



UNIVERSITI PUTRA MALAYSIA

**EFFECT OF LEVEL OF SUPPLEMENTARY PROTEIN ON
MILK PRODUCTION OF DAIRY COWS**

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**An animal industry project paper submitted in partial
fulfilment of the requirement for the degree of Doctor
of Veterinary Medicine (DVM) in the faculty of Veterinary
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The image features a large, semi-transparent watermark of the Universiti Putra Malaysia (UPM) logo. The logo is a shield-shaped emblem with a red and white color scheme. At the top left, the letters 'UPM' are displayed in white on a red background. The central part of the shield contains a stylized white bird or wing design. To the right of the bird is an open book. The bottom of the shield is decorated with vertical white lines. The watermark is oriented diagonally across the page.

**For my parents and fiancée, whose love, patience
and understanding, I can never hope to
repay.**

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ABSTRACT

In a study conducted over two months, 9 dairy cows from the Dairy Unit, Universiti Pertanian Malaysia, were randomly divided into 3 groups; A, B and C with 3 animals in each group. Over a duration of 8 weeks, 4 weeks were allowed for the adaptation of feed and the other 4 weeks, the actual experimental period. During the adaptation period, the cows were individually fed a ration formulated according to the National Research Council requirements. In the experimental period, group A was assigned to feeding a ration formulated according to National Research Council requirement and rations for groups B and C were 20 and 40 per cent crude protein above National Research Council requirement. Thus, the crude protein level in rations of group A, B and C were 12-13, 14.4-15.6 and 18.4 per cent respectively. There was no significant difference between treatment means in milk yield during the experimental period. There was no change in the butter fat and protein content of the milk, during both periods. No significant change in the dry matter intake was observed among the treatments between the adaptation and experimental periods. An increase of 1-1.7 kilogram in the mean daily milk yield in all the groups obtained, could be due to the effect of the excess metabolizable energy the animals had consumed.

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INTRODUCTION

Facing an ever increasing demand for animal protein in general and milk and milk products in particular, the government has set 1990 as the year by which Malaysia must produce 20 per cent of its requirements of milk and milk products (16). Malaysia presently depends heavily on importation of dairy products. While about 5.4 million litres of fresh milk were produced locally in the year 1982, a total of 440 million litres of liquid milk equivalent was imported the same year. Total consumption of dairy products increased by 40 per cent between 1973 and 1980, when domestic production only increased marginally about 3 per cent of total milk consumption. Much attention should, therefore be given to the dairy development in the country (18).

One way of increasing the milk production is by improving the nutrition of dairy cows. This can be done partly by protein supplementation. Protein can affect milk production by providing more amino acids, increasing available energy and altering the efficiency or pattern of use of absorbed nutrients (1). Oldham and Smith (14) suggested 35 per cent to 75 per cent of the production responses were due to the direct effect of protein, whereas 25 to 65 per cent were the result of indirect energy effects. Effects via altering the efficiency or pattern of use of absorbed nutrients might be mediated, at least in part, by additional absorbed amino acids, causing adjustments of endocrine status to affect lipid and glucose metabolism, and increase nutrient supply to the mammary glands by increasing blood flow (13).

My objective is to determine the effects of different levels of supplementary protein on milk production of dairy cows at the Dairy Unit in Universiti Pertanian Malaysia.

LITERATURE REVIEW

There has been considerable controversy about the amount of dietary crude protein needed by dairy cows. This probably has been brought about by the differences in source of protein and its contribution to either rumen ammonia or protein digested in the intestines. Also under different feeding systems the availability of microbial protein is affected by variation of turnover of microbes within the rumen and the out-flow rate from the rumen (10).

Requirements of ruminants for amino acids are met from microbes grown in the rumen and digested in the small intestines and from dietary protein that is not degraded in the rumen but is intestinally digestible (by pass protein) (10).

There is extensive evidence that milk production will increase with crude protein intake (1). With diets based on corn and soybean meal large increases of milk yield are obtained when crude protein concentration is raised from 9-10 to 13-14 per cent. Increasing crude protein above 14 per cent results in smaller and declining rates of increase (1). On the other hand, there are experiments which showed a higher milk yield in cows receiving 15 or 17 per cent protein ration than those receiving 13 per cent protein ration (4).

A low nitrogen intake can reduce rumen micro-organism activity and consequently the digestibility of organic matter and the ingestibility of feed. It can also reduce amino acid supply and consequently the milk yield as well as the intake capacity of the cows (9).

Gordon and Forbes (5), has shown that an increase in the level of protein intake above the requirements has little effect on milk yield and composition, but levels of dietary proteins considerably below requirements lead to a decline in milk yield and protein content.

The utilization of digestible nitrogen for milk secretion and milk production was influenced by the nitrogen intake level only when the crude protein content dropped below a limiting value; this influence did not cause a reduction in the protein content of the milk but affected the daily milk production. Daily nitrogen intake and protein content of diet above this limiting value was not utilized by the animal, but was lost in the urine (15).

When a diet was given for about one month the optimum crude-protein content was 15-16 per cent (dry matter basis). When daily milk production exceeds 20 kilograms, 12-13 per cent for a production of 15-17 kilograms and 11-12 per cent when the cows give less than 10 kilograms of milk per day (15). Also Huber and Thomas (7) concluded that when milk production was under 20 kilogram per day, a ration with a crude protein content of 10.5-11 per cent was adequate.

The minimal crude protein requirement for increments in milk yield are close to 85 gram crude protein per fat-corrected-milk (14). Waldo and Glenn (19) predicted minimum protein in dietary dry matter ranges from 9 to 13 per cent at 10 kilograms milk per day and 11 to 17 per cent at 40 kilograms milk per day.

Evidence of decreasing milk output with increasing protein intake is rarely found, but Daufaer et al (3) found that milk yield in cows fell from 24.5 to 23.1 kilograms fat-corrected milk per day, as ration crude protein increased from 19 to 23 per cent. Also Gordon and McMurray (6) concluded that maximum milk yield occurred in their rations at approximately 20 per cent crude protein in ration dry matter - beyond this level milk yield decreased. The decrease in milk yield (1.4 kilogram fat-corrected milk per day) with increase protein intake would have been associated with an increase energy loss of 3 MJ per day to excrete surplus nitrogen

as urea. This energy cost might therefore, account for about half the reported decline in milk output (14).

Cows given ad libitum feed, dry matter intake generally increases with increased ration crude protein content (14). An increase in ration crude protein up to sixteen per cent or more, will also increase the dry matter digestibility (14).

Clay and Satter (2) attributed an increase in milk production of the dairy cows on the concentrate diets to increases of total feed intake apparently brought about by increase protein content of the diet. Oldham and Smith (14) concluded in ad libitum feeding experiments milk yield responses are approximately two kilograms per unit change fat-corrected milk per kilogram per unit change dry matter intake stimulated by protein feeding. Approximately half of this response is due to energy status and half to a positive 'protein' effect.

The level of energy intake significantly affected both milk yield and milk output. Cows receiving 119 per cent of their energy requirements produced 1.6 kilograms of milk per day more than those animals receiving 81.1 per cent of the requirements (5).

The effect of energy intake on milk yield or composition is related to the level of protein in the diet, and conversely the effect of protein is related to the level of energy (5).

Oldham's (13) discussion concerning the implication of low, medium, and high ratios of amino acids to energy yielding nutrients absorbed from the gut are as follows :

(a) When amino acid supply is inadequate, milk production will be less than optimal, and excess energy-yielding nutrients can be stored as fat or

oxidized resulting in decreased utilization of metabolisable energy.

- (b) When amino acid supply is inadequate in relation to energy-yielding nutrients, the latter do not need to be stored as fat or oxidized and furthermore, amino acids may increase milk synthesis directly to 'pull' more nutrients out of the tissues or indirectly by causing mobilization of nutrients from tissues to 'push' milk production up.
- (c) When amino acids supply is high in relation to energy-yielding nutrients amino acids in excess of those secreted into milk are deaminated with the energy cost of synthesis and excretion of urea, resulting in reduced efficiency of utilization of metabolizable energy.

When proteins requirements of the cows were compared with diet protein supply (microbial protein plus undegraded feed proteins), a large deficit of proteins appeared very early in lactation under normal feeding conditions. It can equal 50 per cent of the protein requirements during the first two weeks of lactation. Meeting this protein requirements stimulates milk synthesis at the expense of body reserves (body fat principally, but also body protein) when roughages were given in limited amounts after calving (9). There is also a large energy-deficit during the same time as a result of a maximum output of energy in the milk during those periods (8).

Liveweight loss can be reduced by increasing protein intake by increasing ration digestibility and/or feed intake. The increased energy intake counterbalances energy release from tissue reducing net tissue mobilization (liveweight loss) (14).

At high levels of feeding or with high concentrate rations, increments of protein intake reduce liveweight loss early in lactation. At low levels of feeding, or with low concentrate rations, increments of protein intake appear to stimulate adipose tissue mobilization and increase liveweight loss (14).

MATERIALS AND METHODS

The study was conducted at the Dairy unit, Field 15, Universiti Pertanian Malaysia over a two month period. Nine animals were used for this study. The animals were randomly divided into 3 groups (A, B and C) with 3 animals in each group. All cows were fed a ration formulated according to the National Research Council (12) requirements. The cows were allowed 4 weeks for the adaptation of feed and they were individually fed during that period. A further 4 weeks were assigned for the experimental period.

Treatments

Group A was assigned to feeding a ration formulated according to the National Research Council requirement. This ration had a crude protein level of 12-13 per cent. The ration for group B and C were fed 20 per cent and 40 per cent crude protein above the National Research Council requirement, respectively. The crude protein level (dry matter basis) in rations, for group B was 14.4- 15.6 per cent and for group C was 18.4 per cent.

Forage

Cut Guinea grass (Panicum maximum) was given to all these animals. The Guinea grass was obtained daily from Field 15, Universiti Pertanian Malaysia. It was cut at 8 to 10 weeks maturity by a double chop forage harvester giving a chop length of 5 to 10 centimeters and was delivered once per day to the unit. Each of the cows were fed with 15 kilograms of this grass on fresh basis.

Concentrate

Commercial concentrate was given to these cows. Maize and soya bean were added to the commercial concentrate and mixed together to formulate the ration for the cows. Cows in group A, received ration containing commercial concentrate, maize and Guinea grass. Whereas cows in group B and C received ration consisting of Guinea grass, commercial

concentrate and soya bean.

Animal Management

All cows were stall fed individually. The cows were fed twice a day, that is at 9 a.m. and at 2 p.m. Clean drinking water was also provided for the cows. The cows were machine-milked twice a day, at 6.30 a.m. and at 4 p.m.

Milk Yield and Composition

The milk yield of each cow was recorded during the whole two month period. Milk samples were taken from individual cows, once during the last week of the adaptation period and again during the experimental period. The samples were collected in the morning and evening. Butterfat was determined by Gerber method and protein by modified Esbach's method.

Forage and feed intake

Forage intake of individual cows were estimated, during one week of the adaptation period and one week of the experimental period, by weighing daily the cut Guinea grass fed and refusals from the cows. During these weeks, concentrate intakes of all cows were estimated from concentrates fed less refusals. As refusals were very little, concentrate intake was taken as concentrate fed. All forage and feed samples were dried at 60 to 65 degrees centigrade in a forced draught oven.

Liveweight change

The cows were weighed one month before the study period and at the end of the study period.

Chemical Analysis

Dried samples were ground through a 1 millimetre screen in a laboratory mill. The samples were analysed for their crude protein, crude fibre, ether extract, ash, nitrogen free extract and dry matter. Metabolizable energy was estimated from equations given by M.A.F.F. (11).

Statistical Analysis

Analysis of variance between means were done according to Steel and Torrie (17),

RESULTS

Table 1: Mean milk production (Kg) during adaptation and experimental period.

Group	Adaptation period milk yield/kg	Experimental period milk yield/kg
	6.03 ± 1.97	7.762 ± 1.56
B	6.143 ± 1.73	7.857 ± 2.73
C	6.143 ± 0.91	7.142 ± 1.62

Table 2: Mean values of milk composition during the adaptation and experimental period.

Period	Group	Butterfat (%)	Protein (%)
adaptation	A	2.6 ± 0.32	1.7 ± 0.29
	B	4.1 ± 0.67	1.8 ± 0.29
	C	3.7 ± 1.33	1.7 ± 0.29
experimental	A	2.6 ± 0.32	1.7 ± 0.29
	B	4.1 ± 0.67	1.8 ± 0.29
	C	3.7 ± 1.33	1.7 ± 0.29

Table 3: Mean values of dry matter intake and crude fibre (CF) intake during the adaptation and experimental period.

Period	Group	DMI (kg)	CF (kg)
Adaptation	A	9.80	1.84
	B	9.70	1.90
	C	10.00	1.92
Experimental	A	9.92	1.91
	B	9.80	1.98
	C	10.40	1.98

Table 4: Calculated mean values of crude protein consumed by animals per day in comparison with National Research Council requirements during the experimental period.

Group	N.R.C.(gm)	Consumed (gm)	Consumed above N.R.C. requirement
A	1149.7	1190.0	3.5%
B	1123.7	1380.0	22.8%
C	1218.7	1740.0	42.4%

Table 5: Mean level of metabolizable energy consumed by animals per day, during the experimental period.

Group	Required by animals ME (MJ)	Consumed by animals ME (MJ)	Excess energy ME (MJ)%
A	92	106.21	15.4
B	91	102.40	12.5
C	100	110.59	10.6

Table 6 : Mean live weight change during the 3 month period

Group	April 1984 liveweight (kg)	July 1984 liveweight (kg)
A	364 ± 54.5	384 ± 62.7
B	306 ± 73.7	310 ± 50.1
C	399 ± 43.9	411 ± 35.4

There was no significant difference between treatment means in milk yield during the experimental period (Table 1).

There was no change in the butterfat and protein content of the milk during the adaptation and experimental period (Table 2).

There was no significant change in the dry matter intake and crude fibre intake between the adaptation and the experimental period among the treatments (Table 3).

The animals in groups A, B and C consumed 3.5 , 2.8 and 2.4 per cent crude protein respectively, above the treatment values in this experiment (Table 4).

The animals in groups A, B and C consumed 15.4, 12.5 and 10.6 per cent excess metabolizable energy than required by the animals in the respective groups (Table 5).

During the 3 month period, there was a 20, 4, and 12 kilogram increase in the mean liveweight change in groups A, B and C respectively (Table 6).

DISCUSSION

There is extensive evidence that milk production will increase with increased crude protein intake (1). Danfaer et al (3) however, found that milk yield decreases slightly when ration crude protein was increased from 19 per cent to 23 per cent. Gordon (6) also reported that ration containing above 20 per cent crude protein, led to reduction in milk yield. In this experiment, the result shows no significant increase in milk although, the level of crude protein of the ration was well below the 20 per cent level. This could probably be due to the short duration of the experiment.

Paquay et al (15) concluded that the optimal crude protein content of the diet was 15 to 16 per cent (dry matter basis) when milk production exceeded 20 kilograms per day, 12 to 13 per cent for a production of 15 to 17 kilograms per day and 11 to 12 per cent for cows giving less than 10 kilograms per day. The cows in this experiment had a daily milk yield of about 10 kilograms only, so a crude protein content of 11 to 12 per cent (dry matter basis) in the diet would be sufficient. Also Gordon and Forbes (5) reported that an increase in the level of protein intake above the requirements has little effect on milk yield and composition but levels of dietary protein considerably below requirements led to a decline in milk yield and protein content.

There is an increase of 1 to 1.7 kilograms in the mean daily milk yield in all the groups. This could not be the effect of protein, since there is also an increase in the milk yield in group A, which does not contain more crude protein than the N.R.C. requirement. The factor that contributed to the increase in the mean milk yield would be due to the effect of the metabolisable energy. This is because all the animals in groups A, B and C had consumed an excess of 15.4, 12.5 and 10.6 per cent of metabolisable energy respectively (Table 5).

This is in accord with the findings of Gordon and Forbes (5) who concluded that the level of energy intake significantly affected milk yield. In their experiment, cows receiving 119 per cent of their energy requirements produced 1.6 kilograms of milk per day more, than those receiving 81.1 per cent of the requirements. Also Oldham and Smith (14) suggested 35 to 75 per cent of the milk production responses were due to the direct effects of protein, whereas, 25 to 65 per cent were the result of indirect energy effects. The excess metabolisable energy consumed by the animals in this experiment, was due to the excess grass intake of the animals.

There was no change in butterfat and protein content of the milk during the adaptation and experimental period (Table 2). These findings were similar to the findings of Edwards et al (4) who found no changes in percentages of milk components between cows fed rations of 13, 15 and 17 per cent crude protein (dry matter basis). Also Gordon and Forbes (5) found that an increase in the level of protein intake above the requirements has little effect on milk composition.

There is evidence of increase in dry matter intake, with increase in the protein content in the ration. This is due to the increase in the digestibility of the diet (14). In this experiment however, there was no significant change in the dry matter intake and crude fibre intake between the adaptation and experimental periods among the groups (Table 3). The short duration of this experiment did not allow for the effect of protein supplement to be seen in the dry matter intake of the cows in the various groups.

The animals in groups A, B and C consumed 3.5, 2.8, and 2.4 per cent crude protein respectively above the treatment values in this experiment (Table 4). This is due to excess grass intake by the animals.

An increase in the mean liveweight of the animals in the groups A, B and C, was noted during the three month period (April, 1984 to July, 1984). This is probably because the cows were receiving better nutrition during the feeding trial as compared to prior the experiment. Liveweight can also increase by increasing protein intake, by increasing ration digestibility and by increasing feed intake (14).

CONCLUSION

From this study, it was found that there was no significant difference between treatment means, in the milk yield of the cows during the experimental period. There was no significant increase in milk yield when the crude protein content in the diet of the cow was increased, probably due to the short duration of this experiment.

REFERENCES

1. Chalupa, W. 1984. Symposium: Protein Nutrition of the lactating dairy cow. J. Dairy Sci., 67 : 1134-1146.
2. Clay, A.B. and Satter, L.D. 1979. Milk production response to dietary protein and methionine hydroxy analogue, J. Dairy Sci., 62 (suppl.1): 75 (Abstr.)
3. Danfaer, A., Thyssen, I. and Ostergaard, V. 1980. Beretn. St. Husdyrbugu forsog., No.492 (Abstr.)
4. Edwards, J.S., Bartley, E.E. and Dayton, A.D. 1980. Effects of Dietary Protein Concentration on Lactating Cows. J. Dairy Sci., 63: 243-248
5. Gordon, F.J. and Forbes, T.J. 1970. The associative effects of level of energy and protein intake in the dairy cow. J. Dairy Res., 37 : 481 - 491.
6. Gordon, F.J. and McMurray, C.H. 1979. The optimal level of protein in the supplement for dairy cows with access to grass silage. Anim. Prod., 29 : 283 - 289.
7. Huber, J.T. and Thomas, J.W. 1971. Urea-treated corn silage in low protein rations for lactating cows. J. Dairy Sci., 54 : 224 - 228.
8. Journet, M. and Remond, B. 1976. Physiological factors affecting the voluntary intake of feed by cows : a review. Livest. Prod. Sci., 3 : 129 -146.
9. Journet, M. and Remond, B. 1981. Response of dairy cows to protein level in early lactation. Livest. Prod. Sci., 8 : 21-35.
10. Leng, R.A. and Nolan, J.V. 1984. Symposium : Protein Nutrition of the lactating dairy cow. J. Dairy Sci., 67 : 1072-1089.

11. M.A.F.F. 1975. Energy Allowances and Feeding Systems for Ruminants, Tech. Bull. No. 33, Ministry of Agriculture, Fisheries and Food. H.M.S.O., London, UK.
12. N.R.C. 1978. Nutrient Requirements of Dairy Cattle (5th. Ed.) National Academy of Science, National Research Council, Washington, D.C., U.S.A.
13. Oldham, J.D. 1984. Symposium : Protein Nutrition of the lactating dairy cow. J. Dairy Sci., 67: 1090 - 1114.
14. Oldham, J.D. and T.Smith. 1982. Protein-energy interrelationships for growing and lactating cattle. In, The Protein Contribution of Feedstuffs for Ruminants : Application to Feed Formulation (Eds. E.L. Miller, I.H. Pike and A.J.H. Van Es). Butterworth, London , UK. p. 103-130.
15. Paquay, R., J.M. Godeau, R.De Baere, and A. Lousse. 1973. The effects of the protein content of the diet on the performance of lactating cows. J. Dairy Res., 40 : 93-103.
16. Peters, K.J. and T.Selvarajah. 1977. Breeding for milk in Malaysia. Mal. Appl. Biol., 6 (2) : 243 -254.
17. Steel, R.G.D. and J.H.Torrie. 1980. Principles and Procedures of Statistics. (2nd. Ed.). McGraw-Hill, New York, U.S.A.
18. Vijchulata, P. and A. Osman. 1984. Dairy cattle. In, Animal Production in Malaysia (Eds. P. Vijchulata, T.A. Bongao and M.D. Mahyuddin Universiti Pertanian Malaysia, Serdang, Malaysia. p. 5-12.
19. Waldo, D.R. and B.P.Glenn. 1984. Comparison of new protein systems for lactating dairy cows. J.Dairy Sci., 67 : 1115 -1133.

APPENDIX

Metabolizable energy (ME) was estimated from equations:

$$\text{ME forage (MJ/ kg DM)} = 13.3 + 0.17 \text{ CP\%} - 0.19 \text{ CP\%}$$

$$\text{ME concentrate (MJ/ kg DM)} = 0.12 \text{ CP\%} + 0.31 \text{ EE\%} + 0.05 \text{ CP\%} + 0.14 \text{ NFE}$$

source:

M.A.F.P. 1975. Energy Allowances and Feeding Systems for Ruminants.

Tech.Bull. NO. 33, Ministry of Agriculture, Fisheries and Food.

H.M.S.O., London, UK.

$$\text{ME forage (MJ/ kg DM)} = 5.19 + 0.293 \text{ CP\%}$$

Lane, I.R. and Mustaffa. 1983. Proc.Vth.Wld.Conf. Anim. Prod.,

Tokyo, Japan.

FEED ANALYSIS

		<u>CP</u>	<u>C. Fat</u>	<u>C.F.</u>	<u>NFE</u>	<u>Ash</u>	<u>DM</u>	<u>ME/MJ</u>
Forage Fed	Adaptation	6.31	1.01	40.82	45.90	5.96	90.33	6.62
	Experimental	5.10	1.09	42.49	47.10	4.26	93.22	6.10
Maize	Adaptation	10.49	5.11	1.74	80.53	2.13	96.73	14.2
	Experimental	10.78	5.01	1.26	81.12	1.83	96.48	14.
Concentrate	Adaptation	16.83	4.89	9.45	61.29	7.54	97.18	12.
	Experimental	16.31	5.04	9.58	61.47	7.60	96.84	12.
Soya Bean	Adaptation	44.71	5.62	5.38	38.12	6.17	97.32	12.
	Experimental	45.06	5.20	5.63	37.81	6.30	97.19	12.59