การศึกษาผลผลิตและคุณค่าทางโภชนะของถั่วไมยราและการใช้ต้นถั่วไมยราป่นเป็นแหล่งเสริมโปรตีนในอาหารไก่ไข่

นาย ครวญ บัวคีรี

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THE STUDY ON YIELD AND NUTRITIVE VALUE OF HEDGE LUCERNE (*Desmanthus virgatus*) AND UTILIZATION OF HEDGE LUCERNE MEAL AS PROTEIN SUPPLEMENT IN LAYER DIETS

Mr. Kruan Buakeeree

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Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for a Doctoral Degree

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ครวญ บัวคีรี: การศึกษาผลผลิตและคุณค่าทางโภชนะของถั่วไมยราและการใช้ต้นถั่วไมยราป่นเป็นแหล่งเสริมโปรตีนในอาหารไก่ไข่ (THE STUDY ON YIELD AND NUTRITIVE VALUE OF HEDGE LUCERNE (*Desmanthus virgatus*) AND UTILIZATION OF HEDGE LUCERNE MEAL AS PROTEIN SUPPLEMENT IN LAYER DIETS): อาจารย์ที่ปรึกษา รองศาสตราจารย์ ดร. วิศิษฐิพร สุขสมบัติ 98 หน้า ISBN 974-533-231-3

การศึกษาผลผลิตและคุณค่าทางโภชนะของถั่วไมยราและการใช้ต้นถั่วไมยราป่นเป็นแหล่งเสริมโปรตีนในอาหารไก่ไข่ ดำเนินการโดยแบ่งออกเป็น 3 การทดลองคือ การทดลองที่ 1 เป็นการศึกษาผลของอายุการตัดและระดับความสูงที่ตัดสูงจากพื้นดินที่มีต่อผลผลิตและองค์ประกอบทางเคมีของถั่วไมยรา โดยจัดสิ่งทดลองแบบ 3 x 3 Factorial in Randomized complete Block มี 4 ซ้ำ 2 ปัจจัย ปัจจัยแรกประกอบด้วยช่วงอายุการตัด 3 ระยะคือ 30 40 และ 50 วัน ปัจจัยที่ 2 ประกอบด้วยระดับความสูงที่ตัดจากพื้นดิน 3 ระดับ 30 40 และ 50 เซนติเมตร เพื่อหาอายุการตัดและระดับความสูงที่ตัดที่เหมาะสมต่อผลผลิตและคุณค่าทางโภชนะของถั่วไมยราที่จะนำไปเป็นอาหารไก่ไข่ ปรากฏว่าอายุการตัดที่เพิ่มขึ้นมีผลให้เปอร์เซ็นต์วัตถุแห้งและเยื่อใยเพิ่มขึ้นอย่างมีนัยสำคัญยิ่ง ($P < 0.01$) ขณะที่มีผลทำให้เปอร์เซ็นต์โปรตีน เถ้าและ NFE ลดลงอย่างมีนัยสำคัญยิ่ง ($P < 0.01$) และไขมันลดลงอย่างมีนัยสำคัญ ($P < 0.05$) ในทางตรงกันข้ามการเพิ่มความสูงที่ตัดมีผลทำให้วัตถุแห้งและเยื่อใยลดลง ซึ่งส่งผลให้เปอร์เซ็นต์โปรตีนและเถ้าเพิ่มขึ้น โดยปรากฏว่ามีปฏิกริยาสัมพันธ์ระหว่างช่วงอายุการตัดและความสูงที่ตัดต่อเปอร์เซ็นต์โปรตีนของถั่วไมยราอย่างมีนัยสำคัญ ($P < 0.05$) เมื่อช่วงอายุการตัดเพิ่มขึ้นโปรตีนของใบและต้นจะลดลงอย่างมีนัยสำคัญยิ่ง ($P < 0.01$) โดยที่ไม่พบปฏิกริยาสัมพันธ์ระหว่างช่วงอายุการตัดและความสูงที่ตัดต่อองค์ประกอบทางเคมีในใบและลำต้นของถั่วไมยรา จากผลการทดลองนี้ชี้ให้เห็นว่า การตัดถั่วไมยราทุก 50 วัน ที่ระดับความสูง 40 เซนติเมตร จะได้ผลผลิตของวัตถุแห้งสูงสุด 559 กิโลกรัมต่อไร่ แต่การตัดที่อายุ 30 วัน ความสูง 30 – 50 เซนติเมตรจากพื้นดิน จะได้ถั่วไมยราที่มีเปอร์เซ็นต์โปรตีนสูงและเยื่อใยต่ำ เท่ากับ 18.55 – 19.00 และ 17.12 – 19.91 เปอร์เซ็นต์ ตามลำดับ

สำหรับการทดลองที่ 2 เพื่อประเมินคุณค่าทางชีวภาพของถั่วไมยราป่นในอาหารสัตว์ปีก โดยใช้ถั่วไมยราป่นที่อายุ 30 วัน ความสูง 50 เซนติเมตร จากการวิเคราะห์องค์ประกอบทางเคมี พบว่ามี โปรตีน 18.95 เยื่อใย 17.50 ไขมัน 3.13 NFE 44.91 เถ้า 7.49 แคลเซียม 1.975 ฟอสฟอรัส 0.100 เปอร์เซ็นต์ตามลำดับ พลังงานรวม 3967 กิโลแคลอรีต่อกิโลกรัม กรดอะมิโนที่จำเป็น เช่น ไลซีน 1.152 เมทไธโอนีน 0.255 ทรีโอนีน 0.953 และ ทริปโตเฟน 0.233 เปอร์เซ็นต์ตามลำดับ นอกจากนี้พบว่าถั่วไมยราป่นมีสารไมโมซิน 1.51 เปอร์เซ็นต์ และ สารสีแซนโทฟิลล์ 309 มิลลิกรัม

ต่อกิโลกรัม การหาค่าพลังงานใช้ประโยชน์ได้ของถั่วไมยราป่นมีค่าประมาณ 1330 กิโลแคลอรีต่อกิโลกรัม โดยสัมประสิทธิ์การย่อยได้ของวัตถุแห้ง 65.04 และโปรตีน 34.61 การย่อยได้ที่แท้จริงของโปรตีน 47.71 คุณค่าทางชีวภาพของโปรตีน 63.11 และโปรตีนที่ใช้ประโยชน์ได้สุทธิ 30.07 เปอร์เซ็นต์ตามลำดับ

การทดลองที่ 3 ศึกษาการใช้ถั่วไมยราป่นในอาหารไก่ไข่ต่อสมรรถภาพการผลิตและคุณภาพไข่ โดยใช้ไก่ไข่พันธุ์ไฮเซค บราวน์ อายุ 22 สัปดาห์ จำนวน 300 ตัวใช้แผนการทดลองแบบสุ่มตลอด (Completely Randomized Design) จำนวน 5 ซ้ำๆ ละ 12 ตัวโดยแต่กลุ่มได้รับอาหารที่ประกอบด้วยถั่วไมยราป่นที่ระดับต่าง ๆ กันคือ 0 2 4 6 และ 8 เปอร์เซ็นต์ตามลำดับ ผลการทดลองปรากฏว่า การใช้ถั่วไมยราป่นเกิน 8 เปอร์เซ็นต์ทำให้ผลผลิตไข่ลดลงอย่างมีนัยสำคัญ (P <0.05) ส่งผลให้ต้นทุนการผลิตไข่ต่อโหลเพิ่มขึ้นอย่างมีนัยสำคัญ (P<0.05) โดยที่การใช้ถั่ว ไมยราป่นระดับต่าง ๆ กันไม่มีผลต่อปริมาณอาหารที่กินเฉลี่ยต่อวัน น้ำหนักตัวที่เพิ่มขึ้น น้ำหนักไข่ มวลไข่ องค์ประกอบของไข่ทั้งฟอง ตลอดจนสุขภาพทั่วไปของแม่ไก่ เมื่อพิจารณาถึงคุณภาพของไข่พบว่าการใช้ถั่วไมยราป่นในระดับ 8 เปอร์เซ็นต์ในสูตรอาหาร มีผลทำให้ไข่แดงมีสีเข้มกว่ากลุ่มอื่น ๆ อย่างมีนัยสำคัญยิ่ง (P<0.01) แต่ไม่มีผลต่อความถ่วงจำเพาะของฟองไข่ ความหนาเปลือกไข่ ความสูงไข่ขาว และค่าฮอกยูนิต จากผลการทดลองนี้ชี้ให้เห็นว่าสามารถใช้ถั่วไมยราป่นในอาหารไก่ไข่ได้ถึง 6 เปอร์เซ็นต์ โดยไม่มีผลกระทบต่อสมรรถภาพการผลิตและคุณภาพไข่

สาขาวิชาเทคโนโลยีการผลิตสัตว์	ลายมือชื่อนักศึกษา	....
ปีการศึกษา 2545	ลายมือชื่ออาจารย์ที่ปรึกษา	....
	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม	....
	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม	....
	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม	....
	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม	....

KRUAN BUAKEEREE: THE STUDY ON YIELD AND NUTRITIVE VALUE OF HEDGE LUCERNE (*Desmanthus virgatus*) AND UTILIZATION OF HEDGE LUCERNE MEAL AS PROTEIN SUPPLEMENT IN LAYER DIETS: THESIS ADVISOR: ASSOC. PROF. WISITIPORN SUKSOMBAT, Ph.D. 98 PP. ISBN 974-533-231-3

Three experiments were conducted in order to study on yield and nutritive value of hedge lucerne (*Desmanthus virgatus*) and utilization of hedge lucerne meal as protein supplement in layer diets. The first experiment was laid out in a 3x3 Factorial arrangement in randomized complete block design with 4 replications in each treatment. Factor A was cutting intervals (30, 40 and 50 days) while factor B was cutting height (30, 40 and 50 cm above ground level). The objective of this experiment was to evaluate the effect of cutting interval and cutting height together with interaction of the two factors on yield and nutrient compositions of hedge lucerne. It is found that the DM and CF contents increased (P<0.01) with increasing intervals of cutting while the CP, Ash, EE and NFE contents decreased (P<0.01 except EE p<0.05) with increasing cutting intervals. On the other hand, the DM and CF contents decreased with increasing cutting height while the CP and Ash contents increased as cutting height increased. There were interaction effects of age of cutting and cutting height on CP contents of hedge lucerne (P<0.05). However, no interaction between cutting intervals and cutting height on yields was found. The effect of cutting interval was significant on percentage of DM, CF, and Ash of leaf and stem (P <0.01). CP content of leaf and stem decreased (P<0.01) with increasing interval of cutting. There were no significant interaction effects on nutrient compositions of leaf and stem. The results of the experiment indicated that DM at 50 day intervals and at 40 cm cutting height gave the highest yields (559 kg/rai). At 30 day intervals and at 30-50 cutting height gave the highest CP (18.55-19.00%) and the lowest CF (17.12-19.91%).

The objectives of the 2nd experiment study were to determine the biological value of hedge lucerne meal (HLM) in poultry diets. The chemical compositions of HLM (DM basis) analyzed by proximate analysis were 18.95%CP, 17.50%CF, 3.13%EE, 44.91%NFE, 7.49%Ash, 1.975%Ca, 0.100%Total P and 3967 kcalGE/kg. The lysine, methionine, threonine and tryptophan contents were 1.152, 0.255, 0.953 and 0.233% respectively. HLM contained mimosine at the level of 1.51% and the mixed sample with leaves and stem contained 309 mg/kg of xanthophyll. Apparent metabolizable energy in HLM for adult chicken was 1330 kcal/kg. Digestibility coefficients of dry matter and protein in HLM feed were 65.04 and 34.61% respectively. True digestibility of protein, protein biological value and net protein utilization were 47.71, 63.11 and 30.07 % respectively.

The 3rd experiment: Three hundred 22 weeks old Hisex brown pullets were randomly divided into 5 groups of 60 hens each. Each group was fed with ration containing 0, 2, 4, 6 and 8% of the HLM. All diets were isonitrogenous and were provided to the layers for five 28-d periods. This experiment was conducted to evaluate the effect of HLM on laying performance and egg quality. The result demonstrated that feeding more than 8% of HLM decreased egg production and increased cost of production (P<0.05). No significant differences among the dietary treatments were found in feed intake, body weight gain, egg weight, egg mass, egg composition and general health of laying hens. For the quality of eggs it was found that there were no significant difference in specific gravity, shell thickness, albumen height and haugh unit among the dietary treatments. The egg yolk colour of control group was paler than the other groups while the group which received 8% of the HLM had highest yolk colour score ($P<0.01$). The results of the experiment indicated that 6% of HLM can be used in layer diets without any adverse effects on laying performance and egg quality.

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Academic Year 2002	Advisor ....
	Co-advisor ....
	Co-advisor ....
	Co-advisor ....
	Co-advisor ....

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Kruan Buakeeree

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CHAPTER I

Introduction

1.1 General background

Thailand's poultry industry has had an important role in country's economic during the last 3 decades. This industry utilizes many feed ingredients to formulate poultry feeds. Plant proteins are the main source of protein utilized in animal diets in countries where the animal protein source such as fish meal and meat meal are in short supply and expensive. In Thailand, soybean meal becomes the main plant protein used in the animal feeds although the domestic supply is inadequate and the demand has to be met by importation. Many attempts have been made to find alternative feed ingredients in order to lower the cost of poultry production and make the production more competitive to the world market.

There are many species of multipurpose forage tree legumes in use throughout the tropical and subtropical regions of the world. The leguminous shrub, *Desmanthus virgatus*, has been proposed as an alternative fodder tree, the leaves of which could be used as animal feed (Battad,1993). Hegde lucerne, donky bean or desmanthus are its common name (Skerman et al, 1988; Battad,1993; Bogdan,1977; Partidge, 1998). Desmanthus is a shrub belonging to the Mimosaceae family, originating in Central and South America, which has been introduced in many other tropical regions, including South East Asia (Allen and Allen ,1981 quoted in Gutteridge,1994). The high crude protein content of Desmanthus leaves (24-30 % in dry matter) and its high yield of 3680 kg dry matter/ rai, have made this legume a potential to use as protein source. In addition, desmanthus does not contain mimosine, therefore, it foliage could be given to monogastric animal species with no harmful effects (Gutteridge,1994).

Egg yolk colour has always been regarded as an important egg quality characteristic and recently has had an even more important role in the marketing of eggs. Traditionally, consumers have associated strong the yolk colour with good quality because eggs from free range, farmyard hens generally show a rich yolk colour derived from the carotenoid content of grass and weeds (Belyavin and Marangos, 1989). There has recently been a trend towards the production of feeds for laying hens which the manufactures claim contain no artificial additives; preservatives and synthetic pigmenters being singled out. In such feed the yolk colourants would therefore have to be of natural origin.

These are factors that suggest the possible introduction of hedge lucerne meal in diets for non- ruminant animals such as pig and poultry. However, The study of hedge lucerne meal for poultry is now unclear and very little known. Therefore, the aim of this thesis is to focus on nutritive value and utilization of hedge lucerne meal in layer diets.

1.2 Research objectives

The objectives of this study were as follows:

1. To study the effect of ages and cutting heights on yield and nutrient composition of hedge lucerne.
2. To determine the nutrient composition of hedge lucerne meal.
3. To determine the toxic substances and pigments of hedge lucerne meal.
4. To evaluate the biological value and metabolizable energy of hedge lucerne meal.

5. To evaluate the effects of hedge lucerne meal on laying performance and egg quality.

1.3 Research hypothesis

Desmanthus virgatus is a weed in Mimosaceae family that can be used as protein supplement in poultry diet. This legume should contain considerably amount of nutrients for poultry, when the suitable cutting interval and cutting height have been applied.

1.4 Scope and Limitation of the study

The studies were conducted to evaluate yield and nutrient composition of hedge lucerne, which cut at different cutting interval and cutting height. Then, their nutritive values were determined, followed by the evaluation of its effect on laying performance and egg quality.

1.5 Outline of thesis

This thesis was divided into eight chapters, including introduction, literature review, general materials and methods, experiment I, experiment II, experiment III, overall discussion and implication, and finally reference and appendix.

CHAPTER II

Literature Review

2.1 Introduction

Trees and shrub legumes are increasingly recommended for feed use in tropical and subtropical regions. One of the widely recommended legumes as supplement to protein feedstuff is *Desmenthus virgatus*. The forage has been used to increase liveweight gain in ruminants (Battad,1993). Recently, there has been some research concerning nutritional evaluation of hedge lucerne for pigs (Ly and Samkol, 2001). However, very little is known of the nutritional value of tree and shrub meals for poultry. There were no reports on the effect of hedge lucerne meal as a laying hen feed. Then, this review would mostly be referred to legume tree meal such as *Leucaena leucocephala*, *Gliricidia sepium* and *Sesbania sesban*.

2.2 Hedge lucerne (*Desmanthus virgatus* L. Willd)

It is a small shrub, 2 to 3 m tall, nearly erect or (more commonly) diffuse or decumbent and branchlets globrous. Leaves are moderately small, bipinnate; 10 to 20 leaflet pairs per pinna, petiole usually no more than 5 mm long. Other morphological characteristics are inflorescence of axillary, pedunculate heads toward the tips of the twigs; head small, dense, few-flowered, the flowers all erect, whitish, sessile; pod linear, 4 to 6 cm long and 3 to 4 mm wide, flat, glabrous, shortbeaked, dehiscent on both values, seeds oblique (Skerman et al,1988).

Desmanthus virgatus is a perennial browse similar to *Leucaena leucocephala* but has slender, angular, pithy stems, smaller leaflets and narrow pods. Grows in sandy and other open textured soils under a rainfall regime of 1000 to 1500 mm at elevations from sea level up to 300 m. It occurs on clay soils, receiving 550- 750 mm rainfall. It has been selected to fill the need for persistent summer-growing neutral to high pH in extensive grazing areas. Grows best in hot weather; its frost tolerance is unknown. It is quite drought tolerant. (Skerman et al, 1988; Partridge, 1998).

Partridge (1998) recommended that hedge lucerne seed is small and need time to weather before it can regenerate. Seed should be treated to reduce the high proportion of hard seed.

Hedge lucerne is suited to both tropics and subtropics, being reasonably cold tolerant, and although defoliated by heavy frost, it will regrow from crowns once there is enough moisture . (Skerman et al, 1988; Partridge, 1998).

Skerman, et al. (1988) reported that hedge lucerne is a plant of high palatability which can be harvested four time a year in Hawaii, cutting it at the early pod stage. It flowers 45 to 50 days after cutting. In Hawaii, the plants were cut 5 to 7.5 cm above ground with a mower. Cutting at 91 day (four cuts per year) intervals gave highest yield, 3680 kg /rai/year over three years.

Vuthiprachumpai et al. (1998) studied on the effect of nitrogen fertilizer and farm manure on desmanthus and indicated that application rate of nitrogen fertilizer at 0, 20, 40, and 60 kg/rai gave the average dry matter yield of 240, 250, 248 and 247 kg/rai respectively and average protein yield of 48, 52, 51 and 51 kg/rai respectively However, there were no statistically significantly different among treatments.

The dry matter yield of hedge lucerne was not responded to phosphorus fertilizer. The dry matter yields when applied phosphorus 0, 5, 10 and 15 kg/rai were 394, 386, 371 and 388 kg/rai respectively (Khemsawat et al., 1993).

Punyavirocha et al. (1992a) reported that there was no significant difference in DM yield and CP among cutting intervals. The dry matter yield of hedge lucerne obtained from 30, 40, and 60 day cutting intervals were 235, 364 and 422 kg/rai respectively. The crude protein yields were 45, 66 and 71 kg/rai respectively.

Punyavirocha et al. (1992b) indicated that dry matter yield of hedge lucerne was not significantly affected by row spacing and cutting height. Dry matter yield obtained from 5, 20, 35, and 50 cm cutting height were 332, 258, 394 and 353 kg/rai respectively.

Battad (1993) recommended that cutting management of hedge lucerne is as follows:

- Initial clipping at 90-120 days after sowing
- 35-45 days cutting interval during rainy season and 45-60 days during the dry season
- 50 cm cutting height is recommended to obtain optimum yield and quality
- 30 cm cutting height can also be used with higher yield but more stem proportion
- 100 cm cutting height can also be used with lower yield but higher leaf proportion

Karachi (1998), who studied on variation in the nutritional value of leaf and stem of leucaena lines, reported that leaf contents in *Luecaena leucocephala* and hybrid selections varied from 51-59% of total dry matter. Essentially, age has a positive effect on yield but has negative effect on chemical composition. The negative effects contribute to a reduction in digestibility and voluntary intake. Therefore, to obtain an optimum combination of yield and quality, it is necessary to know the forage age and size that should be harvested.

Cheeke (1999) reported that age and high temperature of season promote lignification of the cell walls of the both leaves and stems. Lignin reduced the pool size of the metabolites in the cell contents, thus decreasing protein and soluble carbohydrate and increasing structural carbohydrate and cell wall.

2.3 Chemical composition and nutritive value of legume tree meals

Determination of the potential of leaf meals in non–ruminant nutrition necessitate a comparative review of nutrient content. The outstanding feature of leguminous leaf meals is their higher crude protein content. The crude protein content of the hedge lucerne cut at 61, 91 and 122 day intervals was 10.55, 12.27 and 15.52 percent respectively and the average protein contents of the leaves and stem were 22.4 percent and 7.10 percent respectively. (Skerman, et al. 1988).

Battad (1993) reported that chemical composition of hedge lucerne contain 17 percent crude protein, 1.4 percent calcium, and 0.3 percent phosphorus on dry matter basis. Higher crude protein can be obtained from leaf alone (22 percent) as compared with foliage and stem (10-15 percent). It has not been found to contain toxic factors yet, hence its utilization in the diet of animal can be maximized. The comparison of nutrient contents between leguminous leaf meals and *Desmantus virgatus* are showed in Table 2.1.

Table 2.1 Proximate composition (g / kg $^{-1}$ DM) of leaf meal.

Nutrient composition	Source of leaf meal				
	Leucaena leucocephala [a]	*Gliricidia sepium* [b]	*Cajanus cajan* [c]	*Sesbania sesban* [d]	*Desmanthus virgatus* [e]
Crude protein	291	296	243	306	197
Crude fiber	89	120	248	169	52
Ether extract	48	30	52	53	55
Ash	70	99	57	102	128

[a] D'Mello and Fraser (1981); [b] Osei et al. (1990); [c]; Udedible and Lgwe (1989);
[d] Brown et al. (1987); [e] Chomchai et al (1992)

Punyavirocha et al. (1992a) found that the crude protein of *Desmanthus virgatus* at 30 day cutting interval were 19.08 % and tended to decrease when cutting prolong (18.8%, 16.74% at 45 and 60 day cutting intervals respectively). Fiber component of hedge lucerne at 30 day cutting interval was lower than 45 and 60 day cutting intervals.

D'Mello and Acamovic (1989) commented on the wide variation in amino acid content of different types and source of *Leucaena leucocephala* leaf meal derived from the same cultivar. Differences were particularly notable for arginine, lysine, phenylalanine, tyrosine, leucine, methionine, cysteine, glycine and threonine with a sample from Malawi generally containing higher concentrations of these amino acids than a sample from Thailand.

Data relating to the essential amino acid composition of leaf meals are available for three Leguminous species (Table2.2): *Leucaena leucocephala* (D'Mello and Fraser, 1981), *Gliricidia sepium* (Chadhokar, 1982) and *Sesbania sesban* (Brown et al., 1987).

Table 2.2 Amino acid profiles (%) of leaf meal

Amino acid	*Leucaena leucocephala*[a]	*Gliricidia sepium*[b]	*Sesbania sesban*[c]
Threonine	1.21	1.20	0.99
Glycine	1.31	-	1.09
Valine	1.44	1.60	1.09
Cysteine	0.2	0.39	0.05
Methionine	0.48	0. 42	0.37
Isoleucine	1.37	1.20	0.92
Leucine	2.17	2.41	1.81
Tyrosine	1.25	1.12	0.69
Phenylalanine	1.48	1.54	1.05
Lysine	1.76	1.12	1.27
Histidine	0.54	0.51	0.44
Arginine	1.51	1.59	1.10
Tryptophan	0.38	-	-

[a] D'Mello and Fraser (1981); [b] Chadhokar (1982); [c] Brown et al. (1987)

D'Mello (1995) recommended that lysine concentrations in leaf meals are appreciably higher than those of cereal grains and certain by products such as coconut oil meal. However, lysine concentrations in soybean meal and fish meal are considerably higher than those for the leguminous leaf meals in particular. Thus any attempt to replace conventional high quality ingredients in diet for non- ruminant animal should give recognition to differences in lysine content. Deficiencies of the sulfur – containing amino acid add a further dimension to the nutritional limitations of the leguminous leaf meals.

The study of nutritive value in leaf meals has been restricted largely to the determination of digestibility of the crude protein . Tangendjaja et al. (1990) reported a depression of digestibility of protein from 75% with control diet to 41% on inclusion of *Leucaena leucocephala* leaf meal in rabbit feed at 600 g/kg diet. In studies with poultry, Ravindran et al. (1983) reported in the digestibility coefficient of 63% for the crude protein fraction of cassava leaf meal in poultry diets. Revindra et al. (1987) reported values of 65%, 67% and 66% for pig diets containing cassava leaf meal at 133, 267 and 400 g/kg diet respectively. The important criterion of nutritional value of feed relates to digestible energy (DE) and metabolizable energy (ME) contents (D'Mello ,1995). For poultry, D'Mello and Acamovic (1982) attributed the low apparent ME values (1422 kcal/kg) of *Leucaena leucocephala* to poor digestibility.

Chaiyanukulkitti et al. (1991) reported that the crossbred native chicken fed 15 % hedge lucerne leaf meal diets had significantly lower average daily gain, feed conversion ratio and longer feeding period than chicken fed 10% hedge lucerne leaf meal diets. Chomchai et al. (1992) recommended that hedge lucerne meal can be used up to 15% in broiler diets. It was no effect on mortality rate of chicken but the chicken on the diet containing 5% hedge lucerne leaf meal had the best average daily gain and feed conversion ratio.

2.4 Anti – nutritional factors in Mimosaceae

Many crop plants contain a wide variety of natural chemical compounds which are capable of inducing adverse effects in animals consuming these plants. Members of the legume family display this feature to the greatest extent. Non-ruminant animals are particularly susceptible to the presence of these compounds in their food.

Among the toxic amino acids occurring naturally in plants, mimosine is probably the best known. It is found in the leaves, stems and seeds of Mimosaceae family. Excessive intakes of mimosine result in poor growth and food utilization. (D'Mello,1982). Concentrations of mimosine in leucaena leaf are 2.5 % in dry matter (D'Mello, 1982); 3.36 % (Pakyavivat et al, 1985); and 3.08 % (Sriwatavorachai, 1989). Chaiyanukulkitti et al. (1991) and Chomchai et al. (1992) reported that mimosine in hedge lucerne 0.29% and 0.18% on dry matter respectively.

Furthermore, many tropical legumes have secondary compounds which exert a negative effect on intake, primarily through their metabolic effect. Secondary compounds may exert their effect in different manner depending on the digestive tract of the animal. Mimosine in *Luecaena leucocephala* is an example of this. In ruminant, it is degrated to 3,4-DHP which can be have adverse metabolic effects unless it is inturn degraded by bacteria (*Synergistis jonesii*) (Jones,1979;Jones and Megarrity,1986) but monogastrics do not and may show depressed food intake. (Poppi and Norton,1995)

2.5 Effects of supplementing legume tree meals in diets on laying performance

The researches of using hedge lucerne meal in layer diets were not found. Then this review was related to other legume tree meal such as leucaena, gliricidia and cajanus. The major problem of leucaena leaf meal is the presence of toxic mimosine. Studies in chickens (Librijo and Hathcock, 1974), feed intake declined 33% and egg production declined 49% when this meal was included at 30% of diet. Berry and D'Mello (1981) showed that egg production and live weight gain of chickens on diets containing 20% of this meal were significantly reduced. Scott et al. (1982) reported that levels of leucaena meal above 5% caused reduction egg production in laying hens. This is probably due to poor amino acid digestibility as well as the toxic mimosine, since Picard et al. (1987) cited by Daghir (1995) presented very low amino acid digestibility values for this meal. These workers concluded that leucaena meal were not suitable for poultry protein nutrition and should be regarded only as a pigment source to be used at low levels of the diet.

On the basis of the limited evidence available, it appears that effect of leucaena meal on body weight of laying hen is generally deleterious. D'Mello (1995) qouted in Springhall and Ross (1965) reported lower total body weights and weight gains of hens fed the leaf meal at the rate of 10% in diet. The egg weight was not affected by feeding leucaena meal at 5% and 10% in diets. Performance of laying hens is more affected by feeding leaf meal from *Gliricidia sepium* than leucaena. Dietary inclusion of *Gliricidia sepium* (2.5, 5.0 and 7.5 % in diets) caused a significant linear depression in egg production (Osei et al, 1990). This effect was accompanied by significant linear deterioration of feed conversion efficiency and of body weight gain of hens over the 11-week experimental period. Udedibie and Igwe (1989) reported that egg production in hens fed *Cajanus cajan* leaf meal at 10% in diet declined by only 4.5% relative to that of hens fed the control diet. In addition, at the two highest inclusion rates (7.5 and 10% in diet), hens incurred body weight losses over the limitation of using legume tree meal in poultry diets 16- week experimental period.

Fiber level will also restrict feed intake and the level of legume tree meal inclusion is restricted to requirements for maximum crude fiber in poultry rations. Smith (1990) recommended that fiber content in layer diets should not excess 7%. The fiber may act as a barrier to the attack of intracellular compounds by enzymes of the gastrointestinal tract. Janssen and Carre (1989) reported that digestibility of added fat were increased when increasing the fiber content from sunflower seed meal or alfalfa meal in the diet, but a decrease in digestibility of added fat when the increased fiber content of of the basal ration was based on wheat bran. Thus the fiber of wheat bran seems to have a negative effect on the digestibility of added fat while the fiber of sunflower seed meal and alfalfa meal seem to have a positive effect.

2.6 Legume tree meals as sources of pigmenting xanthophyll

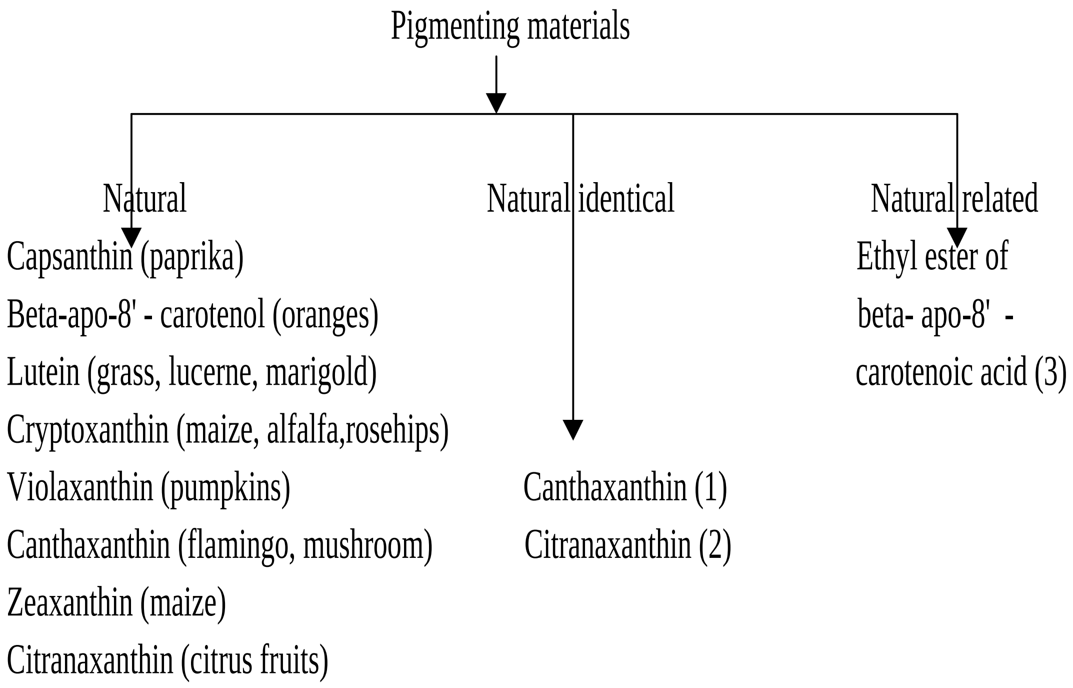
Egg yolk colour is becoming important criteria of egg quality, and in many countries, there is a consumer preference for egg yolks of a particular yellow colour. Jeffries (1981) reported on favour and accepted scale of egg yolk in many countries (Table 2.3).

Table 2.3 Roche yolk colour scale of egg yolk on consumer acceptation

Country	Favour scale	Accepted scale
Belgium	_	11-12
Canada	_	3-8
France	_	4-15
Japan	10	8-13
Holland	7-8	6-9
New Zealand	9	6-10
Norway	10-12	10-10.5
Switzerland	11	9-12.5
Turkey	10	9-11
England	9-10	5-13

Source: Adapted from Jeffries (1981)

Belyavin and Marangos (1989) recommended that there are effectively two ways in which yolk pigmenters can be included in poultry feed. Firstly, feed ingredients such as raw materials, or secondly, a commercially available concentrated form of a synthetic pigment. An attempt has been made to classify the pigmenting materials as in Figure 2.1.



Registered trade names: (1) Carophyll red
(2) Lucantin CX
(3) Carophyll yellow

Figure 2.1 A classification of pigmenting materials

This applies in all cases to caroteniods, namely xanthophyll, which, because they are fat soluble and are transferred to follicles at the same time and through the same mechanisms as with lipids. The coloration obtained depends upon both the natural and quality of xanthophylls employed, each being defined by its colouring ability. As with other micro-constituents, transportation to the egg depends on many factors. Some are linked to the bird, being genetic origin, age, rate of laying. Others are associated with the composition of the diet. Lipid, particularly saturated fatty acid, vitamin E, antioxidants and virginiamycin are positive factors, which promote the best colour with the minimum concentration of pigments (Larbier and Leclercq, 1994).

D'Mello (1995) suggested that an important attribute of leucaena leaf meal emanate from its relatively generous content of caroteniods. There are a class of compounds which include the carotenes, the precursors of vitamin A, and xanthophylls, which do not posses vitamin activity but which can be used by poultry as a source of pigments. Since the pigments deposited in eggs and carcasses can not be synthesized by poultry an exogenous source must be supplied in the diet if an acceptable product is to be obtained. Belyavin and Marangos (1989) showed that natural materials that suitable for feed ingredients are given in Table 2.4.

Table 2.4 Xanthophyll contents of the principal pigment carriers in mixed feeds

Ingridients	Xanthophylls (lutein and zeaxanthin fraction)	
	Mean content (mg/kg)	Range of variation (mg/kg)
Lucerne meal (15-17% protein)	140	40 to 620
Grass meal	320	140 to 500
Yellow maize	17	8 to 40
Maize gluten meal (42% protein)	110	60 to 340

Source: Belyavin and Marangos (1989)

Leucaena leaf meal is well endowed with xanthophyll concentrations from 741 to 766 mg/kg DM (D'Mello and Taplin, 1978); 318 mg/kgDM (Kanto,1986) and 235 mg/kg DM (Khanampan,1991) for different cultivars of *Leucaena leucocephala.* Scott et al. (1982) recorded xanthophyll concentrations of 400 to 550 mg/ kg DM in dehydrate alfalfa leaf meal . It is assumed that other leguminous leaf meals are also well supplied with the pigmenting caroteniods. The concentration of caroteniods in leaf meals will depend upon the duration and method of drying.

In the previous research, Springhall and Ross (1965) quoted in D'Mello (1995) reported that hens may reach the maximum of their ability to absorb xanthophylls from *Leucaena leucocephala* when inclusion rates of 5.0% in diet are employed. (Table 2.5).

Table 2.5 Roche fan colour scores of egg yolks in relation to graded levels of leaf meals in diets of laying hens.

	Dietary level of leaf meal (%)						
Source of leaf meal	0	2.5	5.0	7.5	10.0	15.0	Reference
Leucaena leucocephala	2.2	-	7.3	-	7.2	-	(1)
Gliricidia sepium	1.0	3.9	6.0	7.2	-	-	(2)
Cajanus cajan	-	2.0	4.0	6.0	8.0	-	(3)

(1) Springhall and Ross (1965) quoted in D'Mello (1995); (2) Osei et al. (1990); (3) Udedibie and Igwe (1989)

Gliricidia sepium (Osei et al., 1990) and *Cajanus cajan* (Udedibie and Igwe, 1989) showed that dietary concentrations of leaf meals induce progressive pigmentation of egg yolk . The beneficial effect of *Gliricidia sepium* occurred within a week of feeding diets containing the leaf meal but pigmenting efficiency was sustained for some considerable time (4 week) after dietary withdrawal of the leaf meal (Osei et al, 1990). Udedibie and Igwe (1989) argued that a deeper colour intensity would be required by the food processing industries which may be attained by increasing rates of inclusion of *Cajanus cajan* leaf meal but egg production would probably depressed in consequence.

2.7 Egg quality

The first consideration is protein- more specifically, amino acid. Deficient dietary protein can cause smaller eggs while extra dietary protein will cause slightly larger eggs (Perry et al, 1999). For strains of birds that produce many extra large eggs during the latter part of their egg production cycle, lowering the level of dietary protein during this period will result in slightly smaller and more uniform eggs (Leeson and Summers, 1997). The protein levels around 13 % and less are necessary to bring about meaningful reduction in egg size (Table 2.6) However, with protein levels much less than this, loss in egg numbers often occurs.

Table 2.6 Effect of reducing dietary protein level on egg size of 60-week-old layers (average for two, 28- day periods).

Dietary protein Level (%)	Egg production (%)	Average feed intake (g/d)	Egg weight (g)	Egg mass (g)	Average protein intake (g/d)
17	78.8	114	64.8	51.0	19.4
15	77.5	109	64.3	49.7	16.4
13	78.3	107	62.2	49.1	13.9
11	72.7	108	61.2	45.1	11.9
9	54.3	99	58.2	36.1	8.9

Source: Leeson and Summers (1997).

Amino acid requirements often depend upon the dietary level of protein. In the case of sulfur amino acids requied for brown layers, the diet must provide approximately 750 mg of which at least 50%, (375 mg), must be in form of methionine, in order to produce 53 g of egg mass daily (Larbier and Leclerco, 1994).

2.7.1 Freshness of the albumen (egg white)

The behaviour of a cracked egg placed upon a flat surface describes its freshness. Under normal conditions, a freshly laid egg will hardly spread at all. The thick albumen has a gel structure whose height is generally expressed in Haugh units:

$$\text{Haugh units:} = 100 \times \log (T - 1.7 \times W^{0.37} - 7.57)$$

Where:

T is the thickness of the thick white layer in millimeters

W is the egg weight in gram

The range of Haugh units is between 20 and 110. Common values are between 50 and 100 depending upon a number of factors (Larbier and Leclercq, 1994). There are many factors that can affect this measurement such as age of egg, age of flock, ambient temperature, strain of chicken and egg – handling procedures (North and Bell, 1990).

2.7.2 Yolk colour

In practice it is easy to obtain the desired colour, ranging from very pale through to orange and almost to red, as measured on Roche scale with units from 0 to 15. The former values correspond to the virtual absence of colour and latter to red. It is sufficient to provide pigmenting agents, included either within raw materials or as natural or semi-synthesis additive. Whilst yellow or yellow orange colorations are very popular with consumers, it is possible to obtain other yolk colorations which are generally considered undesirable. This is the case with a green colour associated with the consumption of some wild cruciferous plants. Salmon brown is based on cotton seed meal or medical additives. Gray may arise from treatment with chlorotetracyclines. Finally numerous synthetic colorants, particularly if they are fat soluble, may readily be found in the yolk and will give unwanted colours (Larbier and Leclercq, 1994).

2.7.3 Specific gravity and eggshell

Specific gravity of an egg and shell thickness are related. Higher specific gravities are an indication of greater shell thickness. Specific gravity above 1.0880 indicates good eggshell quality, but annual averages of all eggs laid by the flock may very between 1.080-1.0880 (North and Bell, 1990).

2.8 Nutrient requirement of laying hen

Nutrient requirements of laying hen in Thailand adopted from NRC to formulate feed. Poultry diets are composed primarily of mixture of several feedstuffs such as cereal grains, soybean meal, fish meal, fats, and vitamin and mineral premixes.

2.8.1 Energy requirement for egg production

The energy necessary for maintaining the chicken's general metabolism and producing egg is provided by the energy –yielding dietary components. The appetite of chicken, is first and foremost, closely linked to their energy requirements. This is very probably explained by the fundamental role played by signals of metabolic origin (glycaemia). This factor which reduce or increase energy balance will affect appetite. The major ones influencing feed intake are therefore ambient temperature, the level of production and the weight of the chicken. NRC (1994) recommended that equation have been developed to relate energy intake to environmental temperature.

$$ME\ (kcal/day) = W^{0.75}\ (173-1.95T) + 5.5\ \Delta W + 2.07\ EE$$

where: W = body weight (kg)

T = temperature (°C)

ΔW = change body weight (g/day)

EE = daily egg mass

2.8.2 Protein requirement for egg production

The protein requirement of laying hen is closely associated with the rate of egg production. Protein in the egg production diets is much lower than the 18 to 20% required for early growth. Just prior to egg production, only 13% of the pullet's diets should be protein; but when egg production reaches its peak, the requirement may be as high as 17 to 19%. At the end of the production cycle, it may drop to as low as 14%.

2.8.3 Calcium requirement

Amongst all the mineral ions, major and micro-elements, calcium must be provided to the hen in appreciable amounts in order to ensure the proper shell formation. The dietary level of calcium must be equal at least to 3.5% to obtain strong shell. At the end of lay, when shell strength tends to fall, the dietary levels of calcium may be reduced and calcium offered in the form of oyster shells or granules of calcium carbonate.

2.8.4 Phosphorus requirement

The phosphorus in plant ingredients is in the form of phytate phosphorus, an organic compound not well-utilized by the chicken; only about 30 to 40% is available. The inorganic forms of phosphorus are commercially available such as dicalciumphosphate or mono dicalciumphosphate, etc. The laying hen's requirement for phosphorus is low, mainly because of a little phosphorus content presented in the eggshell. The recommended daily intake of available phosphorus in the laying ration is controversial, but levels of 400 to 450 mg/hen/day are considered adequate.

2.8.5 Trace minerals and vitamins requirement

The requirements for trace minerals are often fulfilled by concentrations present in conventional feed ingredients. Soil vary, however, in their content of trace minerals, and plants vary in their uptake of minerals. Consequently, feedstuffs grown in certain geographic areas may be marginal or deficient in specific elements. The requirements for most vitamins are given in term of milligram per kilogram of diet. Exceptions are vitamins A, D, and E, for which requirements are commonly stated in units. Units are used to express the requirements for these vitamins because different forms of the vitamins have different biological activities. In practice, poultry diets may require supplementation to ensure adequate intake mineral and vitamins.

Table 2.7 Nutrient requirements of brown-egg laying hens at 110 g of feed per hen daily adapted from NRC (1994)

Nutrients	(mg)
Protein and amino acid	
Crude protein	16,500
Arginine	770
Histidine	190
Isoleucine	715
Leucine	900
Lysine	760
Metionine	330
Methionine+cystine	645
Phenylalanine	520
Threonine	520
Tryptophan	175
Valine	770
Macrominerals	
Calcium	3,600
Nonphytate phosphorus	275
Potassium	165
Sodium	165
Trace minerals	
Iodine	0.004
Iron	5.0
Zinc	3.9
Fat soluble vitamins	
A	330 IU
D3	33 IU
E	0.55 IU
K	0.055
Water soluble vitamins	
B12	0.0004
Biotin	0.011
Choline	155
Folacin	0.028
Niacin	1.1
Pantothenic acid	0.22
Pyridoxine	0.28
Riboflavin	0.28
Thiamin	0.08

CHAPTER III

General Materials and Methods

3.1 Introduction

The aims of the present study were to elucidate the effect of cutting interval (age) and cutting height on yield and nutritive value of hedge lucerne and to evaluate the effects of hedge lucerne meal in layer rations. The studies were divided into three experiments. The first experiment was designed to study the age of cutting and cutting height on yield and nutrient compositions of hedge lucerne. The second experiment was designed to determine the biological values of hedge lucerne meal in poultry diets. The third experiment was conducted to study the effects of hedge lucerne meal in layer ration on egg production and quality.

The materials and methods of each experiment vary from trial to trial according to the nature of the studies. Therefore, in this chapter, abroad outline of materials and methods of each experiment will be briefly given.

3.2 The effect of cutting interval and cutting height on yield and nutrient compositions of hedge lucerne

The first experiment was laid out in a 3x3 Factorial arrangement in randomized complete block design with 4 replications in each treatment. Factor A was cutting intervals (30, 40 and 50 days) while factor B was cutting height (30, 40 and 50 cm above ground level). The parameters measured were nutrient composition, nutrient yields and the leaf: stem ratio.

3.3 Determination of biological value of hedge lucerne meal in poultry diets

The second experiment was conducted to determine the biological values, particularly energy and protein, of hedge lucerne meal which was harvested at 30 d cutting interval and at 50 cm cutting height. The procedures of obtaining energy and protein values were modified from and described by Scott et al (1982) and Isshiki and Nakahiro (1988) respectively.

3.4 Utilization of hedge lucerne meal in layer diets

The final experiment was carried out to evaluate the utilization of hedge lucerne meal in layer diets. Three hundred 22 weeks old Hisex brown pullets were randomly divided into 5 groups of 60 hens each. Each group of the animals was randomly fed diets containing 5 levels of hedge lucerne meal at 0, 2, 4, 6 and 8%. The experimental design was completely randomized design. The parameters measured were egg production, feed intake, egg quality and general health of laying hens.

3.5 Growing, harvesting and storage of hedge lucerne meal

In order to conduct the 2^{nd} and 3^{rd} experiment, a large amont of hedge lucerne meal was required. Hedge lucerne was grown on 3 rais area at the Suranaree University of Technology. After 80 days from sowing, the plants were cut at 30 cm above ground level and the upper part was removed. The plants were then allowed re-growth and were later cut at 30 days and at 50cm height. Both leaves and stems were then chopped into small pieces (1-2 inches) by chopper driven by diesel power motor. Chopped pieces were then air-dried on concrete floor for 3 days. The dried hedge lucerne was subsequently ground through 1 mm- mesh sieve hammer mill and stored in polyethylene bags.

CHAPTER IV

The Effect of Cutting Interval and Cutting Height on Yield and Nutrient Compositions of Hedge Lucerne

4.1 Introduction

Hedge lucerne is suitable to both tropics and subtropics. It is productive, drought-tolerant and although defoliate by heavy frosts. It will regrow from crowns once there is enough moisture. Hedge lucerne should contain large amount of nutrients for animal, when it has been cut on the suitable age and cutting height.

4.2 Objective

The objective of this experiment was to evaluate the effect of cutting interval and cutting height together with interaction of the two factors on yield and nutrient compositions of hedge lucerne.

4.3 Materials and Methods

The experiment was conducted at the Suranaree University of Technology during March to October 2001. The plant used for this study was hedge lucerne (*Desmanthus virgatus*). There were 9 treatment combinations, consisting of 3 levels of cutting height (30, 40 and 50 cm above ground level) and 3 cutting intervals (30, 40 and 50 days). The experiment was laid out in Factorial in randomized complete block design with 4 replications.

The whole area was ploughed twice, followed by a single harrowed, over a period of 10 days to produce an excellent seedbed. It was then assigned in to experimental plots. Totally, there were 36 plots with the net size of 9 m^2 (3m x 3m). The distance between plots was 100 cm. Six rows were divided per plot with the distance between rows of 50 cm. All plots received a basal dressing of compound NPK fertilizer (15:15:15) at the rate of 30 kg per rai.

Plant seeds were applied at the rate of 2 kg per rai. Prior to sowing, seeds were soaked in hot water (80^{o}C) for 1 min to break the dormancy. All plots were watered once per week by sprinkler system.

At 80 days after sowing, the plants were cut at 30 cm above ground level and the upper part of these plants was removed. The plants were then allowed to re-growth and were cut after 30,40 and 50 days with 3 level of cutting height mentioned earlier to measure the production. The second and third harvesting times were repeated after 30, 40 and 50 days of re-growth with similar cutting height for further production measurements.

When production measurements were made the fresh forage was weighed and subsamples taken for dry matter determination and nutrient compositions analysis by the proximate method (AOAC, 1990). On the third harvest, plants were separated to determine leaf and stem ratio, then, analyzed for the nutrient composition of leaf and stem.

All data were subjected to analysis of variance by the procedure of SAS (1985). Data from three cuts and from each treatment were combined. The difference among mean values were compared by Duncan's New Multiple Range Test (DMRT) at 5% significance level.

4.4 Results

4.4.1 Effect of cutting interval and cutting height on average nutrients and yield of hedge lucerne

The average nutrient composition of hedge lucerne are presented in Table 4.1. Cutting intervals had a significant effect on DM, CP, CF, EE, Ash and NFE contents of hedge lucerne. The DM and CF contents increased (P<0.01) with increasing intervals of cutting whereas the CP, Ash, EE and NFE contents decreased (P<0.01 except for EE p<0.05) with increasing cutting intervals.

Similarly, there were significant effects of cutting height on DM, CP, CF and Ash contents but not EE and NFE contents. The DM and CF contents decreased with increasing cutting height while the CP and Ash contents increased as cutting height increased.

There were significant interaction effects of age of cutting and cutting height on CP content of hedge lucerne. The CP content reduced with increasing age of cutting while it increased with increasing height of cutting.

When significant interaction effects between cutting interval and cutting height were observed, separate statistical analysis of each single factor was done (see Appendix: Table A2 and A3). Cutting at 30 day interval, cutting height had no effect on CP content, however, at 40 and 50 intervals, cutting height greater than 30 cm resulted in higher CP content.

Table 4.1 The average nutrient composition of hedge lucerne

AGE	HEIGHT	% DM	% CP	% CF	% EE	% ASH	% NFE
30 D	30 CM	31.77	18.62[a]	19.91	2.97	7.26	51.24
	40 CM	31.64	18.55[a]	18.91	2.92	7.48	52.14
	50 CM	31.16	19.00[a]	17.12	2.84	7.14	53.90
40 D	30 CM	32.58	15.81[c]	26.27	2.75	6.21	49.05
	40 CM	30.47	17.19[b]	22.37	2.66	6.68	50.50
	50 CM	29.85	17.18[b]	22.98	2.86	6.45	50.54
50 D	30 CM	35.36	14.37[d]	28.55	2.62	6.00	48.46
	40 CM	33.31	14.37[d]	27.51	2.81	6.45	48.59
	50 CM	33.59	15.53[c]	27.30	2.89	6.60	47.88
SEM ±		0.58	0.34	0.96	0.07	0.14	0.84
% CV		3.58	4.06	8.18	5.14	4.21	3.35
………………………………………….P-value………………………………………							
BLOCK		0.0055	0.8238	0.3736	0.0004	0.0038	0.4628
AGE		0.0001	0.0001	0.0001	0.0309	0.0001	0.0001
HEIGHT		0.0029	0.0084	0.0109	0.3515	0.0097	0.2226
AGE*HEIGHT		0.2926	0.0495	0.4394	0.0551	0.1631	0.3655

Noted: separate statistical analysis of each single factor was attached in Appendix; Table A2 and A3.

Table 4.2 shows the average various yields of hedge lucerne. DM, CP, CF, EE, NFE and Ash yields increased significantly ($P<0.01$) with increasing cutting intervals. However, all yields at 50 day intervals and at 40 cm cutting height were the highest while the least was at 30 day intervals at 50 cm height of cutting. Height of cutting had no significant effects on yields. No interaction between cutting intervals and cutting height on yields was found.

Table 4.2 The average nutrient yield of hedge lucerne (kilogram per rai)

AGE	HEIGHT	DM	CP	CF	EE	ASH	NFE
30 D	30 CM	247.24	46.02	49.39	7.36	17.98	126.53
	40 CM	239.06	43.33	48.33	6.81	17.94	122.65
	50 CM	220.13	41.40	40.97	6.33	15.52	115.91
40 D	30 CM	408.31	63.31	110.81	10.90	24.53	199.42
	40 CM	393.61	68.79	90.87	10.25	25.65	198.04
	50 CM	384.75	63.63	92.32	10.82	23.64	194.35
50 D	30 CM	483.80	68.51	138.69	12.69	28.64	235.27
	40 CM	559.50	79.82	158.20	15.66	34.91	270.91
	50 CM	454.98	67.73	127.97	13.17	28.78	217.34
SEM ±		35.71	5.18	12.30	1.14	2.38	16.41
% CV		18.86	17.18	25.82	21.76	19.65	17.57
………………………………………..P-value………………………………………….							
BLOCK		0.0092	0.0065	0.0250	0.0169	0.0112	0.0065
AGE		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
HEIGHT		0.3307	0.3108	0.3831	0.6728	0.1988	0.2991
AGE*HEIGHT		0.6033	0.7232	0.5654	0.4625	0.7101	0.5293

Noted: separate statistical analysis of each single factor was attached in Appendix; Table A4 and A5.

4.4.2 Effect of cutting interval and cutting height on leaf:stem ratio and nutrients composition

The leaf:stem ratio and nutrient compositions of leaf and stem are shown in Table 4.3. The effect of cutting interval was significant on percentage of DM, CF, Ash of leaf and stem ($P<0.01$). CP contents of leaf and stem decreased ($P<0.01$) with increasing interval of cutting . Cutting intervals had a significant effect on EE of leaf and NFE contents of leaf and stem.

There were significant effects of cutting height on ash of stem but not DM, CP, CF, EE, NFE of leaf, stem and ash of leaf. The DM of leaf increased with increasing cutting height while DM of stem decreased as cutting height increased.

In this study, effects of age of cutting and cutting height were found that there were no significant interaction effects on nutrient compositions of leaf and stem.

Table 4.3 The ratio leaf : stem and nutrient compositions of leaf and stem

AGE	CUT HEI	RATIO (DM)		%PROTEIN		%FIBER		%ASH		%EE		%NFE	
		LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM
30 D	30CM	61.61	38.39	23.72	9.31	9.87	40.98	6.49	4.94	3.32	1.73	56.61	43.04
	40CM	59.82	40.18	23.42	9.30	9.45	41.01	6.67	5.24	3.56	1.18	56.90	43.27
	50CM	61.60	38.40	23.27	9.94	9.12	39.56	6.69	5.36	3.24	1.31	57.78	43.83
40 D	30CM	50.51	49.49	20.75	6.81	10.26	46.21	6.92	4.49	2.78	1.29	59.29	41.20
	40CM	53.10	46.90	22.14	7.95	8.99	43.72	6.69	5.20	2.87	1.35	59.31	41.79
	50CM	52.58	47.42	22.15	7.46	9.52	44.07	6.54	4.87	2.70	1.37	59.09	42.23
50 D	30CM	45.33	54.67	19.43	7.13	10.97	46.38	7.99	3.79	3.40	1.27	58.21	41.43
	40CM	49.23	50.77	20.10	6.99	12.00	46.77	7.95	4.11	3.15	1.18	56.81	40.96
	50CM	51.53	48.47	19.51	7.47	11.83	45.74	7.78	4.60	3.16	1.39	57.73	40.80
SEM±		3.42	3.41	0.61	0.44	0.60	1.08	0.23	0.15	0.23	0.13	0.82	1.10
%CV		12.66	14.82	5.67	10.81	11.68	4.95	6.40	6.41	14.56	18.87	2.82	5.21
……………………………………………P-value…………………………………………………………													
BLOCK		0.8619	0.8621	0.1473	0.8635	0.2229	0.3657	0.1781	0.0001	0.0015	0.1231	0.0073	0.4349
AGE		0.0006	0.0005	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0109	0.4873	0.0100	0.0467
HEIGHT		0.6180	0.6182	0.5097	0.3221	0.8802	0.3040	0.6584	0.0005	0.6523	0.1831	0.7245	0.8990
AGE*HEIGHT		0.8736	0.8736	0.5548	0.5642	0.3674	0.6959	0.8460	0.1253	0.8589	0.1094	0.7345	0.9482

Noted: separate statistical analysis of each single factor was attached in Appendix; Table A6 and A7.

4.5 Discussion

Cutting interval and cutting height treatments chosen in the present study were apparently sufficient to observe differential responses to chemical composition in HLM. The results of the present research showed that DM and CF contents increased with increasing intervals of cutting while other chemical contents decreased with increasing age of cutting. However, the research publications on the effect of cutting intervals on chemical composition of HLM are very scarce. In general, as age of cutting prolongs the DM and CF contents are often increased while other chemical composition decreased. This is certainly due to the accumulation of fiber content in the plants, particularly in the stem together with increasing degree of lignification (Cheeke, 1999). This is confirmed when the chemical compositions in leaf and stem of HLM are taken into account, the DM content of leaf decreased while content of stem increased with increasing cutting intervals (Table 4.3). In addition, the leaf:stem ratio decreased with increasing age of cutting. However, the CF contents of both leaf and stem increased with increasing cutting intervals. The CP, EE and NFE contents of plants decreased with increasing cutting intervals in this study. One publication (Skerman et al, 1988) reported the CP contents of 15.52, 12.27 and 10.55% when the plants were cut at 61, 91 and 120 days intervals respectively. The present study showed the same trend, the CP contents of 18.72, 16.72 and 14.78% were observed when the plants were cut at 30, 40 and 50 day intervals respectively. When the chemical composition in leaf and stem are taken into account, the CP content of both leaf and stem decreased with increasing age of cutting. The same findings of the effect of cutting intervals on chemical composition were also reported (Punyavirocha et al, 1992a).

There was also significant effect of cutting height on chemical composition of HLM. The DM and CF contents in HLM decreased when height of cutting increased. This is because the upper parts of the plants contain less branches and stem than the lower parts. The stem contains higher CF contents than leaf (Table 4.3) when height of cutting increased the CF contents therefore decreased.

The effect of age of cutting on yields of HLM was observed in the present study. The DM, CP, CF, EE and NFE yields increased with increasing cutting intervals. This is not consistent with the trial of Punyavirocha et al (1992a) who reported there was no significant difference in DM and CP yields among cutting intervals. The DM and CP yields obtained from 30,40 and 60 day intervals were 235, 45; 364, 66 and 422, 71 kg/rai respectively.

Battad (1993) reported that the optimum yields can be obtained at 50 cm cutting height and at 35- 45 days cutting intervals during rainy season or 45- 60 days cutting intervals during the dry season. The present study found that yields at 50 day intervals and at 40 cm cutting height gave the highest yields. The suggestion to this would be 40-50 cm cutting height and at 50 day intervals.

There was no report of the effects of cutting intervals and cutting height on the leaf:stem ratio and nutrient composition of leaf and stem of HLM. However, these effects on leucaena leaf: stem ratio and leaf and stem composition would be comparative.

The experimental design in the present study was a 3 x 3 factorial arrangement. Any attempt to interpret the result may be confounded by the two factor together with its interaction. Statistical analysis is therefore separately conducted to determine the effect of each factors i.e. age of cutting or cutting height. The results of separated analysis are presented in appendix (p.76 -.78). Cutting at 50 day interval gave the highest DM and CF contents, but gave the lowest CP, EE and NFE contents. While cutting at 30 day interval gave the highest CP, EE and NFE contents but gave the lowest CF content. Cutting at 40 and 50 cm height gave similar DM, CP and CF contents but gave higher CP and lower CF contents than cutting at 30 cm height. Similarly, the effect of cutting interval or cutting height which was separately analyzed showed the same conclusion as did with factorial analysis.

Before any conclusion will be mode, single factor i.e. age of cutting or cutting height should separately be taken into account. In terms of CP content or CP yield, it would be better to choose 30 day cutting interval and at 30 cm cutting height. Since at this interval and at this height gave similar CP content to those cut at 40 and 50 cm height but gave the highest CP yield. If the CF content and utilization of HLM in poultry diet are taken into account at 30 day intervals gave the lowest CF content regardless of any cutting height. However, increased height of cutting tended to reduce the CF content; and at 50 cm height gave the numerical lowest CF content.

The present study took into account on high crude protein and low crude fiber content at suitable cutting interval and cutting height of the plants. Hedge lucerne which plants are used for poultry feed, Karachi (1998) suggested that age has a positive effect on yield but has a negative effect on chemical composition.

Cutting interval of 30 day and cutting height of 50 cm enhanced protein content in hedge lucerne and this in turn decreased dry matter and crude protein yield. This suggest that crude protein and crude fiber are active source of assimilates in hedge lucerne. Hence, decreased crude fiber due to cutting potentially enhanced crude protein content.

4.6 Conclusion

The present study clearly indicates that cutting interval has a positive effect on yield but has a negative effect on chemical composition in terms of nutritive values. However, height of cutting has a negative effect on yield but has a positive effect on chemical composition. A high CP content and low CF content in HLM are taken into account in the present study, therefore, yield and chemical composition should be compromised. The optimum yield and chemical composition, particularly CP and CF contents, can be obtained at 30 day intervals and at 30-50 cm cutting height. At this interval and at this height, CP contents were the highest while CF contents were the lowest.

CHAPTER V

Biological Values of Hedge Lucerne Meal in Poultry Diets

5.1 Introduction

Hedge lucerne is a shrub belonging to the Mimosaceae family. It has been proposed as an alternative fodder tree the leaves of which could be used as animal feed. However, very little is known about the biological value of hedge lucerne meal for poultry. This study was undertaken to determine the biologial value of hedge lucerne meal for poultry.

5.2 Objective

The objective of the experiment was to elucidate the biological value of hedge lucerne meal which was cut at 30 day cutting interval and 50 cm cutting height as dicussed earlier in the previous chapter. In this study, the experiment was separated into two parts 1) The evaluation of apparent metabolizable energy and 2) The evaluation of protein utilization.

5.3 Materials and methods

5.3.1 Evaluation of apparent metabolizable energy

A study was carried out to evaluate the apparent metabolizable energy of hedge lucerne meal in adult chicken. Eight 7-week old male Cobb broilers were kept individually in raised floor wire cage in open house. The ingredients compositions of the experimental diets are shown in Table 5.1. The animals were pre-fed with the experimental diet for 5 days for acclimatization. The experimental period was 4 days thereafter. The animals were allowed to access to feed and water ad libitum and the light was provided 24 hours daily.

The birds were divided into 2 groups of 4 birds each. Each group of the birds was fed different diets, which were modified from Scott et al. (1982) as follows:

Diet 1: reference diet.

Diet 2: test diet.

Table 5.1 Feed ingredients of the chicken diets for metabolizable energy determination

	Diets (kg)	
	Reference	Test
Dextrose	45.70	15.70
Skim milk	53.50	53.50
Hedge lucerne meal	-	30.00
Vitamin-mineral	0.50	0.50
Chromic oxide	0.30	0.30
Total	100.00	100.00

Excreta was collected after five day adaptation period by plastic wrap on tray. Total excreta was collected 1 time a day for 4 days at the same time, in order to avoid the contamination of foreign materials such as feed and feathers. All the samples were dried in an electric oven at 60 °C for 3 days. Excreta samples were pooled, subsampled and then freeze dried. All samples were then prepared for chemical analysis.

The experimental feeds and excreta were analyzed for Chromic oxide by the method of Suzuki and Early (1991). Gross energy was analyzed by adiabatic bomb calorimeter. Apparent metabolizable energy of hedge lucerne meal was then calculated as follows:

Calculation of metabolizable energy

$$\text{ME/gm diet} = \text{Energy /gm diet} - (\text{Excreta energy / gm diet} + 8.22 \times \text{gm N retained /gm diet})$$

$$\text{Excreta energy / gm diet} = \text{Energy / gm excreta} \times \frac{Cr_2O_3 \text{ in diet}}{Cr_2O_3 \text{ in Excreta}}$$

$$\text{Gm N retained / gm diet} = \text{N / gm diet} - \text{N / gm excreta} \times \frac{Cr_2O_3 \text{ in diet}}{Cr_2O_3 \text{ in Excreta}}$$

To compute ME of material substituted for glucose, the following equation applies:

$$\text{ME / gm substitute} = 3.64 - \frac{\text{ME / gm reference diet} - \text{ME / gm diet with substitute}}{\text{Proportion of substitute}}$$

5.3.2 Evaluation of protein utilization

A study was carried out to examine the protein digestibility and utilization of hedge lucerne meal in adult chicken. Eight 7-week old male Cobb broiler chickens were kept individually in raised floor wire cage in open house. A colostomy method was performed to each bird according to the procedure of Isshiki and Nakahiro (1988). All broilers were allowed to recover from surgery for a period of 2 weeks before being subjected to the study.

The birds were divided into 2 groups of 4 birds each. Each group of the birds was fed different diets as following.

Diet 1: N- free basal diet.

Diet 2: Semi- purified diet containing protein supplied by hedge lucerne meal.

Table 5.2 Feed ingredients of the chicken diets for protein determination

	Diets (kg)	
	Control	Test
Corn flour	95.7	57.30
Hedge lucerne meal	-	40.00
Oyster shell	1.40	-
Dicalcium phosphate	1.90	1.70
Vitamin – mineral	0.50	0.50
Salt	0.50	0.50
Total	100.00	100.00

Ingredient compositions of the experimental diets are shown in Table 5.2. The animals were pre-fed with the experimental diet for 5 days for acclimatization. The experimental period was conducted for 4 days thereafter. The animals were allowed to access to feed and water ad libitum and the light was provided 24 hours daily.

The experiments were carried out from January to March 2002 at the Poultry farm, Suranaree University of Technology, Nakorn Ratchasima, Thailand.

In this case, feces and urine were kept separately. Feces were collected after five day of adaptation by plastic wrap on tray. Total feces were collected 1 times a day for 4 days at the same time, in order to avoid the contamination of foreign materials such as feed and feathers. All the samples were dried in an electric oven at 60 °C for 3 day and measured dry weights. Dried feces samples were pooled, subsampled and then freeze dried. All samples were then prepared for chemical analysis.

Plastic bags collected total urine 3 times a day for 4 days. Subsamples were then kept for the determination of nitrogen component.

The experimental feeds and excreta were analyzed for compositions by the method of proximate analysis. Biological value and protein digestibility of the experimental diets were calculated as follows:

1. Apparent digestibility $= (I – F) / I \times 100$

2. Apparent digestible coefficiency of protein

$$= (NI – Fn) / NI \times 100$$

3. True digestibility of protein

$$= [NI – (Fn – Fnm)] / NI \times 100$$

4. Protein biological value

$$= [NI – (Fn – Fnm) – (Un – Une)] / NI- (Fn – Fnm) \times 100$$

5. Net protein utilization

$$= [NI – (Fn – Fnm) – (Un – Une)] / NI \times 100$$

Where:

I	=	Feed intake (dry matter)	F	=	Fecal excrete (dry matter)
NI	=	Nitrogen intake	Fn	=	Fecal nitrogen
Fnm	=	Metabolic fecal nitrogen	Un	=	Urinary nitrogen
Une	=	Endogenous urinary nitrogen			

5.4 Results

Chemical compositions and gross energy contents of hedge lucerne meal are presented in Table 5.3. The average gross energy content of hedge lucerne meal was 3967 kcal/kg. Under the condition of this study, hedge lucerne meal contained crude protein, ether extract, ash and crude fiber at the levels of 18.95%, 3.13%, 7.49% and 17.50% respectively.

Table 5.3 The chemical compositions of hedge lucerne meal

Compositions	**Units**
Moisture	8.02%
Crude Protein	18.95%
Ether Extract	3.13%
Ash	7.49%
Crude Fiber	17.50%
NFE	44.91%
Calcium	1.975%
Phosphorus	0.100%
Gross Energy	3967 kcal/kg

The amino acid compositions of hedge lucern meal on dry matter basis are shown in Table 5.4. The results showed that hedge lucerne had higher contents of glutamic acid than other amino acid. The content of essential amino acid such as lysine, methionine, threonine and tryptophan were 1.152, 0.255, 0.953 and 0.233% respectively. The results of mimosine and xanthophyll determination (Table 5.5) indicated that hedge lucerne contained toxic mimosine at the level of 1.51% and the mixed sample with leaves and stem contained 309 mg/kg of xanthophyll.

Table 5.4 The amino acid compositions of hedge lucerne meal

Types	%	Types	%
Aspartic acid	1.760	Cystine	0.476
Serine	1.169	Tyrosine	0.672
Glutamic acid	2.025	Valine	0.907
Glycine	0.942	Methionine	0.255
Histidine	0.436	Lysine	1.152
Arginine	1.116	Isoluecine	0.752
Threonine	0.953	Luecine	1.477
Alanine	1.250	Phenylalanine	0.896
Proline	1.565	Tryptophan	0.223

Table 5.5 Mimosine and xanthophyll contents in hedge lucerne meal

Contents	**Units**
Mimosine	1.51%
Xanthophyll	309 mg/kg

The result of the apparent metabolizable energy and protein quality of hedge lucerne meal are presented in Table 5.6 and 5.7. Apparent metabolizable energy in hedge lucerne meal for adult chicken was 1330 kcal/kg. Digestibility coefficients of dry matter and protein in hedge lucerne meal feed were 65.04 and 34.61% respectively. True digestibility of protein, protein biological value and net protein utilization were 47.71, 63.11 and 30.07 % respectively.

Table 5.6 Calculation of metabolizable energy of hedge lucerne meal

Analytical values	Diet	Excreta
Reference diet values		
Nitrogen, g/g	0.0127	0.0394
Chromic oxide, mg/g	3.0	16.48
Gross energy, kcal/g	3.840	3.295
Substituted diet values		
Nitrogen, g/g	0.0383	0.0434
Chromic oxide, mg/g	3.0	9.28
Gross energy, kcal/g	3.890	3.675
Reference diet		
Excreta energy /g diet	= 3.295 x 3/16.48 =0.5998	
Nitrogen retained /g diet	= 0.0127-0.0394 x 3/16.48 = 0.0055	
Nitrogen correction	= 0.0055 x 8.22 = 0.0452	
ME of reference diet	= 3.840 – (0.5998 + 0.0452) = 3.195	
Substituted diet		
Excreta energy/g diet	= 3.675 x 3/9.28 = 1.1880	
Nitrogen retained /g diet	= 0.0383 -0.0434 x 3/9.28 = 0.0243	
Nitrogen correction	= 0.0243 x 8.22 = 0.1998	
ME of substituted diet	= 3.890 – (1.1880 + 0.1998) = 2.5022	

Therefore, ME of hedge lucerne meal = 3.64 – (3.195 - 2.5022) / 0.30

= 1.3307 kcal/g

= 1330 kcal/kg

Table 5.7 Protein determination of hedge lucerne meal in poultry

Items	Units
Apparent digestibility	65.04 %
Apparent digestible coefficiency of protein	34.61 %
True digestibility of protein	47.71 %
Protein biological value	63.11 %
Net protein utilization	30.07 %

5.5 Discussion

Under the condition of this study, hedge lucerne meal contained crude protein, ether extract, ash and crude fiber (Table 5.3) which differed from the results of Chomchai et al. (1992) who indicated that the content of crude protein, ether extract, ash and crude fiber of hedge lucerne leaf meal were 19.7, 5.5, 12.8 and 5.2% respectively. The variation in these nutrient composition was largely influenced by the difference of processing methods.

The amino acid profiles of the hedge lucerne meal (Table 5.4) were found to closely relate with *Leucaena leucocephala* (D'Mello and Fraser., 1981); *Glircidia sepium* (Chadhokar, 1982) and *Sesbania sesban* (Brown et al, 1987). It was low in sulphur-containing amino acids and none had the favorable amino acid balance of soya bean which is normally taken as the poultry industry standard to which other tree legumes are compared. However, synthetic lysine and methionine are now competitively priced and it is not difficult to improve the protein quality of this legume tree meal. With more competitively priced synthetic amino acids coming on the market, they may also be economically incorporated into supplementary hedge lucerne meal diets.

The contents of total mimosine was higher in hedge lucerne than reported previously by Chaiyanukulkitti et al. (1991) and Chomchai et al. (1992). While Gutteridge (1994) suggested that hedge lucerne does not contain mimosine, it foliage could be given to non- ruminant animal with no harmful effects. However, hedge lucerne consists less mimosine than leucaena leaf [2.5% (D'Mello, 1982); 3.36% (Pakyavivat et al.1985) and 3.08% (Sriwatavorachi,1989)].

The concentrations of xanthophyll in hedge lucerne meal was closely related to leucaena meal in Thailand of 318 mg/kg DM (Kanto,1986) and 235 mg/kg DM (Khanampan,1991), which were higher than lucerne meal, yellow corn and corn gluten meal (Belyavin and Marangos,1989) but less than in leucaena leaf (D'Mello and Taplin, 1978) and alfalfa leaf meal (Scott et al, 1982). The concentration of pigment in legume tree meals will depend upon the duration and method of drying.

An apparent metabolizable energy value of HLM was not highly related to leucaena leaf meal reported by D'Mello and Acamovic (1982) but comparisions are often difficult because of insufficient detail regarding adjustment to nitrogen balance. The value for leucaena leaf meal agrees with that reported by D'Mello and Acamovic (1982) of 1422 kcal/kg. The study of nutritive value in legume tree meals has been restricted largely to determinations of digestibility of crude protein. Because of this study used more hedge lucerne meal for protein source in diet, though the relatively high fiber content of the stem made hedge lucerne difficult to formulate into poultry diets.

The lower net protein utilization found in the present study can be attributed to an imbalance of amino acids in the test diet. Boorman and Burgess (1986) noted that adverse effects of imbalance (in relative terms: one amino acid deficient and the others in excess) on growth or egg production, it was assumed that the condition caused impairment of the utilization of the limiting amino acid. With respect to response experiments, the traditional supplementation procedure involves differing severity of imbalance, from very severe at low amino acid intakes to mild at adequate intake, at constant total protein concentration. Accepting that effects on food intake are accommodated by method of expression, conventional theory would suggest that if there were any effect on utilization it would tend to be an enhancement, greater at low intakes of the limiting amino acid.

The present study did not formulate the test diet in relation to balance amino acid requirement of the chicks, therefore, the net protein utilization, particularly the limiting amino acid, obtained was low.

When calculation of amino acid in the test diet was made, 0.102, 0.461, 0.090 and 0.381% of methionine, lysine, tryptophan and threonine were founded in the diet respectively. However, the requirement of these amino acids were 0.750, 1.000, 0.180 and 0.650% respectively, thus all limiting amino acids did meet the minimum requirement. The major amino acids, first limiting – methionine, can only supply 12% of the total requirement, while others, lysine, tryptophan and threonine can supplied in the present study that the low net protein utilization caused by imbalance amino acids is mainly due to lack of methionine and follow by the rest amino acids.

5.6 Conclusion

The present determination of apparent metabolizable energy, digestibility coefficient of DM and CP, true digestibility of CP, protein biological value and net protein utilization showed that these values were 1330 kcal/kg, 65.04, 34.61, 47.71, 63.11 and 30.07% respectively.

CHAPTER VI

Utilization of Hedge Lucerne Meal in Layer Diets

6.1 Introduction

Legume tree meals have generally been given to poultry either as a source of protein or of carotenoid pigments to provide yellow yolk. They may also be sources of other nutrients. Among the legume tree meals studied so far are those of leucaena, gliricidia and alfalfa. Their high levels of fiber or the presence of anti-nutritional factors usually limits their use in poultry diets. However, there are few reports on the utilization of hedge lucerne meal as a poultry feed.

6.2 Objective

The trial was conducted to study the effect of feeding hedge lucerne meal on laying performance and egg quality.

6.3 Materials and Methods

6.3.1 Animal and treatments

Three hundred 22 weeks old Hisex brown pullets were randomly divided into 5 groups of 60 hens each. Each group of the animals was further divided into 5 replications of 12 animals each. The hens were kept individually in metal cage in an evaporative cooling system house where feed and water were provided ad libitum. A lighting schedule of 16 L: 8 D was maintained through out the study.

6.3.2 Feed and management

Each group of the animals was randomly fed an experimental diet as follows.

Diet 1: A diet containing 0 % hedge lucerne meal -control diet

Diet 2: A diet containing 2 % hedge lucerne meal

Diet 3: A diet containing 4 % hedge lucerne meal

Diet 4: A diet containing 6 % hedge lucerne meal

Diet 5: A diet containing 8 % hedge lucerne meal

All experimental diets were isonitrogenous and provided to the birds for five 28- day periods. Feed ingredients and chemical compositions of the experimental diets are shown in Table 6.1 and 6.2 respectively.

6.3.3 Measurements

Records of daily egg production and feed consumption were measured in each period. All the eggs produced during the last 3 d of every 28 -day period were used for measuring egg weight, egg shell thickness, specific gravity, albumen height, haugh units, egg yolk colour and separating egg composition for yolk, albumen and shell.

Blood samples were randomly collected from 2 birds of each replication for screening procedure to assess general health. Blood samples were determined for plasma protein and packed cell volume in the last period.

6.3.4 Statistical analysis

The main effects between treated group were statistically analyzed by ANOVA in completely randomized designed and significant different among means were tested by Duncan New Multiple Range's Test (DMRT) according to methods described by SAS (1985).

6.3.5 Research farm

The experiment was carried out from June 1 st to October 18 th ,2002 at the Poultry Research and Development Center, Kasetsart University , Kampaengsaen Campus, Nakorn Pathom, Thailand.

Table 6.1 Feed ingredients of the layer diets

Ingredients	Diets 1	2	3	4	5	Price (Baht/kg)[1/]
Corn	**62.15**	**60.89**	**59.14**	**57.03**	**54.91**	**4.20**
Palm oil	1.00	1.00	1.41	2.11	2.82	18.00
Hedge lucerne meal	-	2.00	4.00	6.00	8.00	5.00
SBM 44 %	**23.50**	**22.86**	**22.30**	**21.80**	**21.31**	**10.20**
Fish meal 60%	4.00	4.00	4.00	4.00	4.00	28.00
Dicalcium phosphate 18%	1.39	1.40	1.40	1.41	1.42	11.00
Oyster shell	7.12	7.02	6.92	6.81	6.71	2.60
Dl- methionine	0.07	0.06	0.06	0.06	0.06	130.00
Salt	0.28	0.28	0.28	0.28	0.28	2.50
Vitamin- mineral premix	0.50	0.50	0.50	0.50	0.50	75.00
Total	100.00	100.00	100.00	100.00	100.00	
[1/] Price (Baht/kg) on May 10, 2002.	7.48	7.46	7.50	7.58	7.67	

Table 6.2 Chemical composition of the layer diets

	Diets				
	1	2	3	4	5
Chemical composition by calculation					
Crude protein (%)	17.50	17.50	17.50	17.50	17.50
ME, kcal/kg	**2790**	**2760**	**2750**	**2750**	**2750**
Calcium (%)	3.50	3.50	3.50	3.50	3.50
Available phosphorus (%)	0.40	0.40	0.40	0.40	0.40
Salt (%)	0.35	0.35	0.35	0.35	0.35
Lysine (%)	0.96	0.97	0.98	0.99	1.00
Methionine (%)	0.38	0.37	0.36	0.36	0.35
Methionine + cystine (%)	0.65	0.65	0.65	0.65	0.65
Tryptophan	0.21	0.21	0.21	0.21	0.21
Threonine	0.69	0.70	0.70	0.70	0.70

Diet 1: A diet containing 0 % hedge lucerne meal -control diet

Diet 2: A diet containing 2 % hedge lucerne meal

Diet 3: A diet containing 4 % hedge lucerne meal

Diet 4: A diet containing 6 % hedge lucerne meal

Diet 5: A diet containing 8 % hedge lucerne meal

6.4 Results

6.4.1 Chemical composition of the diets

The experiment was conducted to evaluate the effects of various levels of hedge lucerne meal in the diet on laying hen performance and egg quality. Increased levels of hedge lucerne in the diet resulted in increasing crude fiber of layer diets. This was due to the high content of fiber in hedge lucerne meal. HLM contained low metabolizable energy for chicken. Then, palm oil was used for add energy source in these diets. In this results, EE and gross energy contents were increased while NFE contents tended to decrease. However the contents of crude protein, calcium and phosphorus were close to the contents by calculation (Table 6.3).

Table 6.3 Chemical composition (% DM basis) by analysis of the layer diets

Nutrients	Diets				
	1	2	3	4	5
Dry matter %	89.02	88.77	88.88	88.73	89.12
Crude protein %	17.54	17.49	17.55	17.53	17.59
Ether extract %	4.18	4.37	4.45	5.32	5.88
Crude fiber %	3.33	4.22	4.57	4.67	4.83
Ash %	12.40	11.47	12.20	12.28	12.25
NFE %	51.57	51.22	50.11	48.93	48.57
Calcium %	3.48	3.58	3.53	3.58	3.55
Phosphorus %	0.79	0.78	0.84	0.80	0.84
Gross energy kcal/kg	3666	3669	3667	3722	3812

6.4.2 Feed intake and body weight gain

The averages body weight of laying hen (mean±SD) at the start of the experiment were 1627 ±18, 1666 ±37, 1625 ±28, 1605 ±27 and 1624 ±31 g/bird for a diet 1-5 respectively. Since there were no interaction between treatment and period in all parameters being measured, therefore, the data for each parameter in all periods were pooled and used for statistical analyses. The effects of dietary levels of HLM on feed intake of layers are summarized in Table 6.4. The data indicated that average feed intake was not significantly different among hens fed diets containing various level of HLM.

Table 6.4 Performance of laying hens fed diets containing 5 levels of HLM

Levels of HLM %	Feed intake (g/bird/day)	Body weight gain (g/bird/140 day)
0	107.69	145.45
2	108.38	117.73
4	108.74	81.16
6	107.31	111.27
8	106.83	108.33
SEM±	0.6768	14.7238
P-value	0.2955	0.0807
%CV	1.4039	29.1897

Body weight gain of hen fed all experimental diets were not significantly different (Table 6.4). No adverse effects on mortality rate was observed when using HLM in the laying hen diets.

6.4.3 Egg production, egg weight and egg mass

Data on egg production of the layers fed diets containing various levels of hedge lucerne meal are showed in Table 6.5. Egg production was significantly ($P < 0.05$) declined when the amount of hedge lucerne meal was added at 8% in the diet. However, the inclusion of 2, 4 and 6% HLM in the diet had no effect on egg production although it tended to increase as the inclusion rate increased from 0 to 6%.

Table 6.5 Egg production of laying hens fed diets containing 5 levels of HLM

Levels of HLM %	Egg production %	Egg weight g	Egg mass g/egg
0	88.33^{ab}	58.88	52.01
2	88.94^{ab}	59.04	52.52
4	90.24^{a}	59.35	53.54
6	91.16^{a}	58.81	53.62
8	86.51^{b}	60.11	51.99
SEM±	1.0485	0.5295	0.7614
P-value	0.0470	0.4253	0.3795
%CV	2.6332	1.9987	3.2281

The mean values of egg weight and egg mass are also presented in Table 6.5. The levels of HLM in the diets did not have any effects on egg weight and egg mass.

6.4.4 Cost of egg production

No significant difference was observed for feed intake per dozen of egg production of laying hens fed diet containing various levels of HLM (Table 6.6). Feed cost per dozen egg (Baht) were significantly ($P<0.05$) increased when the inclusion the level of hedge lucerne meal was over 8% (Table 6.6). The results have been related to the increasing ($P<0.05$) in egg production of the layers fed rations containing 6% of hedge lucerne meal.

Table 6.6 Cost of egg production of laying hens fed diets containing 5 levels of HLM

Levels of HLM %	Feed intake/Egg production (kg/dozen)	Cost of feed /dozen eggs (Baht)
0	1.462	10.930^{b}
2	1.462	10.906^{b}
4	1.446	10.842^{b}
6	1.421	10.772^{b}
8	1.484	11.378^{a}
SEM±	0.0178	0.1344
P-value	0.1909	0.0367
%CV	2.7363	2.7398

6.4.5 Egg quality determination

Increasing levels of HLM did increase egg yolk colour score, which were significant (P<0.01) increased with increasing the levels of HLM in the diets (Table 6.7). Which was referred to chapter V. HLM contained xanthophyll at 309 mg/kg. This was probably due to the fact that the highest dietary xanthophyll levels in the present experiment was 37 mg/kg, which was much higher than the other levels that caused high score of egg yolk colour.

It was also observed that the inclusion of various levels of HLM had no adverse effect on the other interior egg quality characteristics i. e. specific gravity, egg shell thickness, egg albumen height and Haugh unit (Table 6.7).

Table 6.7 Egg quality of laying hens fed diets containing 5 levels of HLM

Levels of HLM %	Specific gravity	Egg shell thickness (mm)	Egg albumen height (mm)	Haugh unit	Egg yolk colour (score)
0	1.0900	0.350	8.77	92.92	4.53[e]
2	1.0902	0.353	8.73	92.43	7.03[d]
4	1.0907	0.352	8.84	92.54	7.74[c]
6	1.0911	0.359	8.44	90.70	8.09[b]
8	1.0913	0.360	9.06	93.68	8.55[a]
SEM±	0.0005	0.0033	0.1939	1.0285	0.0516

P-value	0.5000	0.1850	0.2855	0.3690	0.0001
%CV	0.1182	2.0519	4.9424	2.4870	1.6063

Compositions of fresh eggs derived from hen fed diet containing 5 levels of HLM are given in Table 6.8. There were no effects of levels of HLM in the diets on the egg yolk, albumen and shell of the fresh eggs.

6.4.6 General health of laying hens

The general health of hens indicated that no significant difference was observed for Packed cell volume and Plasma protein contents in the blood of laying hens fed diet containing various levels of HLM (Table 6.9).

Table 6.8 Egg compositions of laying hens fed diets containing 5 levels of HLM

Levels of HLM %	Egg yolk %	Egg albumen %	Egg shell %
0	24.18	65.89	9.93
2	25.86	63.67	10.47
4	24.06	66.18	9.76
6	25.58	63.81	10.61
8	23.81	65.60	10.59
SEM±	0.9474	1.3480	0.4867
P-value	0.4322	0.5474	0.6196
%CV	8.5766	4.6353	10.5971

Table 6.9 Packed cell volume and plasma protein in blood of laying hens fed diets containing 5 levels of HLM

Levels of HLM %	**Packed cell volume** %	**Plasma protein** (g/dl)
0	26.3	6.52
2	28.7	6.60
4	24.2	5.98
6	27.7	7.14
8	26.9	6.40
SEM±	1.1018	0.3718
P-value	0.0887	0.3187
%CV	9.2067	12.7375

6.5 Discussion

The present study demonstrated no statistically significant difference in feed intake among laying hens receiving diets containing various levels of HLM. However, at 2 and 4% inclusion rates tended to give the highest intake while at 6 and 8% inclusion rate tended to reduce feed intake. A tendency towards a reduction in feed intake of 6 and 8% HLM was probably due to firstly a higher content of CF and secondly a higher content of energy than other diets. Smith (1990) recommended that fiber content in layer diets should not excess 7%. Since beyond this level the high CF content will limit feed intake. However, the 4.8% CF of the diet containing 8% HLM in the present study should not limit feed intake. Any attempt to include high fiber ingredient in the diet is usually associated with a reduction in other form of carbohydrate i.e. water soluble carbohydrate. When a high fiber ingredient such as rice bran, sunflower meal as well as lucerne meal is included in the diet, dietary fat is often added to balance the energy concentration in the diet. The present study also followed the same procedure. Thus, increasing HLM resulted in increasing CF content and in decreasing carbohydrate content in the diets. Dietary fat had to be increasingly added as the HLM level increased. Addition of dietary fat resulted in increasing GE content in the diet. A high GE content tended to limit feed intake. However, there were some reports noted both positive and negative effects of supplementing high fiber ingredient in the diet. Janssen and Carre (1989) reported that digestibility of fat was increased when increased the fiber content from sunflower seed meal or alfalfa meal in the diet, but a decrease in digestibility of the fat when the increased fiber content of the basal ration was based on wheat bran. Thus the fiber of wheat bran seems to have a negative effect on the digestibility of added fat while the fiber of sunflower seed meal and alfalfa meal seem to have a positive effect.

Inclusion rate of HLM in the diet had no effect on body weight gain in the present study. There was no report on the effect of HLM level in the diet on laying hen's performance. However, it is very difficult to explain the direct effect of inclusion of HLM in the diet on body weight gain. Since, a complex partitions of nutrient between maintenance, body weight gain and egg production generally occurs. For instance, researches often found a negative relation between body weight gain and egg production. Once body weight gain increased, the egg production often decreased. In turn, when the egg production increased, the body weight gain decreased.

Comparative research would be stressed with leucaena meal. Berry and D'Mello (1981) reported that egg production and body weight gain of chickens on diets containing 20 % of leucaena meal were significantly reduced. The highest inclusion rate of the present study was 8% of HLM. This is the result why the present study found no significant difference in body weight gain.

The present study showed no significant difference in egg production when HLM was included at 2, 4 and 6% in the diets. However, when the inclusion rate was 8%, the egg production was significantly decreased when compared to 2, 4 and 6% inclusion rate. Study on the effect of leguminous meal inclusion in the diets, Librijo and hathcock (1974) and Berry and D'Mello (1981), both found significant reduction in egg production when leucaena meal was included at 30% and 20 % respectively. Scott et al (1982) suggested that levels of leucaena meal above 5 % reduced egg production in egg laying hens.

The reason why egg production decreased when HLM was included at 8% or more is unclear. This would probably be due to a tendency toward lower feed intake, high bulkiness of the diet or to mimosine level in the diet. This study found that 8% HLM inclusion rate tended to reduce feed intake. Previous discuss on the effect of CF content of 4.8% or 2750 kcalME/kg in the 8% HLM diet would not limit feed intake. Concerning with mimosine level in the diet, mimosine concentration increase from 0 to 120 mg/kg diet with increasing HLM inclusion rate from 0 to 8%. The highest mimosine concentration of 120 mg/kg diet is considered to be a very low level found in many trials. The toxicity of mimosine for poultry has not been established beyond reasonable doubt. Springball (1965) demonstrated that the adult cockerel is capable of metabolizing a single oral dose of mimosine without adverse consequences. In relative by – term study Tangendjaja and Sarmanu (1986) showed that pure mimosine did not affect the onset of sexual maturity in laying hen. However, D,Mello and Acamovic (1989) showed that the young chick is more sensitive than the older bird. Both growth rate and feed intake were severely reduced in chicks given 330 mg mimosine/kg diet. Meulen et al. (1984) observed that a dietary mimosine concentration of 494 mg/kg diet severely retarded growth and feed intake of chicks. Most of these trials were based on studies involving feeding with leucaena meal.

Therefore, CF contents, energy concentration and mimosine level found in the present study would not be able to reduce feed intake in theory. Another possible cause of a tendency of reduction feed intake in this study might be a bulkiness of the feed. Larbier and Lecleraq (1994) suggested that one of the most important regulatory factors must be the bulk of the diet, suggesting a significant controlling role of the physical effect of the diet within the gastro-intestinal tract i. e. pressure. The presence of large amounts of plant cell wall constituents within the diet explains the effect of bulk on the limitation of feed intake.

Although many factors can affect feed intake, it is not possible to indicate clearly, general values as each factor has its on mode of action. In the present study, a reduction in egg production is probably due to a tendency towards reduction in feed intake rather than mimosine level in the diet. In addition, a tendency reduction in feed intake is possibly related of the bulkiness of the feed. It is important to note that a cause of reduction in feed intake is probably due to a single factor or a combination of many factors together with their interaction effect regulated feed intake.

There were no statistically significantly differences in specific gravity, egg shell thickness, albumen height and haugh unit. However, increases in HLM in the diets resulted in increasing egg yolk colour. The yellow-orange coloration of egg yolks is influencing by a number of carotenoid pigments. The xanthophylls, which are characterized by presence of hydroxyl groups, are the caroteniods of most interest in poultry nutrition. There are effectively two ways in which yolk pigmenters can be included in poultry feed. Firstly, feed ingredients such as alfalfa and corn, or secondly, a commercial available synthetic caroteniods. However, the levels desired pigments in natural feedstuffs are not always constant and many of the caroteniod-containing natural feedstuffs are relatively low in energy content. Synthetic pigments can be used to control pigmentation more previously to yield varying degrees of yellow-orange-red coloration. In natural product, xanthophylls are unstable and effective levels may decline as a result of oxidation during prolonged storage. Various levels of HLM were incorporated in the diets to supply xanthophylls to the egg yolk in the present study. Roche fan colour score of egg yolks linearly increased with increasinng levels of HLM in the ration. The range of egg yolk colour was between

7.0 and 8.5 when 2 to 8% of HLM are included. The score in the present study is generally within the range accepted by consumers in many countries (Jeffries, 1981). For example, the accepted scales of 8.0-13, 6.0-9.0 and 5.0-13.0 are in Japan, The Netherlands and England respectively.

Many published data (D' Mello, 1995; Osei et al, 1990; Udedibie and Igwe, 1989) were with other legume meal supplemented in the diets. They all found that inclusion of legume meal in the diets induced progressive pigmentation of egg yolk. No research on the effect of inclusion of HLM in the diet on egg yolk colour was found. However, Belyavin and Marangos (1989) showed that colour fan score of egg yolk increased with increasing natural xanthophyll level of feed. The colour fan score drastically increased from 0.0 to 8.0 when level of xanthophyll in the diet increased from 0 to 10 mg/kg, after this level (10 mg/kg) the colour fan score increased little. It seems that supplementation of xanthophyll greater than 20 mg/kg had minor effect on egg yolk colour. The same was true in the present study. The respective concentrations of xanthophyll 14, 20,25, 31 and 37 mg/kg were found in the diet containing 0, 2, 4, 6 and 8% HLM which resulted in colour fan score of 4.53, 7.03, 7.74, 8.09 and 8.55 respectively.

6.6 Conclusion

Although, there were no significant effect of HLM on general laying performances, adding 8% HLM in the diet caused a reduction in egg production. The major finding in the present study was that egg yolk colour score increased with increasing HLM in the diets. The recommendation of using HLM in the laying diets was at 6%.

CHAPTER VII

Overall Discussion and Implication

The aims of the present study were to elucidate the effect of cutting intervals and cutting height on yield and nutritive value of HLM and to evaluate the effects of HLM in the diet on laying performances. The present study suggested that the optimum yield and chemical composition can be obtained at 30 day cutting interval and at 30-50 cm cutting height. At this cutting interval and cutting height 220-247 kgDM/rai of HLM can be harvested each cut. If 7 cuts per year are applied, 1540-1730 kgDM/rai/year of HLM can be obtained. With this yield together with moderate quality of 18.55-19.00% CP of HLM, 2770-3011 Baht/rai/year can be sold. Baht/rai/year income is quite reasonable compared to 2730 Baht/rai/year of cassava, 3081 Baht/rai/year of corn and 2054 Baht/rai/year of rice. Growing of hedge lucerne will be another option for Thai farmers to gain more income. Hedge lucerne should be alternative crop for those farmers who grow those crops that risk to a low price and to drought. Hedge lucerne is easy growing legume with a high production and high quality feedstuff for poultry feed. It can grow in various types of soil. The present study also found that HLM can be used as feedstuff in layer diet up to 6% inclusion rate. HLM can not only be used as source of protein supplement in layer diet but also as source of xanthophylls. However, the major constraint arises from the relatively high fiber and low energy content of HLM.

The future research should be emphasized on fertilizer application, development of forage harvester and on other management to ensure a high production per unit area and a convenient harvesting method. To improve the utilization of HLM by pelleting, which increase feed density and birds can consume more low- energy (high fiber) feed. Bulky diets reduce dry matter consumption hence, very bulky feeds are sometime pelleted or added in order to increase energy density and feed consumption.

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APPENDICES

APPENDICES

Table A1. Meteorological data during the experimental periods of the 3rd experiment

Experimental periods	Max (°C)	Min (°C)	Mean (°C)	Diff (°C)	RH (%)
June 1- June 7	-	-	-	-	-
June 8- June 14	28.57	24.86	26.71	3.71	69
June 15- June 21	27.86	25.00	26.43	2.86	75
June 22- June 28	28.14	25.57	26.86	2.57	75
June 29 - July 5	29.29	25.43	27.36	3.86	69
July 6 - July 12	28.43	25.29	26.86	3.14	75
July 13- July 19	28.29	25.29	26.79	3.00	75
July 20 - July 26	28.29	24.86	26.57	3.43	75
July 27 – Aug 2	28.43	25.57	27.00	2.86	75
Aug 3 – Aug 9	28.29	24.86	26.58	3.43	75
Aug 10 – Aug 16	28.71	25.00	26.86	3.71	69
Aug 17 – Aug 23	27.86	24.43	26.15	3.43	75
Aug 24 – Aug 30	28.43	24.86	26.65	3.57	68
Aug 31 – Sep 6	28.71	24.43	26.57	4.28	69
Sep 7 – Sep 13	29.29	24.57	26.93	4.72	63
Sep 14 – Sep 20	28.43	24.86	26.65	3.57	69
Sep 21 – Sep 27	28.00	24.00	26.00	4.00	69
Sep 28 – Oct 4	28.71	24.57	26.64	4.14	63
Oct 5 – Oct 11	27.86	23.29	25.58	4.57	63
Oct 12 – Oct 18	27.71	23.71	25.71	4.00	63

Max = maximum temperature

Min = minimum temperature

Mean = mean temperature
Diff = different temperature
RH = relative humidity

Table A2 The effect of cutting interval on nutrient composition of hedge lucerne

Age (days)	% DM	% CP	% CF	% ASH	% EE	% NFE
30	31.52[b]	18.72[a]	18.86[c]	7.29[a]	2.91[a]	52.42[a]
40	30.96[b]	16.72[b]	23.87[b]	6.44[b]	2.75[b]	50.02[b]
50	34.08[a]	14.78[c]	27.78[a]	6.35[b]	2.77[b]	48.31[c]
	**	**	**	**	**	**

Within a given factor, means in column without a common letter differ significantly (P<0.01).
** (P<0.01)

Table A3 The effect of cutting height on nutrient composition of hedge lucerne

HEI (CM)	% DM	% CP	% CF	% ASH	% EE	% NFE
30	33.23[a]	16.26[b]	24.91[a]	6.48[b]	2.78	49.58
40	31.80[b]	16.70[a]	22.93[b]	6.87[a]	2.79	50.02
50	31.53[b]	17.17[a]	22.46[b]	6.72[a]	2.86	50.77
	**	**	*	**	ns	ns

Within a given factor, means in column without a common letter differ significantly
** (P<0.01), * (P<0.05), ns = No significant difference

Table A4 The effect of cutting interval on nutrient yield of hedge lucerne

Age (days)	DM	CP	CF	ASH	EE	NFE
	kg/rai					
30	235.48[c]	43.58[b]	46.22[c]	17.14[c]	6.83[c]	121.70[c]
40	395.56[b]	65.24[a]	98.00[b]	24.60[b]	10.65[b]	197.27[b]
50	499.43[a]	72.01[a]	141.62[a]	30.77[a]	13.83[a]	241.17[a]
	**	**	**	**	**	**

Within a given factor, means in column without a common letter differ significantly (P<0.01).
** (P<0.01)

Table A5 The effect of cutting height on nutrient yield of hedge lucerne

HEI (CM)	DM	CP	CF	ASH	EE	NFE
	kg/rai					
30	379	59.23	99.62	23.71	10.31	187.07
40	397	63.97	99.13	26.16	10.90	197.20
50	353	57.58	87.09	26.65	10.10	175.80
	ns	ns	ns	ns	ns	ns

ns = No significant difference

Table A6 The effect of cutting interval on leaf and stem composition of hedge lcerne

Age (days)	% DM leaf	% DM stem	% CP leaf	% CP stem	% CF leaf	% CF stem	% ASH leaf	% ASH stem	% EE leaf	% EE stem	% NFE leaf	% NFE stem
30	61.01[a]	38.99[b]	23.47[a]	9.52[a]	9.48[b]	40.52[b]	6.58[b]	5.17[a]	3.37[a]	1.40	57.09[b]	40.08
40	52.06[b]	47.94[a]	21.68[b]	7.41[b]	9.59[b]	44.67[a]	6.72[b]	4.85[b]	2.78[b]	1.33	59.23[a]	41.74
50	48.69[b]	51.30[a]	19.68[c]	7.19[b]	11.60[a]	46.29[a]	7.90[a]	4.17[c]	3.23[a]	1.28	57.58[b]	41.06
	**	**	**	**	**	**	**	**	*	ns	*	ns

Within a given factor, means in column without a common letter differ significantly
** (P<0.01), * (P<0.05), ns = No significant difference

Table A7 The effect of cutting height on leaf and stem composition of hedge lucerne

HEI (CM)	% DM leaf	% DM stem	% CP leaf	% CP stem	% CF leaf	% CF stem	% ASH leaf	% ASH stem	% EE leaf	% EE stem	% NFE leaf	% NFE stem
30	52.48	47.52	21.30	7.75	10.36	44.52	7.13	4.40[b]	3.16	1.43	58.03	41.89
40	54.05	45.94	21.88	11.37	10.14	43.83	7.10	4.85[a]	3.19	1.23	57.67	38.71
50	55.23	44.76	21.64	8.29	10.16	43.12	6.97	4.94[a]	3.03	1.35	58.19	42.28
	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	ns	ns

Within a given factor, means in column without a common letter differ significantly
** (P<0.01), ns = No significant difference

Table A8.1 Analysis of Variance of nutrient compositions of hedge lucerne

Source	df	SS	MS	F-value	Pr>F
Dry matter					
Block	3	21.548	7.183	5.40	0.0055
Age	2	66.560	33.280	25.03	0.0001
Height	2	20.019	10.009	7.53	0.0029
Age*Height	4	6.996	1.749	1.32	0.2926
Error	24	31.909	1.330		
Total	35	147.032			

C.V.= 3.58%

CP					
Block	3	0.4221	0.1407	0.30	0.8232
Age	2	93.382	46.691	100.14	0.0001
Height	2	5.476	2.738	5.87	0.0084
Age*Height	4	5.195	1.299	2.79	0.0495
Error	24	11.191	0.4663		
Total	35	115.665			

C.V.= 4.06%

Table A8.2 Analysis of Variance of nutrient composition of hedge lucerne

Source	df	SS	MS	F-value	Pr>F
CF					
Block	3	11.994	3.998	1.09	0.3736
Age	2	504.888	252.444	66.63	0.0001
Height	2	40.399	2.0199	5.49	0.0109
Age*Height	4	14.348	3.587	0.98	0.4394
Error	24	88.275	3.678		
Total	35	659.904			

C.V.= 8.18%

EE					
Block	3	0.5562	0.1854	8.86	0.0004
Age	2	0.1687	0.0843	4.03	0.0309
Height	2	0.0457	0.0228	1.09	0.3515
Age*Height	4	0.2253	0.0563	2.69	0.0551
Error	24	0.5021	0.02090		
Total	35	1.4981			

C.V.= 5.14%

Table A8.3 Analysis of Variance of nutrient composition of hedge lucerne

Source	df	SS	MS	F-value	Pr>F
Ash					
Block	3	1.392	0.4640	5.84	0.0038
Age	2	6.471	3.235	40.71	0.0001
Height	2	0.9004	0.4502	5.66	0.0097
Age*Height	4	0.5701	0.1425	1.79	0.1631
Error	24	1.9074	0.0795		
Total	35	11.2404			

C.V.= 4.21%

Source	df	SS	MS	F-value	Pr>F
NFE					
Block	3	7.4277	2.4759	0.89	0.4628
Age	2	102.6979	51.3489	18.36	0.0001
Height	2	8.9540	4.4770	1.60	0.2226
Age*Height	4	12.6544	3.1636	1.13	0.3655
Error	24	67.1253	2.7969		
Total	35	198.8594			

C.V.= 3.35%

Table A9.1 Analysis of Variance of nutrient yields of hedge lucerne

Source	df	SS	MS	F-value	Pr>F
DM					
Block	3	73607.2629	24535.7543	4.81	0.0092
Age	2	424337.4927	212168.7463	41.59	0.0001
Height	2	11827.0428	5913.5214	1.16	0.3307
Age*Height	4	14166.4983	3541.6246	0.69	0.6033
Error	24	122445.9163	5101.9132		
Total	35	646384.2130			

C.V.= 18.96%

Source	df	SS	MS	F-value	Pr>F
CP					
Block	3	1673.277586	557.759195	5.20	0.0065
Age	2	5295.089756	2647.544878	24.69	0.0001
Height	2	263.220556	131.610278	1.23	0.3108
Age*Height	4	222.197978	55.549494	0.52	0.7232
Error	24	2573.201289	107.216720		
Total	35	10026.987164			

C.V.= 17.18%

Table A9.2 Analysis of Variance of nutrient yields of hedge lucerne

Source	df	SS	MS	F-value	Pr>F
CF					
Block	3	6755.30116	2251.76705	3.72	0.0250
Age	2	54737.40527	27368.70264	45.21	0.0001
Height	2	1209.60029	604.80014	1.00	0.3831
Age*Height	4	1825.14694	456.28674	0.75	0.5654
Error	24	14530.05696	605.41904		
Total	35	79057.51063			

C.V.= 25.82%

Source	df	SS	MS	F-value	Pr>F
EE					
Block	3	64.1451889	21.3817296	4.14	0.0169
Age	2	295.4431500	147.7215750	28.61	0.0001
Height	2	4.1608667	2.0804333	0.40	0.6728
Age*Height	4	19.2338333	4.8084583	0.93	0.4625
Error	24	123.9350611	5.1639609		
Total	35	506.9181000			

C.V.= 21.76%

Table A9.3 Analysis of Variance of nutrient yields of hedge lucerne

Source	df	SS	MS	F-value	Pr>F
Ash					
Block	3	311.121789	103.707263	4.59	0.0112
Age	2	1117.866217	558.933108	24.75	0.0001
Height	2	78.087150	39.043575	1.73	0.1988
Age*Height	4	48.479783	12.119946	0.54	0.7101
Error	11	541.927961	22.580332		
Total	35	2097.482900			

C.V.= 19.65%

Source	df	SS	MS	F-value	Pr>F
NFE					
Block	3	16833.58353	5611.19451	5.21	0.0065
Age	2	87651.87632	43825.93816	40.71	0.0001
Height	2	2733.85287	1366.92643	1.27	0.2991
Age*Height	4	3500.92347	875.23087	0.81	0.5293
Error	24	25836.2746	1076.5114		
Total	35	136556.5108			

C.V.= 17.57%

Table A10.1 Analysis of Variance of nutrient compositions of leaf and stem

Source	df	SS	MS	F-value	Pr>F
DM of leaf					
Block	3	34.7188222	11.5729407	0.25	0.8619
Age	2	972.9069556	486.4534778	10.43	0.0006
Height	2	45.8155056	22.9077528	0.49	0.6180
Age*Height	4	56.3906278	14.0976569	0.30	0.8736
Error	24	1119.427178	46.642799		
Total	35	2229.259089			

C.V. = 12.67%

Source	df	SS	MS	F-value	Pr>F
DM of stem					
Block	3	34.6592528	11.5530843	0.25	0.8621
Age	2	972.9742722	486.4871361	10.43	0.0005
Height	2	45.7604389	22.8802194	0.49	0.6182
Age*Height	4	56.3579778	14.0894944	0.30	0.8736
Error	24	1118.911222	46.621301		
Total	35	2228.663164			

C.V. =14.82%

Table A10.2 Analysis of Variance of nutrient compositions of leaf and stem

Source	df	SS	MS	F-value	Pr>F
CP of leaf					
Block	3	8.81616389	2.93872130	1.96	0.1473
Age	2	86.27280000	43.13640000	28.73	0.0001
Height	2	2.08126667	1.04063333	0.69	0.5097
Age*Height	4	4.62963333	1.15740833	0.77	0.5548
Error	24	36.0308111	1.5012838		
Total	35	137.8306750			

C.V. =5.67%

Source	df	SS	MS	F-value	Pr>F
CP of stem					
Block	3	0.55808889	0.18602963	0.25	0.8635
Age	2	40.08600556	20.04300278	26.48	0.0001
Height	2	1.79868889	0.89934444	1.19	0.3221
Age*Height	4	2.28812778	0.57203194	0.76	0.5642
Error	24	18.16911111	0.75704630		
Total	35	62.90002222			

C.V. =10.81%

Table A10.3 Analysis of Variance of nutrient compositions of leaf and stem

Source	df	SS	MS	F-value	Pr>F
CF of leaf					
Block	3	6.71416389	2.23805463	1.57	0.2229
Age	2	34.14845000	17.07422500	11.97	0.0002
Height	2	0.36621667	0.18310833	0.13	0.8802
Age*Height	4	6.42943333	1.60735833	1.13	0.3674
Error	24	34.24081111	1.42670046		
Total	35	81.89907500			

C.V.=11.68%

Source	df	SS	MS	F-value	Pr>F
CF of stem					
Block	3	15.6173194	5.2057731	1.11	0.3657
Age	2	212.7552056	106.3776028	22.62	0.0001
Height	2	11.7745056	5.8872528	1.25	0.3040
Age*Height	4	10.4799611	2.6199903	0.56	0.6959
Error	24	112.8865056	4.7036044		
Total	35	363.5134972			

C.V. =4.95%

Table A10.4 Analysis of Variance of nutrient compositions of leaf and stem

Source	df	SS	MS	F-value	Pr>F
Ash of leaf					
Block	3	1.09269722	0.36423241	1.78	0.1781
Age	2	12.76251667	6.38125833	31.16	.0001
Height	2	0.17421667	0.08710833	0.43	0.6584
Age*Height	4	0.28126667	0.07031667	0.34	0.8460
Error	24	4.91497778	0.20479074		
Total	35	19.22567500			

C.V. =6.40%

Source	df	SS	MS	F-value	Pr>F
Ash of stem					
Block	3	3.64215556	1.21405185	13.16	0.0001
Age	2	6.34428889	3.17214444	34.38	0.0001
Height	2	1.97073889	0.98536944	10.68	0.0005
Age*Height	4	0.74136111	0.18534028	2.01	0.1253
Error	24	2.21414444	0.09225602		
Total	35	14.91268889			

C.V. =6.41%

Table A10.5 Analysis of Variance of nutrient compositions of leaf and stem

Source	df	SS	MS	F-value	Pr>F
EE of leaf					
Block	3	4.35851111	1.45283704	6.99	0.0015
Age	2	2.28157222	1.14078611	5.49	0.0109
Height	2	0.18083889	0.09041944	0.43	0.6523
Age*Height	4	0.26966111	0.06741528	0.32	0.8589
Error	24	4.98923889	0.20788495		
Total	35	12.07982222			

C.V. =14.56%

Source	df	SS	MS	F-value	Pr>F
EE of stem					
Block	3	0.40868889	0.13622963	2.13	0.1231
Age	2	0.09483889	0.04741944	0.74	0.4873
Height	2	0.23348889	0.11674444	1.82	0.1831
Age*Height	4	0.54307778	0.13576944	2.12	0.1094
Error	24	1.53626111	0.06401088		
Total	35	2.81635556			

C.V.=18.86%

TableA10.6 Analysis of Variance of nutrient compositions of leaf and stem

Source	df	SS	MS	F-value	Pr>F
NFE of leaf					
Block	3	40.70806667	13.56935556	5.07	0.0073
Age	2	30.04055000	15.02027500	5.61	0.0100
Height	2	1.74831667	0.87415833	0.33	0.7245
Age*Height	4	5.37723333	1.34430833	0.50	0.7342
Error	24	64.21603333	2.67566806		
Total	35	142.09020000			

C.V. =2.82%

Source	df	SS	MS	F-value	Pr>F
NFE of stem					
Block	3	13.59018889	4.53006296	0.94	0.4349
Age	2	33.48733889	16.74366944	3.49	0.0467
Height	2	1.02675556	0.51337778	0.11	0.8990
Age*Height	4	3.39191111	0.84797778	0.18	0.9482
Error	24	115.15046111	4.79793588		
Total	35	166.64665556			

C.V. =5.21%

Table A11 Analysis of Variance of feed intake and body weight gain

Source	df	SS	MS	F-value	Pr>F
Feed intake					
Treatment	4	12.12400384	3.03100096	1.32	0.2955
Error	20	45.80345120	2.29017256		
Total	24	57.92745504			

C.V. =1.40%

Source	df	SS	MS	F-value	Pr>F
Body weight gain					
Treatment	4	10567.89062	2641.97266	2.44	0.0807
Error	20	21679.02504	1083.95125		
Total	24	32246.91566			

C.V. =29.19%

Table A12 Analysis of Variance of egg production

Source	df	SS	MS	F-value	Pr>F
Egg Production					
Treatment	4	64.26126400	16.06531600	2.92	0.0470
Error	20	109.93788000	5.49689400		
Total	24	174.19914400			

C.V. =2.63%

Source	df	SS	MS	F-value	Pr>F
Egg weight					
Treatment	4	5.67029600	1.41757400	1.01	0.4253
Error	20	28.04184000	1.40209200		
Total	24	33.71213600			

C.V.=1.99%

Source	df	SS	MS	F-value	Pr>F
Egg mass					
Treatment	4	12.86456000	3.21614000	1.11	0.3795
Error	20	57.96924000	2.89846200		
Total	24	70.83380000			

C.V. =3.23%

Table A13 Analysis of Variance of production cost

Source	df	SS	MS	F-value	Pr>F
Feed intake/ egg production					
Treatment	4	0.01074504	0.00268626	1.69	0.1909
Error	20	0.03172320	0.00158616		
Total	24	0.04246824			

C.V. =2.74%

Source	df	SS	MS	F-value	Pr>F
Cost per dozen					
Treatment	4	1.13825600	0.28456400	3.15	0.0367
Error	20	1.80536000	0.09026800		
Total	24	2.94361600			

C.V. =2.74%

Table A14.1 Analysis of Variance of egg quality

Source	df	SS	MS	F-value	Pr>F
Specific gravity					
Treatment	4	0.00000577	0.00000144	0.87	0.5004
Error	20	0.00003327	0.00000166		
Total	24	0.00003905			

C.V. =0.12%

Source	df	SS	MS	F-value	Pr>F
Shell Thickness					
Treatment	4	0.00036504	0.00009126	1.72	0.1850
Error	20	0.00106080	0.00005304		
Total	24	0.00142584			

C.V. =2.05%

Source	df	SS	MS	F-value	Pr>F
Albumen Height					
Treatment	4	1.01666400	0.25416600	1.35	0.2855
Error	20	3.75832000	0.18791600		
Total	24	4.77498400			

C.V.= 4.94%

Table A14.2 Analysis of Variance of egg quality

Source	df	SS	MS	F-value	Pr>F
Haugh Unit					
Treatment	4	23.98978400	5.99744600	1.13	0.3690
Error	20	105.78896000	5.28944800		
Total	24	129.77874400			

C.V. =2.49%

Source	df	SS	MS	F-value	Pr>F
Yolk colour score					
Treatment	4	50.41678400	12.60419600	945.69	0.0001
Error	20	0.26656000	0.01332800		
Total	24	50.68334400			

C.V.= 1.61%

Table A15 Analysis of Variance of egg composition

Source	df	SS	MS	F-value	Pr>F
Yolk					
Treatment	4	17.89625600	4.47406400	1.00	0.4322
Error	20	89.75324000	4.48766200		
Total	24	107.64949600			

C.V. =8.58%

Source	df	SS	MS	F-value	Pr>F
Albumen					
Treatment	4	28.58365600	7.14591400	0.79	0.5474
Error	20	181.72984000	9.08649200		
Total	24	210.31349600			

C.V. =4.64%

Source	df	SS	MS	F-value	Pr>F
Eggshell					
Treatment	4	3.17968000	0.79492000	0.67	0.6196
Error	20	23.68892000	1.18444600		
Total	2 4	26.86860000			

C.V. =10.60%

Table A16 Analysis of Variance of Packed cell volume and Plasma protein

Source	df	SS	MS	F-value	Pr>F
Packed cell volume					
Treatment	4	57.16000000	14.29000000	2.35	0.0887
Error	20	121.40000000	6.07000000		
Total	24	178.56000000			

C.V. =9.21%

Source	df	SS	MS	F-value	Pr>F
Plasma protein					
Treatment	4	3.48240000	0.87060000	1.26	0.3187
Error	20	13.82800000	0.69140000		
Total	24	17.31040000			

C.V. =12.74%

Cirriculum Vitae

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