crude protein, %ash and %ether extract of raw goat meat (P>0.05). The overall mean of %moisture, CP and ether extract were 76.09%, 19.93% and 0.45%, respectively.

The ether extract values obtained in this experiment were rather low (ranged from 0.40 to 0.50) and close to those obtained in previous experiment (Chapter III and Chapter IV) The low lipid deposition on goat carcass in the several experiments in this study could be because of the younger animals used for this study as it has been reported that lipid deposition only occurred in goat upon reaches maturity or when body weight approaching 40 kg (Madruga et al., 2000). In addition, crossbred of Thai native goat which is known for its low meat fat content were used for this study.

Table 5.8 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on chemical composition in raw goat meat

Item	Treatment*					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Moisture (%)	76.13	75.03	76.47	75.17	77.67	0.47	ns	ns	ns	ns
Ash (%)	1.33	1.08	1.24	1.17	1.05	0.75	ns	ns	ns	ns
Ether extract (%)	0.42	0.42	0.48	0.51	0.40	0.80	ns	ns	ns	ns
Crude protein (%)	19.88	20.52	20.26	20.45	18.52	0.58	ns	ns	ns	ns

*T1 = Control; T2 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 250 µg/d; T3 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 500 µg/d; T4 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 750 µg/d; T5 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 1000 µg/d; L = linear; Q = quadratic; C = cubic; O_4 = quartic

5.5.7 Feed intake and growth performance

The effects of different levels of phytoestrogen from *Pueraria mirifi*ca on feed intake and growth performance of meat goats are presented in Table 5.9. Increasing level of phytoestrogen supplementation did not significantly affecting (P>0.05) overall intake of 61.01, 53.91, 56.59, 57.06 and 54.85 g/kgBW$^{0.75}$, respectively for 0, 250, 500, 750 and 1000 µg/d. The feed intake of concentration, roughage and overall are shown in Figure 5.2.

The results show not significant difference in final weight and ADG among groups (P>0.05). The increasing level of phytoestrogen were not effects on the overall FCR (range from 30.56 to 41.59) (P>0.05) (Figure 5.3). Although the using of phytoestrogen in this study did not negative affect growth of the goat meat, but the data shown ADG of all treatment quite low that result might in this study use roughage source is un-treat rice straw that low quality feedstuff might effect to ADG of goat. Upreti and Orden (2008).who mention that utilization of urea treated rice straw could improve roughage quality and increased ADG of goat.

The cost per gain during the study had not effect form increasing level of estradiol from *Pueraria mirifi*ca (P>0.05) while the data showed the level of phytoestrogen from *Pueraria mirifi*ca at 1,000 µg/d in diet has higher cost per gain (127.51 bath/kg of meat) than other groups.

Table 5.9 Effects of different level of phytoestrogen from *Pueraria mirifi*ca on feed intake and growth performances in meat goats

Item	Treatment					SEM	P-value			
	T1	T2	T3	T4	T5		L	Q	C	O_4
Initial weight, kg	21.38	18.88	18.50	20.00	18.75	1.237	ns	ns	ns	ns
Final weight, kg	23.50	20.75	20.75	22.125	20.38	1.208	ns	ns	ns	ns
ADG, g/d	18.98	16.74	20.09	18.97	14.51	1.094	ns	ns	ns	ns
Overall										
Intake, g/d	663.87	519.38	562.35	588.01	530.58	45.044	ns	ns	ns	ns
%BW	2.78	2.57	2.65	2.63	2.58	0.094	ns	ns	ns	ns
g/kg $BW^{0.75}$	61.01	53.91	56.59	57.06	54.85	2.387	ns	ns	ns	ns
FCR										
Concentrate	10.99	13.15	10.36	11.15	14.83	1.209	ns	ns	ns	ns
Roughage	23.35	20.67	20.20	20.62	26.76	2.146	ns	ns	ns	ns
Overall	34.34	33.82	30.56	31.77	41.59	3.215	ns	ns	ns	ns
Cost/gain, bath/kgBW	94.45	113.09	89.10	95.85	127.51	10.396	ns	ns	ns	ns

*T1 = Control; T2 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 250 µg/d; T3 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 500 µg/d; T4 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 750 µg/d; T5 = Supplemented with phytoestrogen from *Pueraria mirifi*ca at level 1000 µg/d; L = linear; Q = quadratic; C = cubic; O_4 = quartic

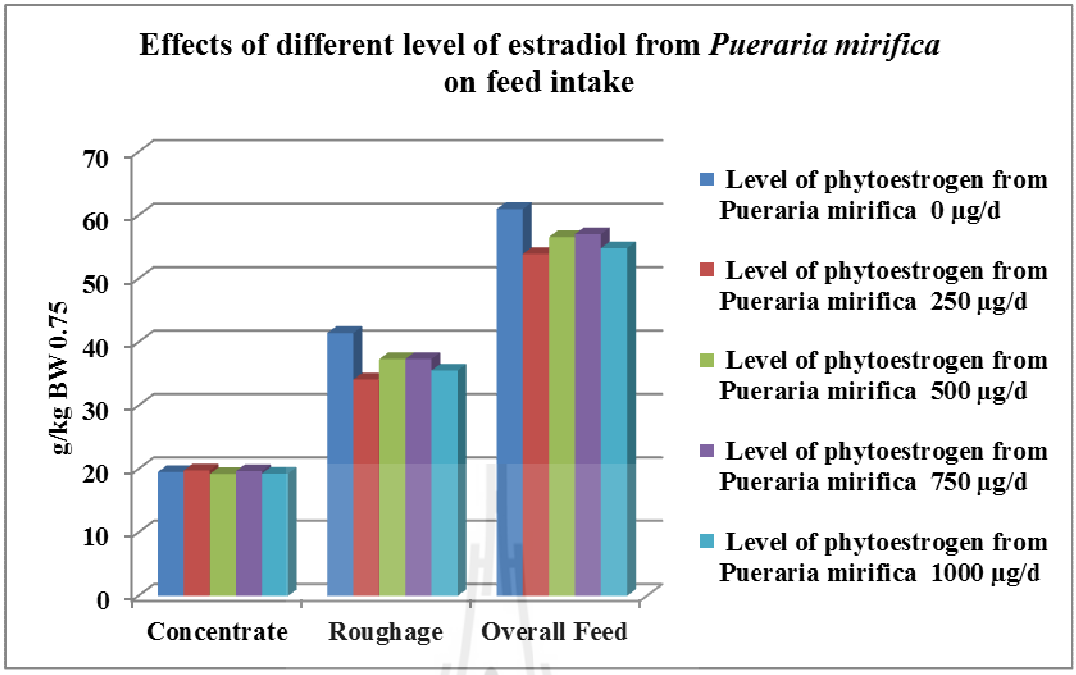

Figure 5.2 The feed intake of meat goats with different level of phytoestrogen from *Pueraria mirifica*

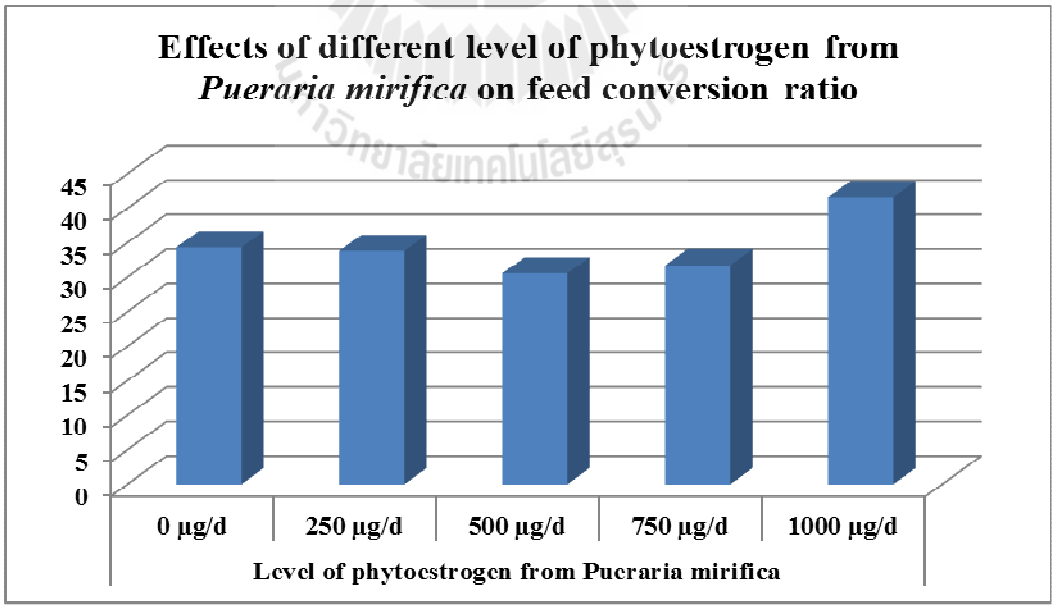

Figure 5.3 The feed conversion ratio of meat goats with different level of phytoestrogen from *Pueraria mirifica*

5.6 Conclusions

The concentration of estradiol and testosterone hormone in serum of meat goat of supplementation phytoestrogen at 0, 250, 500, 750 and 1000 µg/d were not significantly difference among groups (P>0.05). Moreover the total cholesterol in serum were significantly difference (P<0.05), the supplemented phytoestrogen at 500 µg/d was higher total cholesterol than other group but not difference with the supplemented phytoestrogen 0, 250 and 750 µg/d. Whereas, the supplemented phytoestrogen at 1000 µg/d was lower total cholesterol than other group but not difference with the supplemented phytoestrogen at 750 µg/d. In addition to the orthogonal polynomial contrast analysis was showed significant difference increased phytoestrogen with quadratic.

The main of odorant fatty acid was higher 4-methyl-octanoic acid than other groups, but not difference with supplemented phytoestrogen at 250 and 500 µg/d group, while phytoestrogen at 1,000 µg/d was lowest 4-methyl-octanoic acid than other group, but not difference with supplemented phytoestrogen at 500 and 750 µg/d group. The phytoestrogen at 1,000 µg/d was lowest 4-ethyl-octanoic acid than other groups but not difference with supplemented phytoestrogen at 750 µg/d. In the term of 4-methyl-nonanoic acid, the control group was highest 4-methyl-nonanoic acid than other group, while the supplemented phytoestrogen at 1,000 µg/d was lowest 4-methyl-nonanoic acid than other groups. The orthogonal polynomial contrast analyses of all odorant fatty acid in this study were significant difference with linear decrease with increase phytoestrogen.

However, using phytoestrogen has effect decrease odorant fatty acid in goat meat while uptake phytoestrogen did not affect the levels of estradiol and

testosterone in goat. Therefore, the effects of estrogenic activity in *Pueraria mirifica* had not effect on level of testosterone that show the testosterone is not factor in occurrence of odor in the goat meat.

The mean of the fatty acid compositions were not significantly difference on amount of total SFA (P>0.05), while, lauric acid (C12 : 0) and tridecanoic acid (C13 : 0) were significantly difference among groups (P<0.05). The orthogonal polynomial contrast analysis was significant difference on lauric acid (C12 : 0) with increased phytoestrogen with increased quadratic and cubic. The tridecanoic acid (C13 : 0) was significant difference with decreased quadratic. The amount monounsaturated fatty acid (MUFA), the increasing phytoestrogen were not significantly different on MUFA and PUFA (P>0.05), while supplemented phytoestrogen from *Pueraria mirifi*ca were difference on alpha-linolenic acid (C18 : 3n3) with decreased cubic, while the conjugated fatty acid isomer (cis-9, cis-11 CLA) also was difference with increased linear and quadratic as increase supplemented phytoestrogen.

In the term of the possible beneficial effects of lipids ratio are the (C18 : 0+C18 : 1)/C16 : 0 value in this study was not difference are range from 2.20 to 2.39 (P>0.05). Whereas, the desirable fatty acid (DFA) in this study shows range from 67.59 to 70.15% of total fatty acid show the DFA value of Thai native meat goat excellence close to Boer, Anglo Nubian and crossing with SPRD goat meat. The PUFA/SFA and UFA/SFA ratio and of supplemented were not significant difference among group (P>0.05) with increasing phytoestrogen.

The carcass characteristics and carcass composition were not significant different with increased level of phytoestrogen, while a* value at font of leg in 1000 µg/d of phytoestrogen was higher than control group (P<0.05). Increasing level of phytoestrogen at 250, 500 and 750 µg/d were similar a* value with 1000 µg/d. On the

other hand, increasing level of phytoestrogen at 0, 250, 500, 750 and 1000 µg/d were not significantly difference on L* value and b* value of meat at loin, front of leg and hind of leg (P>0.05). Percentage of drip loss, pH_0 and pH_{24} were not significantly difference with increasing level of phytoestrogen (P>0.05).

The increasing phytoestrogen from *Pueraria mirifi*ca were not difference effect on final weight, ADG and overall feed intake among groups (P>0.05). The cost per gain during the study had not effect form increasing level of phytoestrogen (P>0.05) while the data showed the level of phytoestrogen at 1,000 µg/d has higher cost per gain (127.51 bath/kg of meat) than other groups.

5.7 Implication

This experiment investigated effect different level of phytoestrogen from *Pueraria mirifica* found that the phytoestrogen at 1000 µg/d was clearly decrease main odorant in goat meat and reduced total cholesterol in serum. However, the data of cholesterol is the total cholesterol; therefore consideration of HDL and LDL ratio need to further study. Moreover, the phytoestrogen from *Pueraria mirifica* was not effect on concentration of estradiol and testosterone in serum, although in this study use high level (1000 µg/d). According to the mention that the odor in goat meat is influenced by the testosterone activity is might be not entirely correct, because the odorant fatty acid in goat meat decreased although the concentration of testosterone was not decrease with supplemented phytoestrogen in high level.

5.8 References

Acharya, R. (1988). Goat breeding and meat production. In **Proceeding of the International Workshop on Goat Meat Production in Asia,** Tando Jam (Pakistan). 12-18 Mar 1988.

AOAC. 2000. Meat and Meat products. In: Official Methods of Analysis. **Association of Official Analytical Chemists Inc.** Gaithersburg, USA.

Bhattacharyya, N. and Khan, B. (1988). Goat meat production in India. In **Proceeding of the International Workshop on Goat Meat Production in Asia, Tando Jam (Pakistan).** 12-18 Mar 1988.

Daskiran, I., Askin, K., and Mehmet, B. (2006). Slaughter and carcass characteristics of Norduz male kids raised in either intensive or pasture conditions. **Pakistan Journal of Nutrition**. 5(3) : 274-277.

Devendra, C. and Owen, J. (1983). Quantitative and qualitative aspects of meat production from goats. **World Animal Review**.

Enser, M., Hallett, K., Hewitt, B., Fursey, G., and Wood, J. (1996). Fatty acid content and composition of English beef, lamb and pork at retail. **Meat Science**. 42(4) : 443-456.

Fisher, A. and De Boer, H. (1994). The EAAP standard method of sheep carcass assessment. Carcass measurements and dissection procedures report of the EAAP working group on carcass evaluation, in cooperation with the CIHEAM instituto agronomico Mediterraneo of Zaragoza and the CEC directorate general for agriculture in Brussels. **Livestock Production Science**. 38(3) : 149-159.

Hara, A. and Radin, N. S. (1978). Lipid extraction of tissues with a low-toxicity solvent. **Analytical Biochemistry**, 90(1) : 420-426.

Kadim, I., Mahgoub, O., Al-Ajmi, D., Al-Maqbaly, R., Al-Saqri, N., and Ritchie, A. (2004). An evaluation of the growth, carcass and meat quality characteristics of Omani goat breeds. **Meat science**. 66(1) : 203-210.

Kebede, T., Lemma, T., Dinka, H., Guru, M., and Sisay, A. (2008). Growth performance and carcass characteristics of Arsi-Bale goats castrated at different ages. **Journal of Cell and Animal Biology**. 2(11) : 187-194.

Madruga, M., Arruda, S., Narain, N., and Souza, J. (2000). Castration and slaughter age effects on panel assessment and aroma compounds of the “mestiço” goat meat. **Meat science**, 56(2) : 117-125.

Madruga, M.S., Stephen Elmore, J., Dodson, A.T., and Mottram, D.S. (2009). Volatile flavour profile of goat meat extracted by three widely used techniques. **Food Chemistry**. 115(3) : 1081-1087.

Manosroi, A. and Manosroi, J. (2003). Determination of Bioactive Compounds in Roots of Different Ages Pueraria mirifica, Airy Shaw Suvatabhandhu and Butea superba, Roxb. from Various Locations in Thailand. In **Proceeding of the III WOCMAP Congress on Medicinal and Aromatic Plants**. Volume 6: Traditional Medicine and Nutraceuticals 680.

Metcalfe, L. and Schmitz, A. (1961). The rapid preparation of fatty acid esters for gas chromatographic analysis. **Analytical Chemistry**. 33(3) : 363-364.

Morrison, W. R., and Smith, L. M. (1964). Preparation of fatty acid methyl esters and dimethylacetals from lipids with boron fluoride–methanol. **Journal of Lipid Research**. 5(4) : 600-608.

Pinkerton, F. (1994). A survey of prevalent production and marketing practices in meat goats of southern origin. **SRDC publication**.

Rhee, K., Waldron, D., Ziprin, Y., and Rhee, K. (2000). Fatty acid composition of goat diets vs intramuscular fat. **Meat science**. 54(4) : 313-318.

Sen, A., Santra, A., and Karim, S. (2004). Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. **Meat science**, 66(4): 757-763.

Simela, L., Webb, E.C., and Bosman, M. (2008). Acceptability of chevon from kids, yearling goats and mature does of indigenous South African goats : **A case study.**

Steel, R. and Torrie, J. (1980). Prnciples and Procedures of Statistics : **A Biometrical Approach : McGraw-Hill. New York.**

Ülker, H., Gökdal, Ö., Temur, C., Budağ, C., Oto, M., deavila, D., and Reeves, J. (2002). The effect of immunization against LHRH on body growth and carcass characteristics in Karakaş ram lambs. **Small Ruminant Research**. 45(3) : 273-278.

Upreti, C. R., and Orden, E. A. (2008). Effect of Rice Bran and Leucaena Supplementation on the Growth Performance of Goats Fed with Urea Treated Rice Straw. **Nepal Journal of Science and Technology**, 9, 29-36.

USDA. (2005). Dietary guidelines for Americans. Available from **http://www.health.gov/dietaryguidelines/dga2005/document/**, accessed at 16 June 2005.

Williams, C.M. (2000). Dietary fatty acids and human health. In **Proceeding of the Annales de Zootechnie.**

Wood, J., Richardson, R., Nute, G., Fisher, A., Campo, M., Kasapidou, E., Enser, M. (2004). Effects of fatty acids on meat quality: **Meat science**, 66(1) : 21-32.

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