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Discussion

Experiment I: Study on the effects of concentrate supplementation levels on growth performance of local goats in Laos

5.1 The chemical composition of the feed

The present study was found that, DM of PML was lower than that reported by Inthapanya and Preston (2009) and Silivong *et al.* (2012) (28.4 % and 29.1 % DM), but higher than the result reported by Cheva-Isarakul *et al.* (2007) 21.3 % MD. For CP value was higher than that reported by Inthapanya and Preston (2009) with 16 % CP and however the result was lower than previous results of Silivong *et al.* (2012) 26.7 % CP and 24.1 % CP of Cheva-Isarakul *et al.* (2007). CF in the present study was higher than the resulted of Cheva-Isarakul *et al.* (2007) (14.5 vs 11.7 %). The result found difference to chemical composition in feed, because it was depend upon harvesting time, place and age of plant (Phengvichith and Ledin, 2007; Sanchez, 2001).

5.2 Growth performance and feed nutrient intake

The goats supplemented with concentrate at different levels with PML were significantly greater body weight change and ADG than the control group. The highest values were observed in goats fed 400 g/head/day of concentrate level (65.2 g/head/day). The highest result of ADG in this study was consistent to the result of ADG (61.3 g/head/day) in Hararghe Highland goats (Getinet and Yoseph, 2014), who was recorded in the group supplemented of concentrate 300 g dry mater plus natural grass hay as basal diet. Berhanu *et al.* (2013) reported that the concentrate supplemented of 0, 200 and 400 g/ head/day to Woyto-Guji goats showed significantly increased of ADG (2.7, 33.5 and 54.7 g/head/day), respectively. Comparing with the present results fed PML with concentrate levels (0, 200, 300 and 400 g/head/day) increased of ADG, respectively. The significant increased in ADG values of goats in the groups

concentrate supplementation levels, which could be associated with the greater DM intake and nutrient intake as a result of higher energy and protein levels in the concentrate than in the basal feed (Berhanu *et al.,* 2013). The high ADG obtained in goats supplemented with the concentrate might be due to the fact that concentrate supplemented goats obtained optimum nutrient combinations such as protein and energy (Getinet and Yoseph, 2014). The present study, percentage of dry matter intake (DMI) per body weight ranged from 3.5 to 4.6 %. The result was consistent with Sahelain male goats 3.9 to 5.1 % BW, which observed by Sanon *et al.* (2007) and in agreement with the estimated DM intake of 4 to 5 % BW (NRC, 1981). The goats in the treatment groups supplemented difference levels of concentrate with PML as basal diet had significant effected on total DMI, when compared with the control group fed only PML. The increased intake can be explained by the increasing levels of concentrate supplementation, lead to increasing nutrient intake as CP and readily available carbohydrates to the ruminal microbes, might improving the rate of degradation of the basal diet, microbial growth in the rumen, which effected to early ruminal digested and lead to increment intake of the basal diet (Getinet and Yoseph, 2014). Lower DMI in control group, might be most likely due to goats had consumed low CP and high NDF in the diet the lower intake of CP supplemented in goats diet might reduce rumen NH_3-N supply leading to lower rate of rumen fermentation (Getinet and Yoseph, 2014), the rumen of animal could be made a longer fermented and lead to animal slowly digested, probably effects to lower feed intake.

5.3 *In vivo* apparent nutrient digestibility

The results revealed that the *In vivo* apparent nutrient digestibility of DMD, OMD, CPD, EED and NFED in goats fed concentrate diet 200, 300, and 400 g/head/day were significantly higher than control group. The current finding was consistent with Ferdous *et al.* (2011) who reported that the significantly higher in DMD, OMD, CPD, CFD, EED, and NFED may due to gradual increased levels of concentrate than the control group diet. When the level of concentrate increased could be attributed to good digestibility (Kraiem *et al.,* 1997). Low total intake in the control group might be most likely due to the low level of CP digestibility (Getinet and Yoseph, 2014).

Experiment II: Study on effect of concentrate supplementation levels on response to estrous synchronization of local female goats in Laos

Until now, very few research has focused on explaining the effects of supplementation of paper mulberry (*Broussonetia papyrifera*) leaf-based diets with concentrate on growth performance, estrous and ovulatory responses, and productivity of synchronized local female goats in Laos. The present study provides the first description of the positive effects of addition of paper mulberry leaves (PML) with concentrate (CONc) on growth performance and subsequent response to estrous synchronization treatment in local female goats in Laos. The present research showed that female goats in the PML + CONc group (well-fed group) had significantly greater positive changes in live weight than those in the PML group. The high level of ME intake described in this dietary treatment increased the positive changes in the body weight relative to the PML + CONc diet. Similarly, in Batina and Dhofari goats which received high ME diet compared to low ME diet, an increase in the daily weight was achieved to enhance the live weight (Mahgoub *et al.*, 2005). The greater final live weight of the concentrate-supplemented goats may probably be due to the greater ME intake of the goats in the PML + CONc group. Moreover, it has been found that feeding female Mashona goats 0.27 MJ ME kg^{-1} $W^{0.75}$ decreased the expression of estrus and reproductive performances compared to feeding them with 0.53 MJ ME kg^{-1} $BW^{0.75}$ and 1.06 MJ ME kg^{-1} $BW^{0.75}$ (Kusina *et al.*, 2000).

Among the extrinsic factors inducing reproduction in female goats, the level of nutrient values is one of the most important factors. In small ruminants, the mechanisms controlling reproduction should comprise both the present nutritional status, particularly energy availability (Wathes *et al.*, 2007; Zetina-Córdoba *et al.*, 2012) and the level of body reserves, as stability for the whole reproductive process (Walkden-Brown and Bocquier, 2000). On the basis of these mechanisms, the effects of nutrition on the reproductive process are separated as follows: dynamic (nutritional balance in terms of energy and protein) and static (live weight, and body condition or body lipid stores) effects (Smith and Stewart, 1990; Walkden-Brown and Bocquier, 2000). During the reproductive cycle, energy status is a major factor playing an important role in the reproductive process of adult female goats. For instance, in multiparous goats, resumptions of estrous and ovarian activities are not correlated to the live weight of the

dam at parturition but to the live weight changes (energy balance) (Walkden-Brown and Bocquier, 2000). Taken together, the present study demonstrated that although the percentage of female goats displaying estrous behavior did not differ between the PML and the PML + CONc diets during the pre-synchronization period (covering two estrous cycles), the percentage of female goats exhibiting estrous behavior at 48 h after the end of the hormonal treatment was significantly greater in the group that was offered the PML + CONc diet than in the group that was offered only the PML diet. Moreover, it was observed that goats receiving the PML + CONc diet had a tendency to be in estrus much earlier after the end of the synchronization protocol in comparison with goats receiving only the PML diet. These results strongly imply that at 48 h after hormonal synchronization with synthetic P_4 and hCG, fewer underfed goats go into estrus, as well as the interval to the onset of estrus tends to be longer, compared to well-fed goats. On the one hand, the interval to the onset of estrus after the end of estrous synchronization tended to be longer in the feed-restricted goats (Mani *et al.,* 1996). Thus, the supplemented goats had increased expression of estrus at 48 h after CIDR removal, by which these data support the hypothesis of feed flushing during the synchronization period playing a crucial role in estrous response to hormonal treatment. Although the concentration of blood E_2 after CIDR withdrawal was not determined in this study, a possible reason for the early time in the estrus of the supplemented goats (PML + CONc group; high ME diet) after the end of the hormonal treatment could be the higher level of blood E_2. These findings are supported by a previous study (Kia *et al.,* 2012), which indicated that E_2 concentration at 48 h after CIDR removal was higher in high energy supplemented (barley grain diet) goats compared with control-treated (basal diet) goats. On the basis of previous observations, extraovarian factors such as dietary mediation in metabolic hormones (e.g., insulin, IGF-I, and GH) also directly affect ovarian folliculogenesis (follicular growth and development) and subsequent oocyte quality (Walkden-Brown and Bocquier, 2000; Webb *et al.,* 2004; Somchit, 2011). On the cellular level, the enhanced production of E_2 which is synthesized by follicular cells is basically related to the development of waves of follicular growth and development in female goats (Pang *et al.,* 2010). During the period of ovarian folliculogenesis, growth is completed by follicular cell (theca and granulosa) proliferation (Moonmanee *et al.,* 2012) and an increase in the number of layers of follicular cells, as indicated by the increase in the diameter of the ovarian follicle (Harris *et al.,* 2014). Moreover, it has

been previously suggested that the level of E_2 increases with the diameter of the ovarian follicles in the follicular phase of female goats (Singh *et al.,* 1999). The present study highlighted that the diameter of the largest preovulatory follicle is significantly greater in synchronized goats receiving high-nutrition diets (the PML + CONc diet) than in induced goats receiving low-nutrition diets (the only PML diet). The sufficient nutrition, particularly energy, of the well-fed goats observed in this study may be the reason for the increased growth rate and the subsequent increase in the diameter of the preovulatory follicle. These findings are supported by a previous study, which reported that nutritional stimulus provided by high-energy diets stimulates the growth of dominant follicles in addition to enhancing the concentrations of glucose and insulin of female goats (Zabuli *et al.,* 2010). In fact, glucose consumed by ovarian follicular cells (theca and granulosa) can be used for major energy production of ovarian folliculogenesis to maintain follicular growth and prevent follicular atresia during the development of a growing follicle (Scaramuzzi *et al.,* 2006; Zabuli *et al.,* 2010; Ying *et al.,* 2011) in which glucose is largely produced in the liver via gluconeogenesis from propionate which is absorbed from the rumen (Roh *et al.,* 2016).

Taking into consideration the response to the estrous synchronization treatment, the diameter of the preovulatory follicle, and the time of ovulation, It was also found that there are two phenomena of well-fed local female goats in Laos: one is that the estrous response and the time of ovulation occurred earlier, and the other is that the largest preovulatory follicle exhibited a greater size after the end of the synchronization protocol. This is consistent with the results obtained in the synchronized sheep model carried out by Moonmanee and Yammuen-art (2015), who found that follicular diameter was negatively related with time to onset of estrus but positively related with blood glucose levels in ewes exhibiting estrus. Additionally, in the cattle model, it was observed that follicular size has a positive relationship with peak concentrations of E_2, but only among synchronized cows displaying estrus (Perry *et al.,* 2014). The results of this study support the hypothesis that supplementing paper mulberry leaf-based diets with 400 g/head/day of concentrate can increase the response to estrous synchronization treatment in terms of the proportion of synchronized goats exhibiting estrus at 48 h after CIDR withdrawal (a short interval) and enhanced preovulatory follicle size. On the other hand, restricted feeding is related with a

decrease in the proportion of female goats displaying the preovulatory surge of gonadotrophins, decreased magnitude of the surge, and subsequent low incidence of ovulation of the preovulatory follicle (Mani *et al.,* 1996). Moreover, nutritional supplementation (high-energy diet) improved number of ovulatory follicles and ovulation rate in cycling goats (Zabuli *et al.,* 2010). In this study, the kids born was observed after finished the dietary treatment for a period 61 days. Then, the animals were allowed to the natural grasses for observation and data collection of the female goats pregnant and female goats kids born. Mean number of kids born was influenced by ovulation rate in dam under better nutritional management (Taye *et al.*, 2013). This is possibly correlated to the availability and sufficient supply of nutrient from well-fed management, which may have influenced ovulation rate and the subsequent productivity in female goats. The increase in pregnancy and kidding rates could be due to improvement in the body weight and body condition of the dam before pregnancy period (Berhanu *et al.*, 2013), which corresponded to the present research.