PRODUCTION CHARACTERISTICS AND RESPONSES TO FEEDING BY FRIESIAN COWS FAT AND THIN AT CALVING OF HIGH AND LOW GENETIC MERIT

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ABSTRACT

A review of literature is given on herbage intake achieved by grazing lactating dairy cows. The lactating cows have higher herbage intake than non-lactating cows. Condition at calving may have an effect on herbage intake by dairy cows. The theory of response, the response to feeding both before and after calving are also reviewed. The literature is reviewed which discusses responses to feeding in Europe (where diet of the cows are mainly concentrates) and in Australia and New Zealand where dairy cows graze mainly on pasture. The evidences of improving cows quality by selection are given with special emphasis on New Zealand dairy cows. Genetic merit of a New Zealand cow for milkfat production is measured by her breeding index (BI).

The main objective of the work was to study production characteristics and response to feeding in early lactation by Friesian cows, fat and thin at calving, of high and low genetic merit. Over lactation High BI cows produced more than Low BI cows. The differences between BI groups in milkfat production was in close agreement with the expected differences based on BI's. High BI cows had slightly higher herbage intake than Low BI cows but no signifcant differences were found. Low BI cows were fatter than High BI cows. No significant difference in fatty acid composition of milk between the BI groups was found. Over lactation Fat cows produced more milkfat than Thin cows. Improving 1 condition score at calving was associated with an increase of 10.5 kg milkfat.

No significant differences in response to feeding in early lactation between High BI and Low BI cows nor between Fat and Thin cows were found. The response to moderate underfeeding during early lactation was mainly immediate response. The residual effects of underfeeding were small and confined to 2 weeks after returning to full feeding. Underfeeding significantly increased mole % of long chain fatty acids of milk and significantly decreased mole % of short chain fatty acids.

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1 LITERATURE REVIEW

1.1 INTRODUCTION

A farmer's aim is to maximize income or profit from given resources. The herd and feed are the major cost on a dairy farm and the farmer must utilize them optimally. Optimum feeding of the dairy cow involves a study of feed inputs and milk outputs and economic evaluation of the relationship between these two. Traditional approach to feeding was based on meeting the current energy and other nutrients needs of the cow, calculated from the current requirements. It became evident that meeting the cow's current requirements was not necessarily the optimum means of achieving high outputs while minimising inputs. From the classic theory of response by the pioneer work of Blaxter (Blaxter, 1956, 1962), that the response of the cow to its level of feeding was related to its past and future nutrition as well as to its current level of feeding. Blaxter suggested that the emphasis should be placed on the need for a more dynamic appoach in which food is allocated to secure the greatest advantage for milk production in the long term. Hence the need to view the response of the dairy cow to its level of feeding over the whole lactation cycle. The relationship between pre-calving and post-calving periods in terms of the response to the feeding can be related in terms of body reserves and planes of nutrition, and also the relationship between the periods of lactation can also be related in these terms. As body reserves play the major role in buffering cows' capacity to meet fluctuation in nutrition supply.

Recent research has investigated the distribution of feed within a lactation cycle for optimum use of feed inputs. As well as analysis of immediate responses to extra feed at the different stages of lactation cycle, the cumulative effects of level of intake over time have to be studied. But because of the complexity of milk production and interaction with other physiological and environmental factors, correct interpretation of the results from the dairy cow experiments is difficult. Actual milk production is not only a result of immediate prevailing feeding and management, but also influenced by the long-term condition as discussed below. Therefore, as suggested by Wiktorsson (1979) it is desirable to study cows not just during parts of a single lactation, but rather over several lactations. However, results in literature from multiple lactation studies are scarce. Thorough understanding the effects of different levels of feeding throughout the year is neccessary for the optimal feeding of the dairy cows.

1.2 HERBAGE INTAKE BY GRAZING DAIRY COWS

1.2.1 HERBAGE ALLOWANCE

The herbage allowance has been defined as the weight of herbage offered per unit of animal liveweight at a moment in time. Leaver (1976) cited literature concerning the production trials with dairy cattle showing the relationship between grazing pressure and animal performance. Increases in grazing pressure reduced DM intake and milk yield of dairy cows (Gordon et al., 1966; Greenhalgh et al., 1966), and liveweight gains of young stock (Hodgson et al., 1971; Leaver, 1974). The terms 'grazing pressure' and another term 'herbage allowance' are inversely related (Hodgson, 1979), the latter is normally used in the context of a predetermined allowance of herbage, whereas grazing pressure may often describe the results of change in the balance between herbage growth and consumption. The concept of herbage allowance is also appropriate to rotational grazing systems where individual plots are grazed down rapidly over a finite interval of time, e.g. daily herbage allowance. Thus, with dairy cows (Combellas & Hodgson, 1979; Bryant, 1980; Le Du et al., 1981), with calves (Jamieson & Hodgson, 1979) the term 'herbage allowance' was used in their grazing studies to describe its effect on animal performance. The herbage allowance is preferred because it gives a better impression of the balance between demand and supply of herbage in grazing systems (Hodgson, 1979).

Minson (1981) recommended that quantities of herbage allowance should be expressed in terms of g DM/Kg LW to elliminate differences in body size. But Hodgson & Jamieson (1981) pointed out that the expression of intake per unit of liveweight has limitation where different liveweight reflect changes in body condition.

The effects of daily herbage allowance on herbage intake are well documented in literature (Gordon et al, 1966; Greenhalgh, 1966; Jamieson & Hodgson, 1974; Combellas & Hodgson, 1975; Gibb & Treacher, 1975; Holmes, 1980). Herbage allowance is an important determinant of the herbage intake and performance of grazing cattle (Reardon, 1975; Hodgson, 1975; Combellas & Hodgson, 1979; Trigg & Marsh, 1979; Bryant, 1980; Glassey et al., 1980; Baker et al., 1981). Rattray & Jagusch (1979) stated that herbage allowance is probably the most important single factor that is responsible for differences in production per animal between farm, between years, and between stocking rates under New Zealand condition.

From grazing trials with growing cattle, it has generally been found that there is a curvilinear relationship between herbage allowance and herbage intake over the range of herbage allowance of 10 - 90 g DM/Kg LW/day (Marsh & Murdoch, 1974; Jamieson & Hodgson, 1979), and similar data have been reported for grazing dairy cows (Greenhalgh et al., 1966; Stehr & Kirchgsser, 1976; Combellas & Hodgson, 1979; Bryant, 1980; Holmes & Mclenaghan, 1980; Glassey, 1980; Ngarmsak, 1982). Holmes (1980) illustrated clearly that under strip-grazing experiments, the relationship is curvilinear or asymptotic in which daily herbage intake is reduced gradually as the daily herbage allowance reduced until a pointed is reached when further reduction of herbage allowance causes a marked decline in herbage intake. Furthermore, according to Bryant (1980), where this occurs there is then a considerable scope for adopting grazing management that is a sensible compromise between high animal performance and efficient pasture utilisation. Hodgson (1975) indicated that under temperate conditions, herbage intake achieved by lambs appears to approach the maximum only at levels of daily herbage allowance (measured to ground level) equivalent to four times the amount eaten. Whereas, with dairy cows, Combellas & Hodgson (1979) found that herbage intake was near maximum when herbage allowance was equivalent to twice intake. Le Du et al.(1979) found that both intake and milk production were depressed once cows were forced to consume more than 50% of herbage on offer or to graze the sward closer than 8-10 cm (residual herbage).

1.2.2 RESIDUAL HERBAGE MASS

As well as herbage allowance, Holmes (1978, 1981) suggested that residual herbage mass can provide useful indications of herbage intake in well defined conditions, and that residual herbage mass may prove easier for farmers to adopted and apply. Nottingham (1978) found that intake, condition score and liveweight changes were significantly correlated to the level of residual herbage mass and suggested that residual mass may be a more useful means of assessing dairy cows requirements than herbage allowance because it was not necessary to known the area being grazed. To assess residual mass needed only the knowledge of herbage mass present per unit area eg. Kg DM/ha.

The relationship between residual herbage mass and herbage intake was also curvilinear (Nottingham, 1978; Bryant, 1980; Glassey, 1980; Ngarmsak, 1982) and was similar to the relationship between herbage allowance and herbage intake. Ngarmsak (1982) pointed out that the herbage intake declined as the residual herbage mass declined could be due to grazing behaviours. Citing the classic works by Stobbs (1973, 1974) who suggested that intake of herbage by grazing animal is a function of both the time animal spent grazing, the rate of biting, and the bite size. It was suggested that as residual herbage mass decreased, the bite size would decrease and the animal would have to spend more time grazing thus herbage intake decreased. Grazing studies (Lazenby, 1981) have revealed a relationship between sward canopy height and intake which differ with grazing system. Cattle have difficulty in eating to appetite when the height of the stubbles on rotationally grazed ryegrass swards falls below 9-10 cm.

1.2.3 HERBAGE INTAKE

The curvilinear relationships between herbage allowance, herbage residual mass and herbage intake by dairy cows are given above. The mechanisms controlling the voluntary herbage intake by dairy cows have been discussed previously (Ngarmsak, 1982). For the present literature review, herbage intake achieved , by dairy cows under different conditions are given.

1.2.3.1 Herbage Intake By Lactating Cows

Lactating cow, because there is a potential increase in energy demand because of its high energy loss through milk production, is expected to have higher food intake than a similar non-lactating cow under similar feeding condition e.g. milk yield 20 l/day 5% fat $\simeq$ to 10 kg DM extra intakes (approx.). From literature, the intakes of lactating cows found to be always more than of dry cows (Campling, 1966; Hodgson, 1977; Hodgson & Jamieson, 1981). The hypotrophy of the alimentary tract which occurs in lactating cows enables them to eat larger amounts of food than non-lactating cows without altering to a great extent the mean retention time of food in the gut (Leaver et al., 1969).

Smith & Baldwin (1974) showed that the weight of the empty rumen of a lactating cow was on average 20% higher than that of a non-lactating cow. Tulloh (1966) show that a gradual enlargement of the alimentary tract occurs after parturition, and this might explain the delay in the increase in intake after calving.

Hutton (1963) shows that in an indoors feeding experiment using 13 sets of identical twins, the lactating twin steadily increased intake from calving so that it was consuming 50% more than its twin sister by the fifth month of lactation. From experiment by Hodgson & Jamieson (1981) with groups of lactating cows grazing a sequence of herbage varying in maturity and herbage mass, under strip grazing management, lactating cows ate 43% - 76% more herbage than non-lactating cows of similar weight. Although lactation has caused intake to increase Broster & Thomas (1981) pointed out that the relationship between the actual milk yield and food intake is poor, partly at least owing to the influence of lactation cycle on intake.

1.2.3.2 The Changes of Herbage Intake and Stage of Latation

Following parturition, the daily milk yield increases rapidly to a maximum between days 35 and 50 of lactation (Bines, 1976; Journet & Remond, 1976); Ostergaard, 1979; Broster et al., 1981; Bryant & Trigg, 1982), and thereafter there is steady decline at the rate about 2.5% per week until the cow is dried off. In contrast, the voluntary food intake of the cow rises much more slowly after parturition and the maximum may not be reached until many weeks after maximum milk yield (Bryant & Trigg, 1982; ARC, 1980). ARC (1980) presented an extensive review of existing information and concluded that relative intake, expressed as a percentage of mean daily intake for the whole lactation is, 81, 98, 107, 108, and 109% for the first five months respectively.

From reviews of published works Bines (1976, 1979) gave evidence that maximum milk yield is reached in 5-8 weeks whereas the time of maximum intake is more variable, ranging from 5 to 36 weeks with a mean value of 16 weeks, this length of time is largely dependent on the diet composition. Journet & Remond (1976), Coppock et al. (1974) showed evidence that food consumption increases more rapidly after calving and reaches a maximum earlier in lactation where the feed has a higher rather than lower energy concentration.

1.2.3.3 Herbage Intake & Mobilisation of Body Reserves in Early Lactation

During the period when voluntary intake lags behind milk yield, body energy reserves in the body act as a buffer which is mobilised to meet the deficit, and which is restored when intake has increased to a level in excess of requirements for current milk yield. During early lactation the intake of energy from the diet is generally lower than the animal's total capacity to synthesis energy into milk. As a result the cow is often seen lose an appreciable amount of body weight over this critical period. Bryant and Trigg (1982) cited the data in the literature which illustrated the ability of the lactating cows in early lactation to mobilize body reserves of energy to support milk production.

Wiktorsson (1980), pointed out that the output from a high yielding cow is so high during the first part of lactation that it is difficult to meet the requirement for energy equilibrium. It may mean that the feeding of high yielding cows in early part of lactation is really a question of the effect of different levels of under-nutrition where the mobilization of the body reserves plays an important role. The ability to mobilize the energy from the body reserves varies between cows (Flatt et al., 1969).

In grazing animals, Journet & Remond (1976) pointed out that the energy reserves accumulated during pregnancy are too small for the potential milk yield to be attained, but Holmes (1984) pointed out that under conditions in which animals can be fed ad libitum they can gain condition even for grazing cows.

1.2.3.4 Herbage Intake & Animal Condition

The upper limit to the voluntary intake of food is assumed to depend on an animal's stage of development rather than age or weight alone (Christian et al., 1978). Increasing degrees of body fatness in ruminants are associated with decreasing of intake of food. The mechanism by which fatness influences appetite is not known (Reid & Robb, 1971).

From indoor feeding trials, it appears that fat animals deposit fat extensively within the abdominal cavity which apparently reduces the effective capacity of the rumen and thus is associated with a reduction in roughage intake by these animals (Bines et al., 1969; Bines, 1971). This reduction in intake is not neccessarily an effect of a physical control mechanism of food intake since the intake of concentrate is also reduced in the fat animal without the rumen being filled (Bines et al., 1969). They pointed out that capacity of the reticulo-rumen did not appear to have limited intake of this diet in either fat or thin cows. They concluded that control of food intake was by a predomiantly metabolic mechanism and that it was flexible in its operation, permitting higher intakes by thin cows than by fat cows.

It has been shown (Bines et al. 1969) that non-lactating dairy cow given ad lib. access to a diet of hay and concentrates consumed approximately 23 % more DM per day when thin than when fat. This was confirmed by Bines & Morant (1983) that when the cows were fat and fed ad lib., the mean total intake was 8.90 kg DM/day and this increased to 11.05 kg DM/day when the cows were thin. This represents a 24 % increase in intake. Cows which are fat at calving have shown depressed intake in early lactation (Bines et al., 1969). Evidence from sheep, Arnold (1970) found that as thin grazing sheep became fat intake reduced.

There is little information available about animal condition effect on intake by the grazing animal. Journet & Remond (1976) pointed out that an increase in the body reserves in grazing cows by deliberate management may also restrict intake by reducing the extent to which the rumen can be expanded after parturition. Grainger et al. (1978) found that cows which calved in poor condition ate more pasture in the first five weeks of lactation than cows that had calved in good condition. And several recent studies have shown the lower voluntary intake in fat cows than in thinner cows (Garnsworthy & Topps, 1982; Land & Leaver, 1980; Neilson et al., 1981)

Garnsworthy & Topps (1982) found that cows that had higher condition scores at calving took longer than thin cows to reach a maximum intake of food and that the fatter cows reached a lower maximum level. They concluded that body fat exerted a physiological inhibitory effect on intake.

1.2.3.5 Herbage Intake Achieved By Grazing Dairy Cows

The grazing cow is subjected to a continually changing pattern of food supply (Freer, 1981). The extent to which the cow achieves its potential intake depends on how it responds to particular condition with which it is faced. Herbage intake of grazing animals may in addition be affected by non-nutritional characteristics of the sward associated primarily with variation in the mass of herbage and its distribution within foliage canopy (Hodgson, 1977). Leaver (1976) pointed out that the herbage intake of a grazing cow is influenced by an additional variety of sward and environmental condition, Leaver (1981) again pointed out that the grazing cow has a range of factors which are likely to influence intake and consequently the potential intake of the cow is rarely met. According to Leaver (1981), the factors affecting herbage intake of grazing cow can be described by;

Actual Intake = Potential Intake - Feed Contraints
- Enviroment Contraints

1.3 RESPONSE TO FEEDING BY DAIRY COWS

1.3.1 THEORY OF RESPONSE TO FEEDING BY DAIRY COWS

Broster & Thomas (1981) have outlined the theory of response to feeding by dairy cows. Yield response to changing feed level may be percieved as immediate (Short term) and residual (Long term) in nature (Ekern & Viko, 1983).

1.3.1.1 Short-term effects

Dairy cows show a continuous response to change in the intake of nutrients, and especially with energy. Such relationship can be used to predict production levels from a knowledge of intake, or to estimate the amount of feed required to achieve a desired level of production. However, in the short terms there is no simple relation between energy intake and milk production because of the role of the body reserve in the balance of energy (Wilson and Davey, 1982). During lactation milk is synthesised from the amount of ME which becomes available from the diet in excess of the costs of maintenance, however this amount of energy may either be supplemented by energy made available from the mobilisation of body tissue, or be reduced by the diversion of energy towards the synthesis of body tissues. Therefore, in the short term, there may be no simple relation between ME intake and milk production because of the important roles of body tissues in the overall balance of energy (Holmes et al.,1981).

The conventional methods for expressing food conversion and marginal response to extra food are;

$$\text{Food Conversion} = \frac{\text{Kg total dietary DM eaten}}{\text{Kg milk fat produced}}$$

For greater precision the equation can be expressed as,

$$\text{Gross Food Conversion} = \frac{\text{energy in DM eaten}}{\text{energy in milkfat produced}}$$

For these equations maintenance cost included, when it is not, it becomes;

$$\text{Marginal Food Conversion} = \frac{\text{Kg extra feed DM eaten}}{\text{Kg extra milk fat produced}}$$

(After Wilson & Davey, 1982)

These conventional methods may yield variable and misleading results because they take no account of the contributions which can be made by changes in body tissues. Holmes et al. (1981) pointed out that such calculation can provide an indication of the magnitude of values to be expected and the extent to which they may vary. And in addition they showed that in the short term and in particular level of feeding, a cow which is synthesising body tissue appears to be less efficient than one which is not. However, if account is taken of future body tissue and of the ME which was mobilised, then the differences in efficiency between the different situations measured over the long term, will be smaller.

Broster & Thomas (1981) cited results from many large-scale experiments involving the addition of concentrates to a conserved forage feeding at fixed level, showed that response in milk output was directly proportional to cow potential or current yield. And that High Yielding cows show greater responses than average but balanced by a lower body weight gain than average. But where conserved forage was given *ad libitum* the results contradicted the theory evolved with fixed feeding, in that response to concentrate was similar among cows of different genetic merit or current yield. This was because when forage was given *ad libitum* the additional concentrate supplement depressed forage intake but increases total intake. Meijs (1982) found that at the low level of allowance, levels of substitution of herbage by concentrated could not be shown to differ from zero, however substitution rate was considerable (0.5) at the high allowance level. From available evidences, Ekern & Vik-Mo (1983) indicated that mean response to changes in energy intake obeys the law of deminishing returns. It is unkown whether this theory evolved from condition prevailing in Europe will be able to applied for pasture grazing cows.

1.3.1.2 Long-term effects

It has been recognised for sometime that the total lactation effects of any change in feed input may be widely different from those assessed as direct effect. Long-terms effects, or residual effects or carry-over effects refer to the effect of the change in level of feeding which is measured after the treatment had finished, expressed relative to the effect measured during the treatment period (immediate effects, Gordon, 1976; Holmes et al., 1981).

Residual Effect =

$$\frac{\text{Total effect on milk produced} - \text{Immediate effect on milk produced}}{\text{Immediate effect on milk produced}}$$

Response in dairy cows to level and changes in feed energy supply depends on a number of factors including yield potential of the cow and stage of lactation, body reserves, and the previous as well as present levels of feed energy, protein and specific nutrients (Ekern & Vik-Mo, 1983).

1.3.2 PRE-CALVING FEEDING

Obviously, with increasing milk production, the dry period becomes more and more important to replenish body reserves which can be drawn upon during the following period of inadequate energy supply (Flatt et al.,1969; Broster, 1971). Flatt et al.(1969) have shown that over a short period, some cows can produce more than 50% of the total yield from body tissues. Good cows are capable of mobilising large amounts of energy for milk production during early lactation provided sufficient stores of body fat exist (Flatt et al., 1972). The advantage for utilization of body reserves in the cows for milk secretion can be based on;

- van Es and van der Honing (1979) assessed much of calorimetric data, and concluded that efficiency of utilization of ME for body gain equalled that for milk production in lactation but was lower in the dry period. Thus, the highest efficiency of conversion of energy to milk is achieved when the cow maintains a stable body weight over lactation and the dry period.

- the relative costs of available feeds.

- the low intake of the cow in early lactation.

But extreme exploitation of energy reserves should, however, be avoided for several reasons (Ekern & Vik-Mo, 1983). As Ekern & Vik-Mo (1983) pointed out, firstly, the succession of fattening and mobilisation for milk production is less efficient than using feed energy directly for milk production. Utilisation of cheap forage or pasture for fattening may however, offset the importance of of these ralationships in practice. Secondly, fat ruminants require more energy for maintenance and consumed less less forage during early lactation. Lastly, excessive fatness at calving may be detrimental to health and fertility (for references see Ekern & Vik-Mo, 1983).

1.3.2.1 The Early Works With Emphasis On Liveweight Changes

In New Zealand, Lees et al.(1948), Campbell and Flux (1948), investigated two levels of feeding in the last three months of pregnancy and the effect of the levels of feeding on the subsequent lactation. These experiments agreed that cows on the higher feeding level before calving produced more milk after calving. There is an indication that larger differences in liveweight at calving were associated with larger differences in milk production. Grainger & McCowan (1982) outlined factors which might have influencing the response to the pre-calving as resulting from the above experiments, these are;

" - level of post-calving feeding,
- absolute level of body condition,
- age of animals (differences in response between cows and heifers) "

Broster (1971) reviewed world literature on pre-calving feeding and suggested that late pregnant cows should gain liveweight at 0 to 0.35 kg/day, and that there is an apparent deminishing returns effect in the milk production response to the level of feeding pre-calving. Rates of gain faster than 0.35 kg/day have progressively less effect on the subsequent milk yield, and finally little advantage is gained for animals approaching late pregnancy to gain weight above 0.5 kg/d. Broster (1971) speculated that as a higher level of feeding in pregnancy leads to a greater liveweight gain in the cow (or less liveweight loss), it will help arrest the potential loss of milk production in early lactation due to underfeeding as there is now increased potential for mobilization of that liveweight to support milk production post-calving. He added that if the objective of increased feeding pre-calving was to build up body energy reserves, then the nutrition of the cow over the preceding lactation also had to be taken into account.

Hutton & Parker (1973) obtained consistently higher milk production in two consecutive years from cows that were maintaining liveweight before calving, compared with cows that were losing maternal liveweight. They showed evidence suggesting that a high level of pre-calving feeding increased the amounts of pasture dry matter consumed after calving. And Bines (1976) commented that it is widely accepted that cows should be 'steamed up' before calving to enable them to use body reserves as a source of energy in early part of the ensuring lactation.

Despite the realization that a beneficial effect on milk production arose from increasing the level of feeding prior to calving, the physiological mechanism by which this was achieved was not apparent. Blaxter (1956) suggested that nutrition exerted its influence on lactation by controlling the activity and the number of secretory cells in the udder. Smith et al. (1967) suggested that sufficient energy supply during the dry period seems vital for the development of the mammary gland. But there is little experimental evidence for this. However, Holmes (1984) commented that the beneficial effect on milk production simply arises from the mobilization of body reserves made more available.

1.3.2.2 Recent Works With Emphasis On Body Condition

From speculation discussed above during the mid 1970's Animal Scientists questioned whether rate of liveweight gain during pregnancy *per se* or the availability of body energy reserves in early lactation was the key factor in determining increases in milk yield obtained from increases pre-calving feeding.

Evidences from Australia and New Zealand

Australian workers carried out three experiments to separate the influences of rate of liveweight gain in the late pregnancy from the body condition of cows at calving, on subsequent production. Rogers et al.(1979) concluded that absolute body condition or liveweight of cows at calving is the important factor affecting production and that whether cows lost or gained condition prior to calving had little effect on production, provided that cows calved in the same condition.

From series of experiment, cows given extra feed before calving produced more milk and lost more liveweight in early lactation which confirm the pattern of the partition of energy in favour milk production. The response to the level of feeding in late pregnancy, when measured as milk yield in the subsequent lactation, is dependent on the feeding rate in early lactation (Grainger et al., 1982). Who showed in agreement with earlier work by Rogers et al.(1979) a positive effect of body condition at calving on the subsequent milk production, but over a much wider range of condition at calving. Improved body condition at calving increased milk production by causing a more favourable partitioning of energy into milk production at the expense of liveweight gain.

To quantify the amount of feed needed in late pregnant cows, series of trials were set up at Massey University (Table 1.1).

Table 1.1: The effects of different levels of feeding in the 7th or 8th months of pregnancy

	Level of feeding in late pregnancy	
	High	Low
Pasture DM eaten in 42 days (kg)	458	286
Liveweight changes in 42 days (kg)	+42	0
Condition score changes in 42 days (score)	+0.5	-0.3
Extra DM required for 1 condition score gained	215	

((Source, Holmes, 1981)

From Table 1, cows on lower level of feeding showed no change in liveweight but they lost condition (Holmes, 1981). And during late pregnancy, the cows required 215 kg pasture DM extra to gain 1 condition score. The trial was repeated again at Massey (Ngarmsak, 1982), which showed consistent result that the cows needed 221 kg pasture DM extra to gain 1 condition score. From experiment by Grainger et al.(1982), increased body condition at calving required extra feed of 272 kg DM or 24.4 kg DM required pre-calving to produce an extra kg milk fat post calving.

Evidences from Europe

Davenport & Rakes (1969), examining the effect of immediate pre- and post-partum feeding, found no differences in feed intake in early lactation due to pre-partum feeding and they concluded that the differences in milk production were due to different amounts of mobilizable body tissue at parturition. Frood & Croxton (1978) reported that condition scores at calving was related to the ability of animal to achieve potential milk yield. They found that cows in poor condition at calving gave low, late peak milk yields with high persistency, and those in good condition at calving gave high, early peak milk yields with a low persistency. Haresign (1981) stated that cows which are in poor condition at calving not only have smaller amount of stored energy to meet the energy deficit of early lactation but also have a changed partition of nutrients to the extent that less of those stores which are potentially available are actually mobilised. The consequence of this is that higher levels of feeding in early lactation can not compensate fully for low level of feeding in late pregnancy, which the result that milk yield will suffer. Two trials were carried out by Garnsworthy & Topps (1982) where cows were fed on a "complete" diet in lactation, they found that in trial 1, no difference was found in milk yield and in trial 2, cows that had lower condition scores at calving produced slightly more milk. In both of their trials, cows that had higher condition scores at calving lost more body weight and condition, over longer period, and started to regain the losses later than cows with lower condition scores. They found that the biological efficiencies of milk production (energy output/energy input) from 8 weeks before calving until 16 weeks after calving were 0.302, 0.299 and 0.295 in trial 1, and 0.312, 0.290 and 0.306 in trial 2, for the low, medium and high groups respectively. They concluded that cows with lower condition scores at calving produced more milk directly from food rather than via body fat, were in positive energy balance earlier in lactation and over total period were biologically more efficient than cows with higher condition scores. They added that, there appears to be no benefit from feeding cows to achieve a conditon score greater than 1.5 to 2 at calving (on 1 to 4 scale where 1 is very thin and 4 is very fat), if high-energy complete diets are offered in early lactation (see Section 1.3.2.3).

1.3.2.3 A Note on Condition Score

Arnold (1970) suggested that the body condition is probably a better indicator of energy demand than liveweight in the mature animal, as differences in liveweight in mature animals may reflect differences in skeletal size.

Condition score is a subjective eye assessment of body condition or body fatness of dairy cows. The use of a scoring system for body condition obviates problems associated with liveweight measurements (Grainger & McCowan, 1982). And condition scoring gives a more detailed description of body tissue reserves of the cows than does liveweight alone, and has the advantage of describing the cows independently of liveweight (Lowman et al., 1973). The method used to score body condition involves assesing visually, the level of fat cover in 5 areas of the animal body. According to Lowman et al. (1973) these are: on the spinous processes of the lumbar vertebrae, over the lower rib cage, at the hip bone, around the tail head, and at the second thigh. In UK, a scoring system has a scale run from 0 to 5 (where 0 is too thin, 5 is aexcessive fat, Lowman et al., (1973) but in practice scale from 1 to 4 is used (Garnsworthy & Topps, 1982). In US, a scoring system has a scale run from 1 to 5 (Wildman et al., 1982). In Australia and New Zealand, the scale of scoring runs arbitrarily from 1 to 10 with 1 being very thin and 10 being very fat (Earle, 1976).

1.3.3 POST-CALVING FEEDING (During Lactation)

1.3.3.1 Response To Underfeeding Early Lactation

Grainger & Wilhelms (1979) postulated that the key factor determining the economic benefit of good feeding in early lactation is whether a residual effect occurs thereafter. Conversly, nutrition that results in a decline in current yield may, on occasions, be followed by residual effects which persist throughout lactation (Bryant & Trigg, 1979).

But the responsiveness of milk to additional feeding decreases as lactation advances (for references see Broster & Thomas, 1981). Hutton (1963) showed that the gross efficiency of milk production decreased from about .3 in early lactation to .15 in late lactation. The reason for most of the difference is because dietary energy for milk production is supplemented by energy made available from mobilising of body reserve early in lacation or is reduced by the diversion of energy towards the synthesis of body tissue later in lactation (Wilson and Davey, 1982).

Evidence from European works

Broster (1972) stated that underfeeding in early lactation not only reduces milk yield at that time but also later in lactation when underfeeding has ceased. For milk yield, Broster (1974) concluded that effects on production occuring subsequently to low level of feeding in early lactation were about 4 time those during low level of feeding. There is evidence to suggest that residual effects of underfeeding in early part of lactation are generally reduced when animals are on high plane of feeding thereafter (Gleeson, 1973; Gordon, 1976, 1980; Le Du et al., 1979). Gordon (1976) suggested that subsequent effects of differential feeding in early lactation are greatly reduced when cows are grazed at pasture. And Broster & Thomas (1981) examined data from literature with contrasting planes of nutrition and indicated that great residual effect on milk yield for energy increments in addition to low basic levels deminishes or even disappears at higher planes of nutrition. Broster & Thomas (1981) added evidence from trials which permitted analysis of body weight changes showed that a more generous plane of nutrition in early lactation benefited current body weight changes, either reducing losses or increasing gains, depending on the trend in individual trials.

Le Du & Newberry (1981) concluded the results from their trials that even quite severe restrictions in amount of grass offered to the grazing dairy cow in rotational grazing system will have only a transient effect upon milk yield during the period of restriction. The scope for offering of additional feed profitably is quite small. Le Du & Newberry (1982) reported that a restriction of feed either 2 or 5 weeks had depressed milk yields by 12 and 8% respectively, but the recovery was rapid on return to adequate quantity of good qualities herbage and during the subsequent 4 weeks milk yield differences were negligible. They stated that any supplementary feeding could therefore only be justified on the basis of the depression in yield during the restricted phase. These effects were tested again in their second trail reported herein.

A herd of spring-calving British Friesian cows was offered a herbage allowance of 55 g DM/kg liveweight in a strip grazing system. The cows were then allocated to one of the five treatments: control (C), offered 55 g DM/kg Liveweight throughout the grazing season; restricted allowance for 2 (L2) or 5 (L5) weeks; half the animals in each of these latter two group were offered concentrates during the period of restricted, 3 Kg/day to the L2 animals (L2S) and 2 Kg/day to the L5 animals (L5S). There were eight cows in each treatment group. At the end of restriction phase all concentrate feeding ceased and the animals were returned to the control allowance for a period of 7 weeks.

The effects upon daily milk yield are shown in Table 1.2. In comparisson to the L2 and L5 treatments of the previous trial Le Du & Newberry (1982) reported that the depressions in milk yield are considerably larger and the recoveries are less marked. The immediate milk yield responses to supplementation during the herbage restriction phases were 35 and 115 kg for the L2S and L5S treatments, equivalent to 1.0 and 1.9 kg milk per kg concentrate DM fed. The residual effects during the 7 weeks following return to adequate herbage were 69 and 127 kg milk respectively. The overall responses were therefore 2.9 and 3.5 kg milk per kg concentrates, giving an extra income substantially greater than the cost of the concentrates.

Table 1.2: The effect upon mean daily milk yield of herbage restriction and supplementation during the treatment periods and during 7 weeks in residual period

	Treatments					
	C	L2	L2S	L5	L5S	s.e.mean
Milk yield (Kg)						
Restricted phase						
2 (5-6)	22.8	18.5	21.0			0.5
5 (5-9)	21.7			17.4	20.7	0.5
Recovery phase						
2 (7-13)	20.7	18.5	19.8			0.5
5 (10-16)	18.8			16.1	18.3	0.9

(Source: Le Du & Newberry, 1982)

From their preliminary results they suggested that the greater depression in milk yield and the slower response following return to control observed as compared to their previous trial might be the result of low pasture quality. And they concluded that in the circumstances of this trial supplementation of grazing dairy cows offered severely restricted amounts of herbage was financially variable. The precise nature of the restriction not only in terms of quantity but also of quality appears to have affected the magnitude of the response. Similarly, herbage quality during the recovery period had an effect. Le Du & Newberry (1982) suggested that this area might e worthy of further detailed study.

Evidence from Australia and New Zealand

In contrast to the unquantitative effects of low level of feeding in early lactation by grazing dairy cows, Grainger & Wilhelms (1979), Grainger et al. (1982) , Bryant & Trigg (1979) carried out experiments to study the effects of low level of feeding in early lactation and the results have also been summarised by Holmes (1981), Bryant & Trigg (1982).

Table 1.3: Effects of levels of feeding in early lactation on milkfat production during week 0-6 of lactation

	Level of feeding		
	High	Low	Diff.
Pasture DM eaten in 42 days (kg)	550	280	270
Milkfat produced in 42 days (kg)	40	27	13
Liveweight changes in 42 days (kg)	+6	-62	68
kg DM eaten per kg milkfat produced	14	10	
Different between levels of feeding			
kg extra DM eaten per kg extra milkfat produced during 42 days			21
Milkfat production in 18 weeks after 42 days			8
LW at 18th week			-70

(source, Bryant & Trigg, 1979)

Bryant & Trigg (1982) presented a table summarized immediate effects of low level of feeding on milk fat yield and liveweight changes from the work done in Australia and New Zealand with cows in their early lactation, showing that on average, a 38% restriction of DM intake resulting in a 24% reduction in milk fat yield, and on average with an increase in DM intake of 1.0 kg resulting in an increase of 39 g milk fat and 174 g LW deriviing values.

Bryant & Trigg (1982) indicated that the results from Australia and New Zealand were compatible with conclusion of Broster & Thomas (1981). These led Bryant & Trigg (1982) to concluded that residual effects of underfeeding in early lactation are .50 or less than the immediate effects. They are confined to the few weeks immediately following underfeeding.

The response to feeding in early lactation by dairy cows is illustrated from experiment by Bryant and Trigg (1979) given in Table 1.3.

The extra 270 kg DM eaten by the cows on the high level of feeding enable them to produce an extra 13 kg milkfat, or 1 kg milkfat per 21 kg DM. However, the cows on the higher level of feeding also gained 68 kg of liveweight relative to the lower level, so that that total response to the extra feed during the 6 weeks was

1 kg milkfat + 5 kg LW per 21 kg DM eaten

or 48 g milkfat + 238 g LW per 1 kg DM

Following the 6 week experimental period all cows were grazed together up to 18 week of lactation. The cows which has formerly been on the lower level of feeding produced 8 kg less milkfat than the cows formally on the higher level, but gained about 70 kg liveweight relative to them. This is the residual effects. And the total response for the first 18 weeks of lactation was;

extra 21 kg milk fat produced in response to an extra 270 kg DM eaten in weeks 0-6. By week 24 of lactation there was no difference in milkfat production or liveweight between the treatment cows.

From an experiment carried out from Australia, Grainger et al (1982) illustrated the effects of a change in level of feeding of pasture on milk production and body condition both in the short and long term are summarised in Table 4. From Table 1.4:, 35 kg DM pasture was required to produce 1 kg milk fat and the long term response to extra 210 kg DM pasture feeding during 5 weeks was 15 kg DM pasture to produce 1 kg milk fat. Residual effect was 7.8 kg milk fat or 1.3 time immediate effect.

Table 1.4: Effect of feeding level during the first five weeks of lactation

	Level of feeding during week 0 to 5 of lactation		
	High	Low	Difference
Immediate Effect			
(Production to week 5)			
Pasture DM eaten in 35 days (Kg)	490	280	210
Milk fat produced in 35 days (Kg)	28.7	22.8	5.9
Condition score at 5th week	4.9	4.5	0.4
Total Effect			
(Production to week 20)			
Milk fat produced	108.6	94.9	13.7
Condition score at 20th week	4.9	4.9	0

(Source, Grainger et al., 1982)

1.3.3.2 Response To Underfeeding Late lactation

Wilson & Davey (1982) summarised the results of responses to feeding during mid and late lactation and they pointed out that from the works cited gross efficiency values are consistent but marginal efficiency values are more variable. And that the merit of the cows have a major effects in milk production responses to change in feeding levels which could explain and account for in the variability in milk production results in different experiments.

The effects of two levels of feeding in the 6th or 8th months of lactation are shown in Table 1.5: as follows. From Table 5, it can be seen that the total response to the extra feed in late lactation was:

1 kg milkfat + 5 kg LW gain per 71 kg pasture DM eaten

or 14 g milkfat + 70 g LW gain per 1 kg pasture DM eaten.

Table 1.5: The effects of two levels of feeding in 7th or 8th months of lactation on milk production

	Level of feeding in late lactation	
	High	Low
Pasture* DM eaten in 42 days (kg)	592	315
Milkfat produced in 42 days (kg)	18.7	14.8
Liveweight change in 42 days (kg)	+ 3	- 15
Pasture DM eaten per kg milkfat produced (kg)	33	21
kg extra DM eaten per kg extra milkfat (differences between levels of feeding)	71	

(Source, King et al. 1980)

* digestibity of summer pasture was 64%

1.3.3.3 Priorities For Feed

Europe

Under dairying in Europe it is generally believed that the key issue in lactation cycle is the peak yield. According to Broster (1976) an increase in peak yield of 1 kg/day results in a 150 - 200 kg increase for the total lactation, provided that there is an adequate energy supply during the descending part of lactation. And 75% of the long-term effect was initiated during the first four weeks of lactation (Broster et al.,1969; 1975). Furthermore as Blaxter (1950) postulated that peak yield was the major determinant of total lactation yield. To the question whether a reduction in peak yield by a redistribution of concentrates from early lactation to late lactation has adverse effect on total lactation yield. As peak yield is the dominant factor influencing total yield irrespective of whether yield is influenced by yield potential or by diet manipulation of peak yield of individual cows. And the response to changes in energy input decline in relation to current yield as lactation progresses. Broster & Thomas (1981) suggested that a distribution of concentrates allocating relatively higher inputs in early rather than mid lactation would result in a higher total lactation yield. Earlier, Rakes & Davenport (1971) reported that a high energy intake has a greater effect on milk production early in lactation rather than later. Therefore, they recommended that in early lactation, the diet must have a high energy concentration and be offered ad libitum in order to obtain a high milk yield.

Australia & New Zealand

High peak production means that the cows must be very well fed immediately after calving. In practice, this level of feeding is very difficult to achieve. As grazed pasture comprises the great majority of feed eaten by dairy cows in Australia & New Zealand, the supply of pasture and the managements to utilise it can have important influences on cows' milk production. Farmers in Australia & New Zealand calve their cows during late winter or early spring at the time when pasture growth is then slow but animal requirements are high and pasture supplies are often insufficient to meet demands for maximum production (Bryant, 1982a; Grainger & McCowan, 1982; Holmes, 1982).

Autumn and winter feeding managements' aims are to start the next lactation with an adequate supply of pasture and with the cows are in reasonable condition (Bryant, 1982; Holmes, 1982). These should be achieved without any marked reduction in the production of the previous lactation. As it is generally accepted that feed conversion efficiency is greatest in early lactation, thus the provision of an adequate feed supply at this time is the priority. To achieve this goal many things must be taken into consideration such as the drying-off time, the calving period, the managements during autumn and winter, the patern of grass growth during autumn , winter and during the spring, the use of supplement feeding (Bryant, 1982; Holmes, 1982). To the question to which priorities to use the feed from pasture to fed to the herd to obtained the maximum return in the long run. From literature, Holmes (1982) presented the table which may be used as a guideline, the priorities for feed are shown in Table 1.6.

Table 1.6: Estimated values for the amounts of extra milkfat produced if an extra 14 kg of pasture DM is fed at different times of the year (Holmes, 1982)

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14 kg of extra pasture DM fed:-

(a) in early lactation will produce extra 1 kg milk fat in the first half of lactation

(b) in late lactation will produce an extra 0.7 kg milk fat partly in current lactation and partly in following lactation.

(c) in the dry period will produce an extra 0.6 kg milk fat in the following lactation

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1.3.3.4 Other Aspects of Underfeeding

The Pattern of Underfeeding, pattern of feeding in early lactation has little effect on milk yield (Johnson, 1977). In their experiments to studies the effect of pattern of underfeeding in early lactation, Grainger & Wilhelms (1979) found that the pattern of underfeeding in early lactation has also little effect on lactation performance of the cows.

Time taken to recover from underfeeding effects, from literature cited in Bryant & Trigg (1982) that the recovery in the production of milk constituents subsequent to underfeeding is not immediate, required 50 to 80 d. Stockdale et al.(1981) also noted that irrespective of prior treatment, all groups of the cows had returned to the same level of daily milk production by 122 d of lactation.

Residual effects on liveweight, rate of liveweight gain following underfeeding was higher than in the previously better fed cows. In some instances return to control liveweight was within 6 - 8 weeks, while in others liveweight lost during underfeeding was not completely regained by the end of lactation (Broster & Thomas, 1981). Broster & Thomas (1981) concluded that the previously less generously fed animals gained 0.15 kg/d more weight in mid lactation than those well fed throughout. Bryant & Trigg (1982) commented that whether the subsequent higher rate of liveweight gain is at the expense of milk yield or the result of the previously underfed cows achieving a higher intake than the cows well fed throughout is unknown.

1.3.3.5 Conclusion For Response To Feeding By Dairy Cows

The intake of a lactating cow is greater than non-lactating cow. After parturition milk yield increases steadily and reach maximum approximately 35 - 50 days and thereafter declines steadily. In contrast, the voluntary herbage intake rises much more slowly and may not reach maximum until many weeks after maximum milk yield. A lactating cow generally losses weight and body condition during this early lactation. A fat cow has a lower voluntary herbage intake than a thin cow. The key factor in determining the benefit of good feeding in early lactation is whether a residual effect occurs thereafter. It appears that the residual effect of a short period of underfeeding in early lactation is small about 0.5 - 0.6 of immediate effect and they are confined to few weeks immediately following. The significant importance of the feeding the cows before calving can be learned through the importance of the body reserve expressed in term of body condition score of the cows at calving. The early lactation is the period in which the cows respond best to feeding, thus the priorities for feed should be in this period. The time of underfeeding is unimportant in early lactation.

1.4 DAIRY COW QUALITY

1.4.1 HIGH AND LOW YIELDING COWS

Experiments concerning the effects of level of nutrition of dairy cows has been concerned mainly with high yielding cows. There are numbers of reviews providing information on the studies concerning what so called 'high yielding' cows (for example: Moe & Tyrrell, 1974; Nelson et al., 1983; Broster & Alderman, 1977; Broster & Swan, 1980). Broster & Alderman (1977) considered that High Yielding cows could be reasonably regarded as producing milk yield of the order 7000 Kg/lactation (As in UK where the number of herds regristing average milk yield of 6500 Kg/lactation).

For grazing cows as pasture supplies are seasonal and varies markedly in both quantities and qualities resulting in wide fluctuation in the level of feeding of cows. Thus milk yield per cow can not compare directly to European standard and even the cows with highest yields in New Zealand could easily be described as Low Yielding cows. Grainger (1982) pointed out that milk yields in New Zealand are relative to environment conditions. Grainger (1982) gave definition of High Yielding cows as "the cow that can produce the most milk under a given set of environmental condition".

1.4.1.1 Production Characteristics of High and Low Yielding Cows

Flatt et al. (1969) demonstrated the capacity of High Yielding cows to mobilise large quantities of body tissue during early lactation and to deposit it late lactation. But could show no clear relation between amount of milk produced and the associated changes in body tissue. Moe & Tyrrell (1975) showed also that there was no relation between the productive ability of the cow and the associated changes in body tissue. From literature reviews Grainger (1982) concluded evidence from calorimetric studies shows that cows differing in productive ability do not differ in the efficiency with which they used ME for total energy balance.

Many experiments have shown that when the feeding level is increased High Yielding cows increase their milk yield to greater extent than do Low Yielding cows (Broster et al., 1969, 1975; Hutton, 1975; Johnson, 1977; Gleeson, 1978), whereas some experiments could not show any different between cows potential and responses (Jeffrey et al., 1976; Johnson, 1979, Oshgaard, 1979; Steen & Gordon, 1980). The response to feeding by dairy cows have been summarised by Broster & Thomas (1981) showed evidence where conserved forage was given at fixed level, High Yielding cow show a greater response to addition feed than average, and that response was directly proportional to cow potential, and that advantage of cow potential is much exploited at higher planes of nutrition. And even when additional feed was given where conserved forage was given ad libitum, when inputs were expressed in term of ME there was still a trend for High Yielding cow to show greater response.

1.4.1.2 Partition of Nutrients towards Lactation

Efficient utilization of absorbed nutrients for milk production involves a partitioning of a high proportion of the nutrients to the mammary gland (Clark & Davis, 1983). If the supply of nutrients from the diet is inadequate to meet the needs of all tissues, a priority is established among tissues for available nutrients (Hammond, 1952 cited in Clark & Davis, 1983), which will vary depending on the physiological state of the animal. Partitioning of nutrients toward specific tissues in the body involves two types of regulation, homeostasis and homeorhesis (see Bauman & Currie, 1980 for definition). At the initiation of lactation, major changes occur in the partitioning and utilization of nutrients by various tissues of the body (Bauman & Currie, 1980). These changes include increased overall nutrient utilization by the mammary gland, increased lipolysis and decreased lipogenesis in adipose tissue, increased gluconeogensis and glycogenolysis in liver, decreased use of glucose and increased use lipids as an energy source in most body tissues, mobilization of protein and catabolism of amino acids in muscle and other tissues and increased absorption and mobilization of minerals from the get and bone.

Bines & Hart (1978) using data from Broster et al. (1969, 1975) showed how the partitioning of energy can vary between first lactation cows given equal ration. From these where data from individuals within group on fixed diets were analysed by regressing liveweight change on milk production, they showed that High Yielding cows produced extra milk at the expense of body reserves. Clark & Davis (1983) also stated that High Yielding cows partition a larger percentage of absorbed nutrients to the mammary gland than do Low Yielding cows.

1.4.2 EVIDENCE OF IMPROVED COW QUALITY BY SELECTION

Hickman (1971) was able to illustrate the evidence of improving production traits by selection based on a series of selection experiment. He showed the response to selection for 180 day total solids yield has improved as much as theoretically expected from selection differential and heritabilities. Growth rate of heifers and feed consumption have improved for both Holstein and Ayrshire. Feed conversion efficiency for growth has improved for Holstein, whereas feed conversion efficiency for milk has improved but improvement was significant only for Holstein. The improved efficiency for milk for Holstein was accompanied by a significant decrease in weight gain during lactation.

Freeman (1975) reviews experimental data relating to genetic variation in nutrition of dairy cattle and was able to conclude that there is no doubt that when selection is applied, milk production is increased but there is little or no real knowledge as to the physiological changes caused by selection. Recently, Grieve et al. (1976), Hind (1979) have provided evidences for the effect of selection on productive traits under a differential feeding regime. Hind (1979) found that selection for increased milk yield resulted in increases in feed intake and efficiency of production.

1.4.3 GENETIC VARIATION IN NUTRITION OF DAIRY COWS

1.4.3.1 Breed Differences

From their trials, Dickinson et al. (1969) concluded that the differences between breeds (namely Ayrshire, Brown Swiss and Holstein) were real for gross efficiency. They found that at given body weight, Holsteins were more efficient than other breeds.

1.4.3.2 Heritabilities of Feed Efficiency

Freeman (1975) indicated that heritability of feed efficiency is greater than zero and is, in fact, relatively large. From literature, Freeman concluded that there are genetic differences within breeds and are large enough that genetic progress could be made if selection is practiced for increasing feed efficiency for milk production.

1.4.3.3 Genetic Differences in Feed Intake

Freeman (1975) showed evidence that the repeatability of food intakes are generally high ranging from 0.22 to 0.86, whereas heritabilities, in general, are clearly greater than zero indicating that a substantial protions of total variation in feed intake is controlled by largely additive genetic effects. An heritability estimate of 0.42 ± 0.1 has been calculated for net energy intake by lactating cows (Miller et al., 1972).

1.4.3.4 <u>Genetic Variation Maintenance Requirement</u>

Tayler et al. (1981) showed evidence that there is significant differences between animal in efficiency of utilisation of enery for maintenance, the genetic coefficient of variation being 0.064 and the repeatability within-animal was 0.7.

1.4.3.5 <u>Heritability of Yield Traits</u>

Kennedy (1982) outlines that heritabilities of yield traits, indcluding milk yield, are about .25. Heritabilities of percentage traits are at least twice as large and range from .50 to .60. Heritabilities od ratios of SNF/fat and protein/fat range from .55 to .60 and are similar to those of percentage traits. Maijala & Hana (1974) calculated weighted averages of heritabilities for first-parity milk is .25 and fat is .23, and they indicated that heritabilities decreased with progressive parities. Berger et al.() computed heritabilities of FCM for yield at 60, 180, 305 days of lactation are, .21, .28 and .24 respectively. Shanks st al. (1982) also showed that heritability of mature-equivalent milk production declined as lactation number increased.

1.4.4 EVIDENCE OF GENETIC IMPROVEMENT OF DAIRY COWS IN NEW ZEALAND

Wickam (1979) provided evidence that the estimated BI value of a cow is a good measure of her genetic merit for milk production, Wickam et al. (1978), MacMillan (1982) provided the evidence of genetic improvement of New Zealand, dairy cattle which has been brought about by the use of genetically superior bulls in the Artificial Breeding (AB) Scheme. And Wickam et al. (1978) indicated that production per cow has certainly increased as a result of this selection program. The average milk fat yield of the artificially bred progeny minus the milk fat yield of the naturally bred progeny ranged from 7 kg in 1970/71 to 11 kg in 1975/76. The measured differences in milk yield between the two sources of the herd sire were in agreement with the predicted differences based on the difference in genetic merit of the sires involved.

The New Zealand Dairy Board, in their Annual Farm Production Report, record the changes that have occured in BI values for cows in New Zealand dairy herd and proven bulls used in artificial breeding. Selected data from the 1979/80 Report are given in Table 1.7.

Table 1.7: The data for genetic improvement in NZ dairy cows.

Season	Average BI of bulls	Average BI of cows	
		Sired by Proven bulls	All others cows
1953/54	107	100	100
1959/60	113	105	100
1969/70	124	110	104
1979/80	134	118	110

From Table 7, there has been clearly an improvement in genetic merit of the proven bulls used in artificial breeding since 1953/54. The average BI of all other cows has increased also but less than the cows sired by proven bulled. This increase is due partly by the fact that artificial breeding has been used somewhere in their ancestry, but the extent of this is not known.

1.4.5 NEW ZEALAND FRIESIAN VS. EUROPEAN- AND HOLSTEIN-FRIESIAN

Jasiorowski et al. (1983) reported the results of the project on testing 10 Friesian strains in Poland. Milk production and conformation characteristics were studied. The average first lactation milk yield was 4970 kg with 3.97% butter-fat and 3.54% protein. The strains of Holstein-Friesian type differed from other genotypes. Heifers by America, Canada, and Israeli sires produced the greatest amount of milk and protein, while the highest compositional quality tended to be in the strains from Dutch and New Zealand sires.

Table 1.8: Rank of total butter fat and protein yield for 10 strains of Friesian cows

Strain	Butter fat and protein yield (Kg)	
	Total per lactation	Per 100 kg of liveweight
New Zealand	386	69
Canada	383	67
United States	380	66
Israel	380	66
Great Britain	378	68
West Germany	375	66
The Netherlands	374	68
Sweden	370	64
Denmark	357	63
Poland	334	60

(Source: Jasiorowski et al., 1983)

As far as milk is concerned F1 cows of New Zealand strain took fifth position, but they produced milk with the highest fat concentration and, the highest fat yield. Deciding which of the test strains in intensive feeding conditions is most efficient is difficult because this evaluation may vary depending on the criteria applied. Table 1.8, gives some guide for the value of the tested strains in intensive dairy husbandry under Polish conditions the genotypes were ranked on the basis of total butter fat and protein yield in the first lactation. These data show that the yield of these two main milk components does not differ greatly in the first five strains.

1.4.6 PRODUCTION CHARACTERISTICS OF HIGH BI AND LOW BI COWS

Work at both Massey University and Ruakura Agricultural Research Centre has highlighted the significance of cow quality (Bryant, 1982b; Grainger, 1982; Davey et al., 1983). The genetic merit of dairy cows in New Zealand for milk or milk fat is indicated by their breeding index (BI), which shows the relative genetic merit of a cow to produce milk or milk fat in comparision to a baseline of 100, representing the average cow in the early 1960's (Davey et al., 1983). For a female, BI is a weighted combination of her own production records and the BI's of her sire and dam. The method of calculating BI has recently been outlined (Rumball, 1975; Wickam & Stichbury, 1980; Holmes, 1981). But the reason for the resultant production advantages of the genetically superior cows are largely unknown especially for dairy cattle grazed mainly on pasture. Bryant (1978) indicated the need to quantify the major component of cow efficiency for exploitation of cow's production potential when grazed on pasture. Series of experiments are carrying out at Massey University and Ruakura Agricultural Research Centre to examine the differences between the cows with differing genetic merit. For Massey's work, two group of NZ-Friesian cows which differed in their genetic merit for milk fat production by 23 BI units ((20 kg Fat on the UK Improved Contemporary Comparision scale), which means that the expected differences in milk fat production between the two groups would be approximately 23% of their average production. The High BI group has an average BI value of 126 while the Low BI group has an average 102 units.

1.4.7 Production Performances

Results from Ruakura and Massey are in agreement in showing that High BI produce more milk fat and gain less liveweight and condition over lactation than Low BI cows (Bryant, 1982; Grainger, 1982; Davey et al., 1983). At Massey, Low BI cows were consistently heavier than High BI cows.

There was general agreement between the Ruakura and Massey experiments that the intake of ME per unit metabolic liveweight was higher for the High BI than Low BI cows. Grainger (1982) indicated that under grazing and indoors system of feeding, the animals of high genetic merit ate more than animals of low genetic merit (but not significant). Bryant (1981, 1982) showed that at given herbage allowance, dry High BI cows grazed more severely than dry Low BI cows. As a consequence the High BI cows achieve higher intake and liveweight gain. Furthermore, when these cows were grazed together Bryant (1982) indicated that High BI cows outcomplete the Low BI cows at restricted pasture allowance and achieve higher rates of liveweight gain.

1.4.7.1 Energy Metabolism

In the Ruakura experiments, during two years a total of 116 energy balances have been established on equal numbers of High BI and Low BI cows at two levels of intake. Trigg (1981) reported that partitioning of gross energy intakes based on 40 balances for each BI was similar for High BI and Low BI cows. Within cow regression of heat, milk and tissue on ME intake for each stage of lactation showed that the regression for the BI group did not differ in term of slope or intercept. The efficiency of use of ME for milk production plus tissue was similar for both High BI & Low BI. In the Massey experiments (Grainger, 1982; Davey et al., 1983), at a fixed intake, High BI cows paritioned more of their ME to the synthesis of milk and less to liveweight gain than the Low BI cows (but the difference was significant only in late lactation).

1.4.7.2 Grazing and Milking Behaviour

Avare & Kilgour (1982) reported that there were no difference in grazing, laying or standing times between High BI and Low BI cows during early or mid lactation. High BI cows grazed longer during late lactation. There were no difference in daytime drinking frequency.

They also reported that High BI cows had shorter milking times in early lactation but these differences deminished as lactation progressed. No relationships between milking entrance order or milking temperment and breeding index were found.

1.4.7.3 Marginal & Gross Efficiency Of Milk Fat Production

Marginal Efficiency

For animals of differing genotypes, Grainger (1982) demonstrated that High BI had a greater marginal efficiencies than Low BI, but the differences between genotypes were not significant. This was in agreement with Bryant (1981).

Gross Efficiency

For milk production, the average gross efficiencies of High BI were almost invariably higher than those of the Low BI cows in both Massey and Ruakura experiment.

For milk fat production, for Massey works Grainger (1982) illustrated that the gross efficiencies at fixed intake was significantly greater ($P<0.05$) for High BI cows than Low BI cows. The reason given appears to be associated with the fact that High BI cows partition more of their ME to milk production than to liveweight gain, whereas it is reverse for Low BI cows.

CHAPTER 2

CHAPTER 2

2 MATERIALS AND METHODS

The experiment was carried out at Dairy Cattle Research Unit, Massey University, Palmerston North, New Zealand during the spring of 1982. The experiments were designed to study the production performances and the response of cows differing in breeding index and these cows when they calve at differing body conditions to differing levels of feeding.

2.1 OVERVIEW OF EXPERIMENT DESIGN

The experiment consists of three periods namely, Pre-experimental, Experimental and Post-experimental periods.

2.1.1 Pre-experimental Period

(7th to 14th October, 1982)

And the cows were managed in one group designated as High and Low BI herd. During Pre-experiment periods, milk yield, milk fat and milk protein content were measured in three consecutive days per week. All High and Low BI cows were weighed and condition scored in two consecutive days before the start of the experiment.

2.1.2 Experimental Period

(15th October to 5th November, 1982)

The cows were allocated to treatments according to their BI and condition at calving groups feeding regime namely Generous and Restricted.
And for each BI group there were two subgroups namely;

(1) Fat at calving,

and (2) Thin at calving.

There were four main groups of cow which were;

(1) High BI, Generous feeding,
(2) Low BI, Generous feeding,
(3) High BI, Restricted feeding,
and (4) Low BI, Restricted feeding.

Totally there were 8 treatments (Table 2.1). And the design was a 2x2x2 factorial design. The four main groups were grazed in plots adjacent to each other in each of the paddock.

Table 2.1: Number of animals in each treatment for grazing trials.

Feeding Regime	Generous		Restricted	
Breeding Index	High BI	Low BI	High BI	Low BI
Condition at calving				
Fat at calving	3	3	3	3
Thin at calving	3	3	3	3

Herbage mass, residual herbage mass, milk yield, milk fat and milk protein concentrate were meassured during this experimental period. The representative samples of pasture grazed to grazing height by cows were mowed by rotary mower and subjected to digestibility trials using sheep, detials are given later.

At the end of the experimental period, the cows were condition scored and weighed.

2.1.3 Post-experimental Period

(6th November 1982 to 1st March, 1983)

During the post-experimental period cows were grazed together in one herd. Milk yield, milk fat and milk protein concentrate were measured weekly in two consecutive days per week throughout the rest of lactation. The cows' liveweights and condition scores were measured at two occasions thereafter.

2.2 ENVIRONMENTS OF THE EXPERIMENTS

2.2.1 Pasture

The pasture consisted predominantly of perennial rye grass and white clover.

2.2.2 Animals

Friesian cows were used. The cows were indentified into High and Low BI by the Farm Production Division of the New Zealand Dairy Board. The High BI were having BI value on average 125 while Low BI were having BI value of 105. The individual cow numbers and their respective BI values are given in Appendix I.

Prior to calving the cows had been grazed on pasture and/or were fed on hay in different amount to ensure that there were two body condition group of cows which were Fat at calving and Thin at calving. The Fat at calving cows had an average condition score of 5.7, the Thin at calving had an average condition score of 3.8.

2.3 FEEDING REGIME AND ASSOCIATED PARAMETERS MEASSURED

2.3.1 Herbage Mass

At the start of the grazing for each paddock, the herbage mass was estimated by the herbage cutting technique (cutting random quadrates to ground level with a portable hand shearing, washing the herbage and measuring the weight of the material after oven dry at 85°C for approximately 48 hours. Twenty random samples were cut from each paddock and the mean herbage mass was used for the calculation of herbage DM allowance and intake..

2.3.2 Herbage Allowance

The levels of herbage allowance were achieved by controlling grazing area using temporary electric fences. The two herbage allowances offered were designed to allow approximately 40 and 20 kg DM/cow/day and were designated as Generous and Restricted feeding regime respectively.

2.3.3 Residual Herbage Mass

Approximately 20 random samples were cut from each of the four main plots from each paddock after grazing by the sward cutting technique to obtained the residual herbage mass.

2.4 ESTIMATION OF HERBAGE DM INTAKE

Two methods were used to estimate herbage DM by the grazing cows namely, sward-cutting and Cr_2O_3 marker techniques.

2.4.1 Estmate Herbage DM Intake Sward-Cutting Technique

Herbage DM intake was estimated by the difference between the herbage allowance per cow and the residual herbage mass per cow.

2.4.2 Estimate Herbage DM Intake Using Chromic Oxide Technique

2.4.2.1 Faecal Output

Faecal output were measured by using chromium sesquioxide (Cr_2O_3) as the marker. Twenty cows were selected from the cows in the pre-experimental experiment and dosed twice daily after milking with a gelatine capsule containing 10 g Cr_2O_3 in oil (R.P. Sherer Pty, Ltd., Australia). An equilibrium period of 7 days was used to allowed steady state condition to be attained, this was followed immediately by the 10 days collection period. Samples of faeces were taken per rectum twice daily after milking and bulked.

The faeces collected from cows were dried in an oven at 85 ^{o}C for 7 days and subsequently ground (1 mm sieve). The chromium concentration of the ground dry faeces was determined by the method of Fenton & Fenton (1979, detials given in Grainger, 1982).

2.4.2.2 Estimate DM intake

Herbage DM intake was calculated by;

$$\text{Herbage DM Intake} = \frac{\text{Faecal Output}}{(1 - \text{in vivo digestibility }\%)}$$

2.5 ESTIMATE OF DIGESTIBILITY OF PASTURE

2.5.1 Estimation of the Quality of Herbage Consumed

Samples of the oven dried herbage from the sward cutting technique from both before and after grazing cutting were taken (Section 2.1.2.1 and 2.1.2.3). The samples were subjected to *in vitro* digestibility estimation by fungal cellulase solubility technique (Roughan & Holland, 1977).

The results were converted to _in vivo_ values and expressed in _in vivo_ digestibility DM (Grassland Analytical Laboratory, Palmerston North, New Zealand), by;

In vivo DMD = 0.98 Cellulase digestibility - 10.12

2.5.2 Estimate In Vivo Digestibility

The _in vivo_ DM digestibility of the pasture was estimated using sheep (non-pregnant, non-lactating) fed to maintain weight (ARC, 1965). Sheep were fed on representative samples of pasture which had been cut with a lawn mower to grazing height before grazing. Allowing for adjusted period for 10 days, the faeces were collected thereafter for 10 days and bulked. The samples of un-eaten feed and faeces were oven dried at 85^{0}C for dry matter determination, and the digestibility DM value was calculated for individual sheep.

2.6 MEASURMENTS OF ANIMAL PRODUCTION

2.6.1 Milk Production

The milk yield was measured by milk sampling meters (Tru-test Distributer Ltd.) which sampled a proportion of milk flow of each cow. Daily milk yield was recorded as the yield of milk at the evening milking plus the milk yield at the next morning milking. The milk yield was measured for two consecutive days weekly throughout lactation except during Pre-experimental and experimental periods. During Pre-experimental periods milk yields were measured for three consecutive days, while during the experimental periods were measured for four consecutive days.

2.6.2 Fat and Protein Concentration in Milk

The milk samples from the evening and the morning milking were combined and tested for fat and protein concentration. For fat concentration, a Milko-tester, Mark III F 3140 (A/s N Foss Electric, Denmark) was used. For milk protein concentration, a Pro-milk tester, Mark II 12500 (A/s Foss Electric, Denmark) was used. From milk yield, milk fat concentration and milk protein concentration the milk fat yield and milk protein yield were calculated for each cows.

2.6.3 Fatty Acid Composition of Milk Fat

Samples of milk and sulphuric acids (18 ml of each) were mixed in Babcock test bottles by rotary action then spun in a centrifuge for five minutes. The fat was siphoned out. Fatty acids were analysed using Varian Aerograph 1200 Gas Chromatograph (Morrison, 1976). Proportion of the individual fatty acids were obtained by using a Varian Aerograph Digital Integrator 480 (see detials in Grainger, 1982).

2.6.4 Liveweight

Cows were fasted overnight (without food and water approximately 10 hours) and weighed the following morning. The weight of each cow after the finish of the experiment were obtained after the cows had returned to the herd for 3 days. This was done to ensure that the the cows in two feeding regime were given enough times to equalise their gut concentrate.

2.6.5 Condition Score

The condition score (see page 18) of each cow was scored independently by three observers on two consecutive days at the start and at the end of each of the experiment and scored again at intervals of two occasions at two months interval.

2.7 STATISTICAL ANALYSES

The data obtained were analysed using SPSS computer package (Hull & Nui, 1981). Cows' milk production records were filed with cows' number and dates. Then the file was read into SPSS system file and through the data manipulation cards, the treatments were able to be sorted. By AGGREGATE PROCEDURE the mean values of each cow and each of the treatment in each week were obtained. The mean values were used in MANOVA options for the analysis of variance and analysis of covariance. These mean values were also used in GRAPHICS options the drawing of the results. The data for milk production (ie. milk yield, FCM, milkfat and protein yield), fat and protein concentration, liveweight and condition scores obtained during Pre-experiment periods were subjected to analysis of variance. The data obtained during Experimental- and Post-experimental periods were subjected to analyses of covariance using the means obtained for each cow as covariates. For pasture DM intake obtained from chromic oxide technique were subjected to analysis of variance.

CHAPTER 3

C H A P T E R 3

3 R E S U L T S

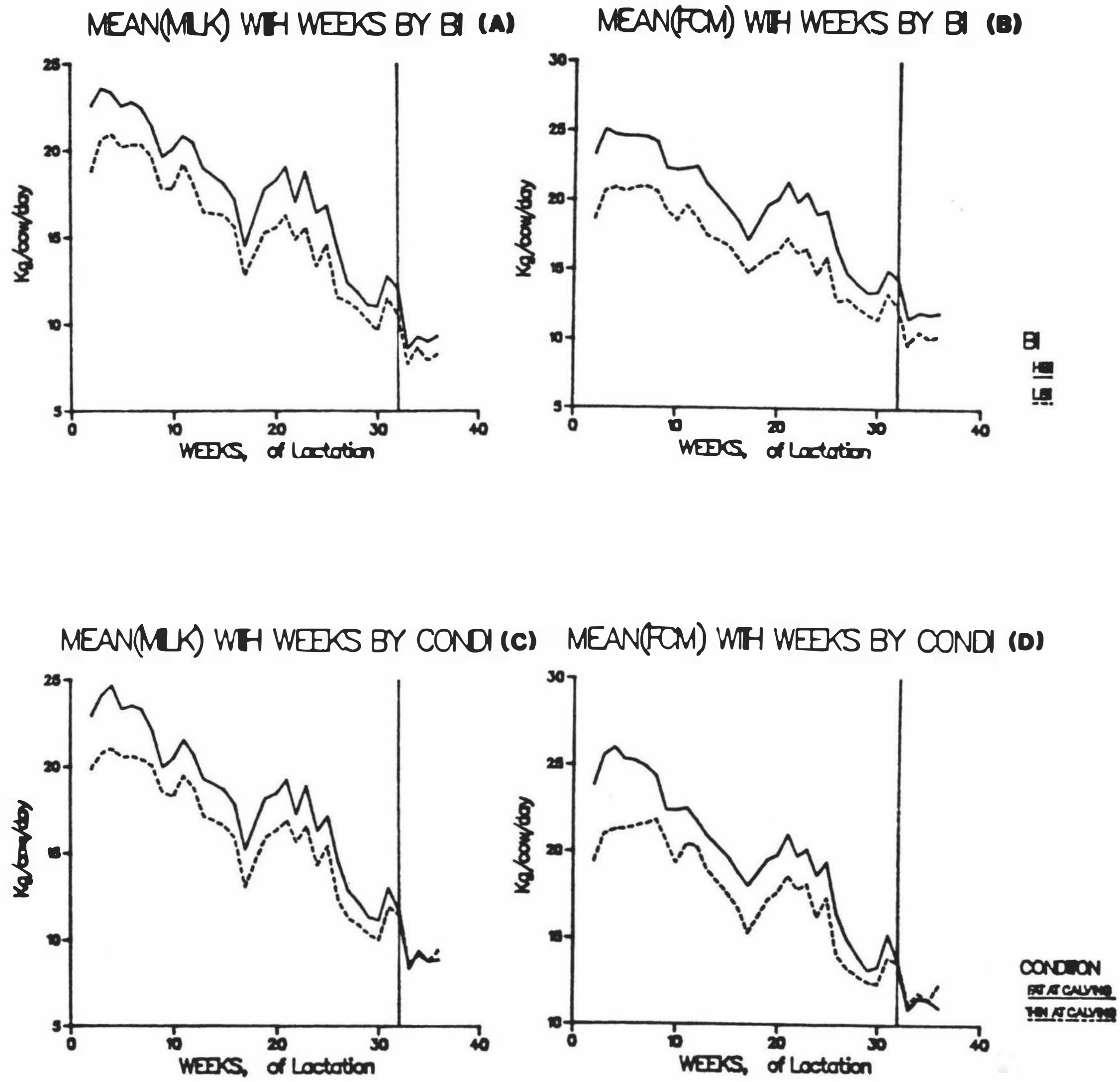
3.1 LACTATION PERFORMANCES

3.1.1 MILK YIELD

Milk yield of individual High BI and Low BI cows obtained during 1982/83 season are illustrated in Figure 3.1A and summarized in Table 3.1 and given in Appendix I & II, which were the actual yield of the cows with differing lactation lengths. The average values (kg/cow/day) over lactation were obtained from the first 30 week of lactation. From Figure 3.1C shows that Fat cows produced more milk than Thin cows. When milk yields were converted into FCM (Fat Corrected Milk) yield using, FCM = (0.4 Milk yield + 15 Fat yield), the results are illustrated in Figure 3.1 B,D.

Table 3.1: Lactation performances of the High and Low BI cows, total yield for 1982/83 season.

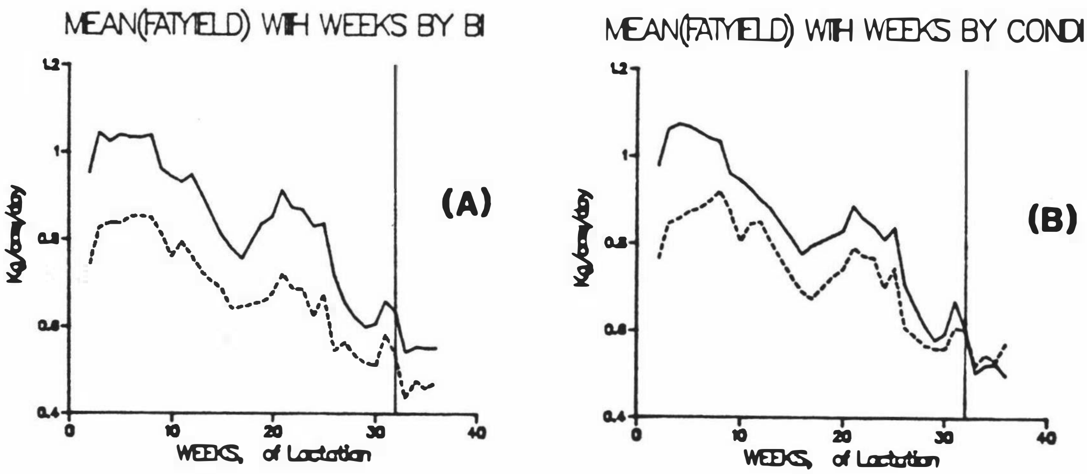
Breeding index	High BI		Low BI		
Condition	Fat	Thin	Fat	Thin	
Milk Yield (kg/cow)	4472	4299	4136	3386	
FCM (kg/cow)	4968	4744	4293	3574	
Fat Yield (kg/cow)	219	208	183	152	
Protein Yield (kg/cow)	167	162	147	125	
Fat Concentration (g/kg milk)	50.4	50.0	46.9	46.2	
Protein Concentration (g/kg milk)	38.4	38.8	37.4	37.6	



<u>Figure</u> 3.1: Milk Yield (A) High BI and Low BI cows
(C) Fat and Thin cows
FCM Yield (B) High BI and Low BI cows
(D) Fat and Thin cows.
(Vertical line indicates drying-off commence)

3.1.2 MILK FAT YIELD

The results of milk fat yield (kg/cow/day) of individual cow throughout lactation are illustrated in Figure 3.2, summarised in Table 3.1 and given in Appendix I & II. High BI cows produced 23 % more than Low BI cows, Fat cows produced 12.4 % more than Thin cows. The declines of milk fat yield for the two genotypes were similar as lactation progressed (Figure 3.2A & Appendix II). The fat production advantages of Fat cows over Thin cows were high during the first 10 weeks of lactation, thereafter the declines of fat yield were similar as lactation progressed (Figure 3.2B & Appendix II).



<u>Figure</u> 3.2: Fat Yield (A) High BI (______), Low BI cows (......)
(B) Fat cows (______), Thin cows (......).
(Vertical line indicates drying-off commence)

3.1.3 MILK PROTEIN YIELD

The results of milk protein yield for individual cows are illustrated in Figure 3.3 summarised in Table 3.1 and given in Appendix I & II. High BI produced 17.9 % more milk protein than Low BI cows and the Fat cows produced 9 % more milk protein than the Thin cows. The declines of protein yield for both genotypes and for both condition at calving cows were similar as lactation progressed.

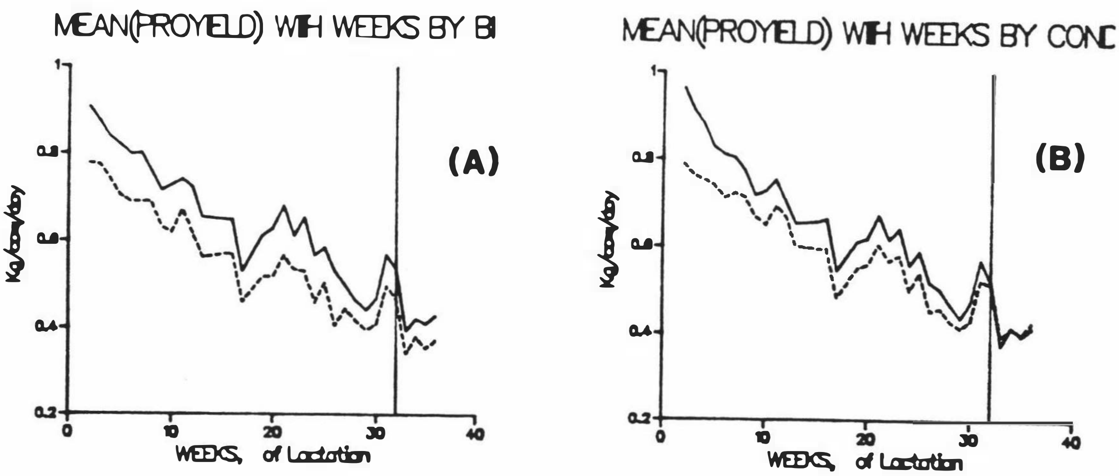


Figure 3.3: Protein Yield (A) High BI (____), Low BI cows (....)
(B) Fat cows (______), Thin cows (......).
(Vertical line indicates drying-off commence)

3.1.4 MILK FAT CONCENTRATION

The results of milk fat concentration (g/kg milk) for individual cows are illustrated in Figure 3.4, summarised in Table 3.1 and given in Appendix I & II. From Figure 3.4A, milk fat concentration of the cows increased steadily as lactation advanced. High BI cows' milk contained more fat than Low BI cows' milk. The fat concentration of milk of Fat cows were higher than the milk of Thin cows during the first 10 weeks of lactation and thereafter their fat concentrations in milk were similar.

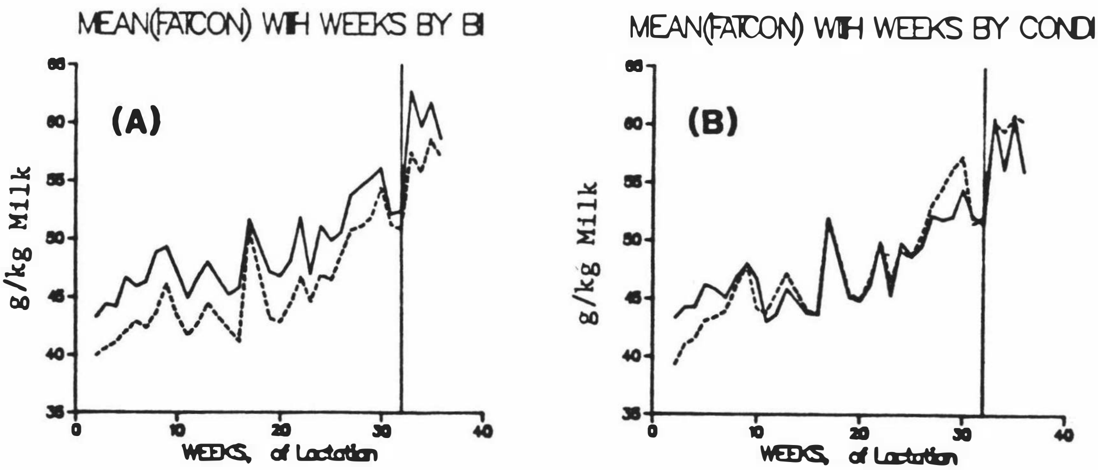


Figure 3.4: Fat Concentration (A) High BI (___), Low BI cows (...)
(B) Fat cows (______), Thin cows (......).
(Vertical line indicates drying-off commence)

3.1.5 MILK PROTEIN CONCENTRATION

The results of milk protein concentration (g/kg milk) for individual cows are illustrated in Figure 3.5, summarised in Table 3.1 and given in Appendix I & II. From Figure 3.5A, milk protein concentration declined suddenly after calving until week 5th of lactation and remained constant until week 25th of lactation when they were increased suddenly until the end of lactation. High BI cows' milk contain more protein than Low BI cows' milk. Thin cows' milk contained slightly more protein than Fat cows' milk.

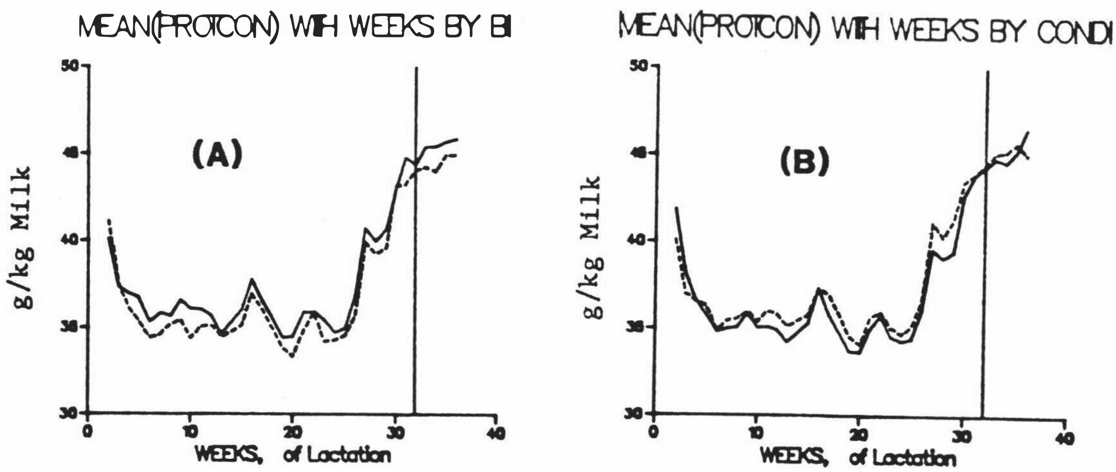


Figure 3.5: Protein Concentration

(A) High BI (____), Low BI cows (.....)

(B) Fat (______), Thin cows (......).

(Vertical line indicates drying-off commence)

3.1.6 FATTY ACID COMPOSITION OF MILK

Fatty acid composition obtained during 2-4 week (12-24 Sept.) of lactation from 24 cows from High and Low BI herd when cows were fed generously are given in Table 3.2. From Table 3.2, which also showed the mean values of High BI and Low BI cows' milk and mean values of the milk of these cows when they were Fat cows and Thin cows, the mean values for entire sample are also given together with the sigficant of F values (only the values greater than unity are given). The fatty acids composition of milk were grouped into three categories namely short chain (C4:0 to C15:0), medium chain (C16:0 to C17:0) and long chain (c18:0 to C18:3) acids. High BI cows' and low BI cows' milk contained similar fatty acids. Fat cows' milk contained significantly (P<.05) lower mole % of short chain acids but contained slightly higher mole % of long chain acids than Thin cows' milk.

3.1.7 LIVEWEIGHT

The cows' liveweight for the 1982/83 at calving and 24th week of lactation are give in Appendix I. The results showed that the Low BI cows were heavier than High BI cows. The cows' liveweight changes throughout the early part of lactation is illustrated in Figure Figure 3.6A. The Fat cows' and Thin cows' liveweights are illustrated in Figure 3.6B.

3.1.8 CONDITION SCORE

The condition scores of individual cows for the 1982/83 at calving and at 24th week of lactation are given in Appendix I, and are illustrated in Figure Figure 3.6 B From Figure 3.6 C, shows that Low BI cows had higher condition score than High BI. Fat cows lost their condition scores during the first 10 weeks of lactation and thereafter they gained condition scores. Thin cows gained their condition scores immediately after calving.

Table 3.2: Fatty acid composition of milk of High and Low BI cows and Fat and Thin cows generously fed early lactation

	Breeding Index		Condition			Sig. of F*		
	HBI	LBI	Fat	Thin	Mean+SE	B	C	BxC
C4:0	4.42	4.42	4.62	4.42	4.42+.51	-	.05	-
C6:0	3.31	3.27	3.37	3.21	3.29+.34	-	-	-
C8:0	1.97	1.93	1.95	1.95	1.95+.23	-	-	-
C10:0	4.11	4.20	3.96	4.35	4.15+.56	-	-	-
C10:1	0.35	0.34	0.33	0.36	0.34+.06	-	-	-
C12:0	4.56	4.62	4.31	4.88	4.58+.73	-	.64	-
C14:0	12.22	12.57	11.90	12.89	12.37+.85	-	.003	-
C14:1	1.50	1.30	1.31	1.53	1.42+.39	-	-	-
C15:0	1.75	1.60	1.55	1.83	1.69+.20	.006	.000	-
C16:0	27.4	27.5	27.1	27.7	27.4+1.82	-	-	-
C16:1	2.79	2.48	2.47	2.85	2.65+.69	-	-	-
C17.0	0.97	0.86	0.94	0.90	0.92+.21	-	-	-
C18:0	11.61	11.18	11.94	10.87	11.43+1.45	-	.093	-
C18:1	20.42	21.23	21.61	19.86	20.77+2.45	-	.092	-
C18:2	1.43	1.53	1.43	1.52	1.47+.59	-	-	-
C18:3	1.23	1.03	1.19	1.09	1.14+.58	-	-	.055
SHORT	34.19	34.24	33.30	35.20	34.21+2.26	-	.049	-
MEDIUM	31.13	30.79	30.54	31.46	30.98+1.71	-	-	-
LONG	34.69	34.97	36.16	33.34	34.81+3.40	-	.053	-

* B = Breeding Index, C = Condition, BxC = Interaction Effect.

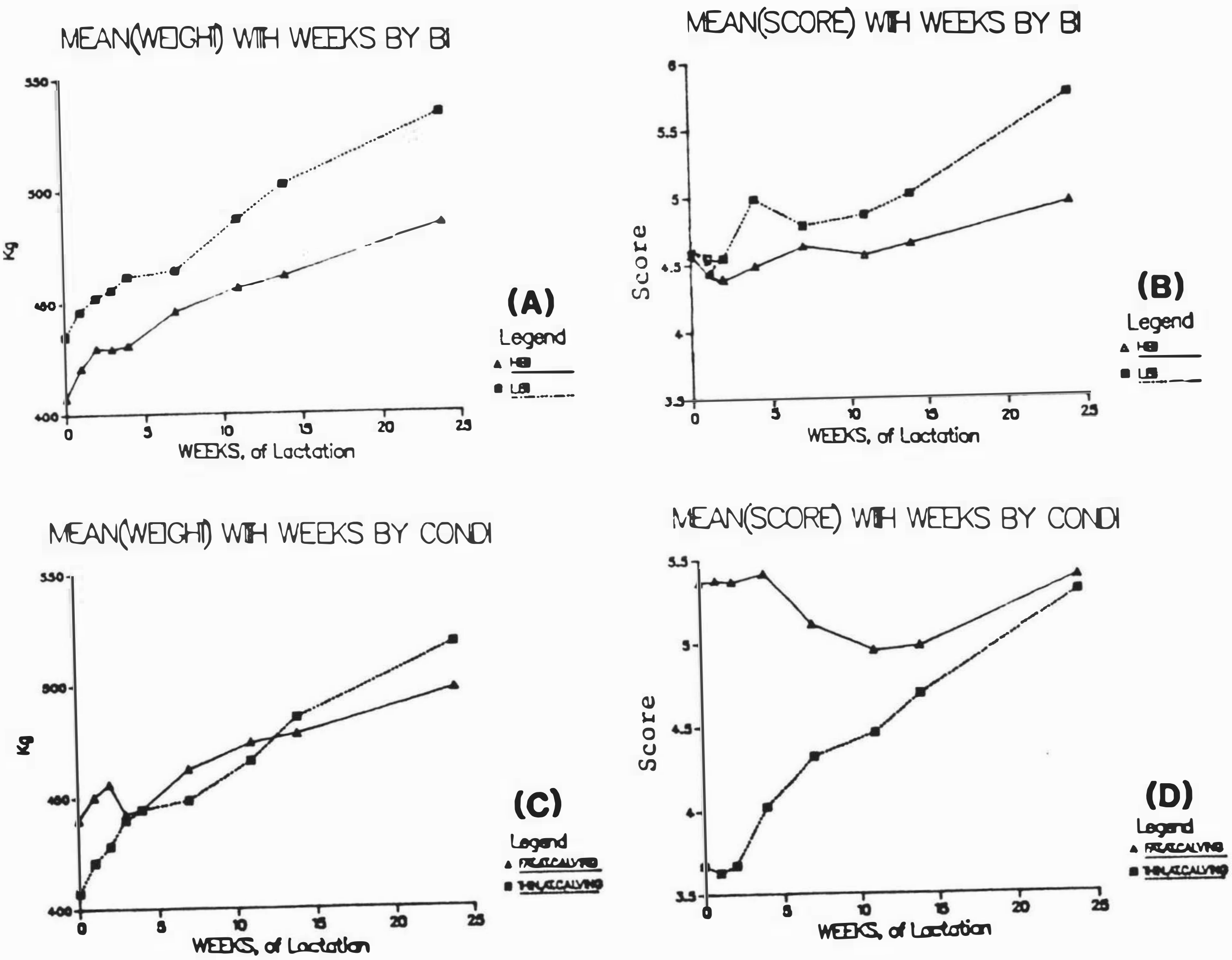


Figure 3.6: Liveweight (A) High BI and Low BI cows
(C) Fat and Thin cows
Condition Score (B) High BI and Low BI cows
(D) Fat and Thin cows

3.2 RESULTS FROM GRAZING TRIALS

3.2.1 MILK YIELD

3.2.1.1 Milk Yield During 3 Week Pre-experimental Period

Milk yield of the cows used during pre-experimental period are given in Table 3.3. High BI cows produced slightly more milk than Low BI cow (not significant) and Fat cows produced slightly more milk than Thin cows (not significant).

Table 3.3: Milk yield during pre-experimental period, (kg/cow/day)

		High BI	Low BI	Diff.
	Mean	24.3	21.3	3.0
Fat at calving	24.6	25.9±3.9	22.8±4.4	3.1
Thin at calving	21.2	22.5±4.2	20.0±2.4	2.5
Diff.	3.3	3.4	2.8	

For Entire Sample Mean 22.9±4.2

SUMMARY OF ANOVA	Source of Variation	Sig. of F
	BI	.061
	Condition	.053
	BI x Condition	.851

3.2.1.2 Milk Yield During Experimental Period, Covariance Adjusted

The unadjusted milk yield of the Generous and Restricted groups during the experimental period are illustrated in Figure 3.7. The covariance adjusted milk yield of the 8 treatments given in Table 3.4, and illustrated in Appendix III. Restricted feeding for 3 weeks significantly (P<.001) reduced covariance adjusted milk yield by 91 kg/cow (4.3 kg/cow/day) during experimental period, and reduced covariance milk yield by 117 kg/cow in 19 weeks (after the start of the experiment). There were no significant differences between High BI and Low BI cows nor between Fat and Thin cows in milk yield in response to differential feeding. There were no significant effects of differential feeding during Post-experimental period.

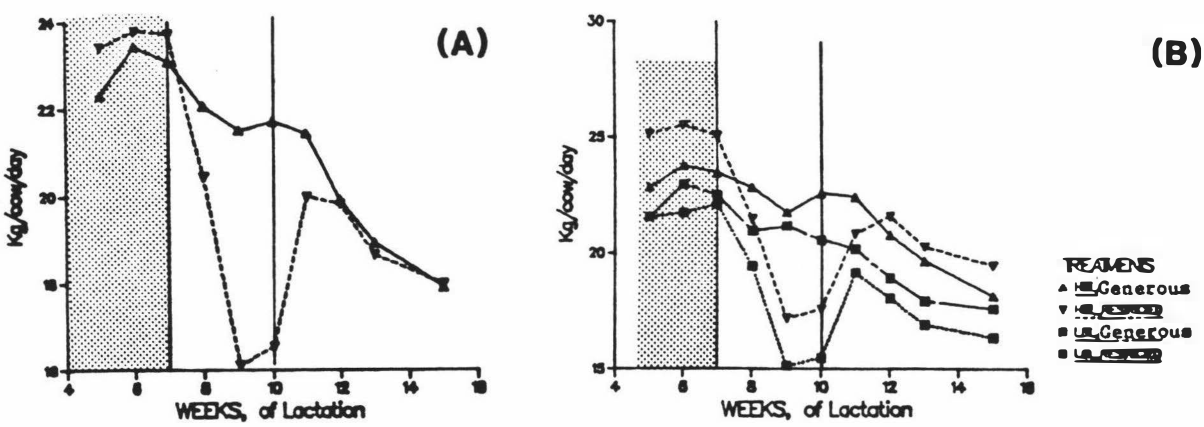


Figure 3.7: Milk yield due to differential feeding
(A) Generous (____) and Restricted Feeding (....)
(B) For the four main treatments

(Experiemtal period week 7-10)
= Pre-experimental period.

Table 3.4: Milk yield due to differential feeding, all values have been covariance adjusted except pre-exper. results

Genotypes	High BI				Low BI			
Condition	Fat		Thin		Fat		Thin	
Feeding regimes*	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Yield (kg/cow/day)								
Pre-experiment	24.0	28.5	23.5	21.4	23.2	22.6	20.0	19.9
Weeks 1-3	22.1	16.5	21.8	18.1	22.4	17.4	21.9	18.5
Yield (kg/cow)								
Yield to 3 weeks	464	346	458	380	471	366	459	388
Yield to 19 weeks	2044	2024	2109	1998	2124	1871	2084	1999
Generous - Restricted kg/cow								
Experimental (3 weeks)	108		78		105		71	
Total (19 weeks)	20		101		253		85	

Summary (yield, kg/cow)	Generous	Restricted	Diff.
In 3 weeks	463	370	93
In 19 weeks	2090	1973	117

* Gen. = Generous feeding, Res. = Restricted feeding.

3.2.2 MILK FAT YIELD

3.2.2.1 Milk fat yield during pre-experimental period

Milk fat yield of the cows used during pre-experimental period are given in Table 3.5. High BI cows produced significantly more milk fat ($P<.001$) than Low BI cows and Fat cows produced significantly more milk than Thin cows ($P<.05$).

Table 3.5: Milk fat yield during pre-experimental period, kg/cow/day.

		High BI	Low BI	Diff.
	Mean	1.13	0.88	0.25
Fat at calving	1.09	1.19±.08	0.95±.15	0.24
Thin at calving	0.94	1.06±.21	0.83±.07	0.23
Diff.	0.15	0.13	0.12	

For Entire Sample Mean 1.02±.19

SUMMARY OF ANOVA	Source of Variation	Sig. of F
	BI	.000
	Condition	.038
	BI x Condition	.915

3.2.2.2 Milk Fat Yield During Experimental Period

The unadjusted milk fat yield for Generous and Restricted groups illustrated in Figure 3.8. The covariance adjusted milk fat yield of the 8 treatments are given in Table 3.6, and also illustrated in Figure 4.4. Restricted feeding for 3 weeks significantly reduced ($P<.001$) covariance adjusted milk fat yield by 3.2 kg/cow (0.15 kg/cow/day) during experimental period and reduced total milk fat yield by 3.6 kg/cow in 19 weeks after the start of experiment. There were no significant differences between High BI and Low BI nor between Fat cows and Thin cows in milk fat yield in responses to differential feeding. There were no significant effects of differential feeding in milk fat yield during Post-experimental period.

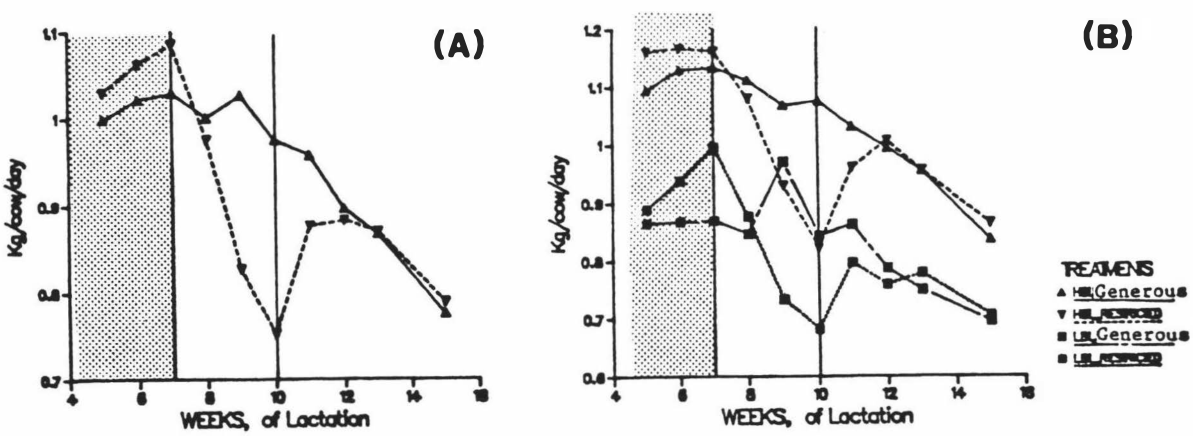


Figure 3.8: Fat yield due to differential feeding
(A) Generous (____) and Restricted Feeding (....)
(B) For the four main treatments

(Experiemtal period week 7-10)
= Pre-experimental period.

Table 3.6: Milk fat yield due to differential feeding, all values have been covariance adjusted except pre-exper. results

Genotypes	High BI				Low BI			
Condition	Fat		Thin		Fat		Thin	
Feeding regimes	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Fat Yield (kg/cow/day)								
Pre-experiment	1.13	1.26	1.10	1.01	0.92	0.97	0.81	0.86
Experimental	1.02	0.93	1.03	0.84	1.00	0.82	0.95	0.81
Fat Yield kg/cow								
Yield to 3 weeks	21.4	19.5	21.6	17.6	21.0	17.2	20.0	17.1
Yield to 19 weeks	96.4	100.0	101.6	93.5	96.0	85.2	89.5	90.5
(Generous - Restricted)								
In 3 weeks, kg/cow	2.0		4.0		3.8		2.9	
Total in 19 weeks, kg/cow	-3.6		8.1		10.8		-1.0	

Summary (yield, kg/cow)	Generous	Restricted	Diff.
In 3 weeks	21.0	17.9	3.2
In 19 weeks	95.9	92.3	3.6

3.2.3 MILK PROTEIN YIELD

3.2.3.1 Pre-experiment milk protein yield

The results of milk protein yield during pre-experimental period for are given in Table 3.7. High BI cows produced significantly more (P<.01) protein than Low BI cows, and Fat cows produced slightly more than Thin cows (not significant).

Table 3.7: Pre-experiment milk protein yield, kg/cow/day

		High BI	Low BI	Diff.
	Mean	.89	.74	.15
Fat at calving	.87	$.93 \pm .12$	$.79 \pm .09$	.14
Thin at calving	.77	$.85 \pm .15$	$.70 \pm .04$	.15
Diff.	.10	.08	.09	
For Entire Sample	$.82 \pm .14$			

SUMMARY OF ANOVA	Source of Variation	Sig. of F
	BI	.004
	Condition	.076
	BI x Condition	.894

3.2.3.2 Milk Protein Yield During Experimental Period

The unadjusted milk protein yields for Generous and Restricted groups are illustrated in Figure 3.9. The covariance adjusted results of the 8 treatments are given in Table 3.8, and illustrated in Appendix III. Restricted feeding 3 weeks significantly reduced (P<.001) protein yield by 2.5 kg/cow during the period of restricted feeding (0.11 kg/cow/day) and reduced the total milk protein production was reduced by 4.7 kg/cow in 19 weeks after the start of the experiment. There were no significant different between High BI and Low BI cows nor between Fat cows and Thin protein yield in cows in response to differential feeding. There were no significant effect of differential feeding during Post-experimental period.

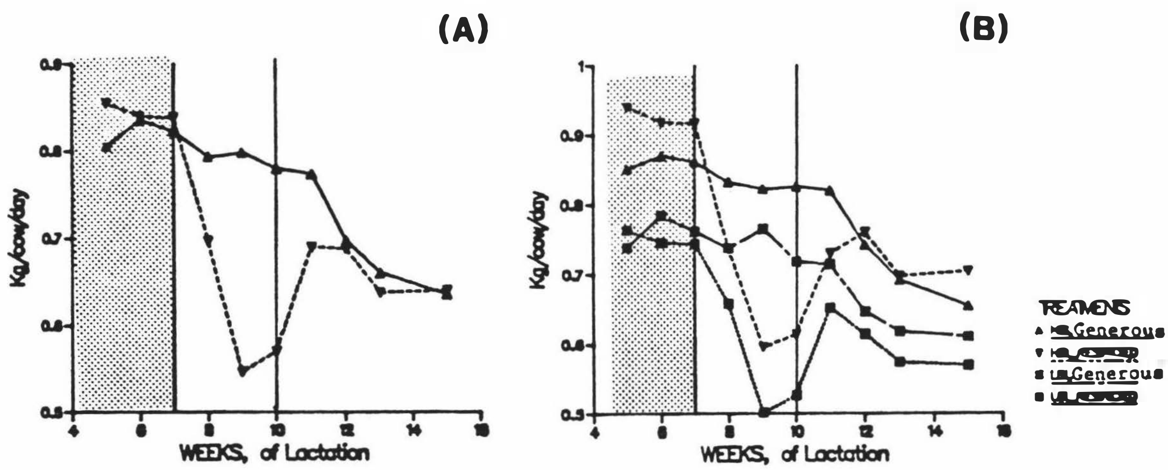


Figure 3.9: Protein yield due to differential feeding
(A) Generous (____) and Restricted Feeding (....)
(B) For the four main treatments

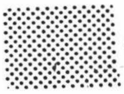

(Experiemtal period week 7-10)
= Pre-experimental period.

Table 3.8: Protein yield due to differential feeding, all values have been covariance adjusted except pre-exper. results

Genotypes	High BI				Low BI			
Condition at calving	Fat		Thin		Fat		Thin	
Feeding regime	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Protein Yield (kg/cow/day)								
Pre-experimental	0.87	1.01	0.87	0.82	.82	0.78	0.69	0.70
Experimental	0.81	0.57	0.79	0.62	0.81	0.62	0.77	0.60
Protein Yield, kg/cow								
Yield to 3 weeks	17.9	15.4	17.9	15.0	17.0	14.5	16.2	14.3
Yield to 19 weeks	73.4	70.6	75.3	70.1	74.8	66.1	71.7	68.8
(Generous - Restricted) kg/cow								
In 3 weeks	2.5		2.9		2.5		0.9	
In 19 weeks	2.8		5.2		8.7		2.9	

Summary (Yield, kg/cow)	Generous	Restricted	Diff.
In 3 weeks	17.3	14.8	2.5
In 19 weeks	73.8	68.9	4.7

3.2.4 MILK FAT CONCENTRATION

3.2.4.1 Milk Fat Concentration During Pre-experimental Period

The results of milk fat concentration (g/kg milk) during pre-experimental period for are given in Table 3.9. High BI cows' milk contained significantly (P<.05) higher fat concentration than Low BI cows' milk, Fat cows' milk contained slightly (non-significant) higher fat than Thin cows' milk.

Table 3.9: Pre-experimental milk fat concentration (g/kg Milk).

		High BI	Low BI	Diff.
	Mean	46.8	42.2	4.6
Fat at calving	45.0	46.8±5.1	42.0±2.9	4.8
Thin at calving	44.6	47.0±1.8	42.3±5.4	4.7
Diff.	0.3	-0.3	0.3	

For Entire Sample Mean 44.7±4.6

SUMMARY OF ANOVA	Source of Variation	Sig. of F
	BI	.014
	Condition	.867
	BI x Condition	.995

3.2.4.2 Milk Fat Concentration During Experimental Period

The results of unadjusted milk fat concentration of the Generous and Restricted feeding regimes are illustrated in Figure 3.10. The adjusted milk fat concentration during experimental period are given in Table 3.10. Restricted feeding increased (not significant) covariance adjusted milk fat concentration. There were no significant differences between High BI and Low BI nor between Fat cows and Thin cows in covariance adjusted milk fat concentration in response to differential feeding.

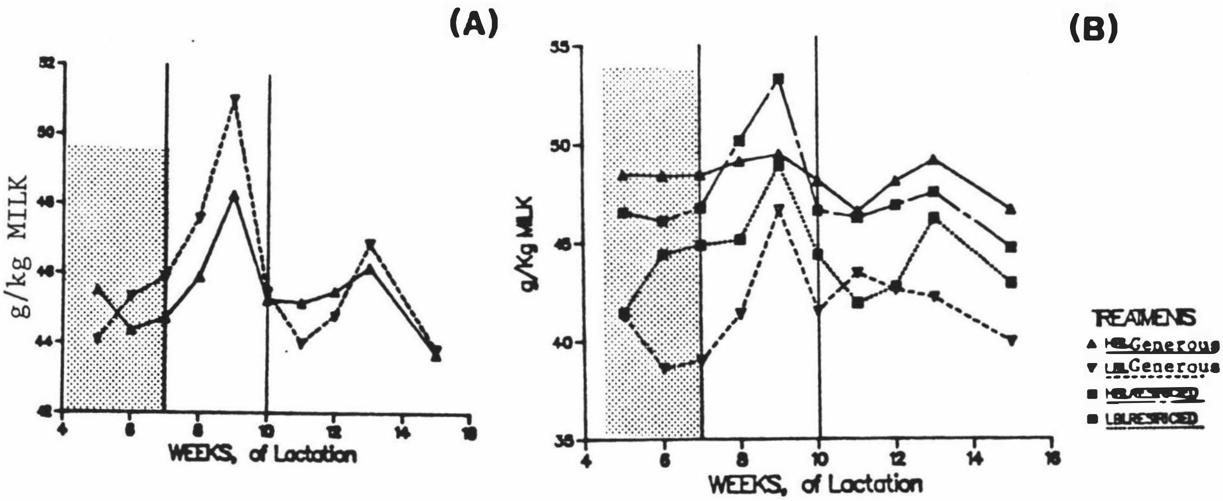


Figure 3.10: Fat concentration due to differential feeding
(A) Generous (____) and Restricted Feeding (....)
(B) For the four main treatments


(Experiemtal period week 7-10)
= Pre-experimental period.

Table 3.10: Milk fat concentration due to differential feeding, all values have been covariance adjusted except Pre-experimental results

Genotypes	High BI				Low BI			
Condition at calving	Fat		Thin		Fat		Thin	
Feeding regime	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Mean fat concentration (g/kg milk)								
Pre-experimental	48.3	44.5	46.7	47.2	40.0	43.4	41.5	43.2
Experimental	44.7	51.5	46.5	46.3	46.2	47.7	46.6	46.4

Summary	Generous	Restricted	Diff.
Mean (g/kg milk) Experimental Period	46.2±5.7	48.3±4.3	-1.9

3.2.5 MILK PROTEIN CONCENTRATION

3.2.5.1 Milk Protein Concentration During Pre-experimental Period

The results of milk protein concentration (g/kg milk) during pre-experimental period for are given in Table 3.11. High BI cows' milk contained slightly higher protein (non-significant) than Low BI cows' milk, and Fat cows' milk contained slightly lower (non-significant) protein than Thin cows' milk.

Table 3.11: Milk protein concentration, pre-experimental period, g/kg Milk.

		High BI	Low BI	Diff.
	Mean	36.6	35.5	1.4
Fat at calving	35.9	36.1±2.4	35.6±2.5	0.6
Thin at calving	36.6	37.8±1.2	35.4±2.1	2.4
Diff.	-0.7	-1.7	0.2	
For Entire Sample Mean	36.3±2.2			

SUMMARY OF ANOVA	Source of Variation	Sig. of F
	BI	.110
	Condition	.338
	BI x Condition	.297

3.2.5.2 Milk Protein Concentration During Experimental Period

The unadjusted milk protein concentration for Generous and Restricted groups obtained during experimental period are illustrated in Figure 3.11. The covariance adjusted milk protein concentration are given in Table 3.12. Restricted feeding for 3 weeks significantly reduced (P<.001)) milk protein concentration by 2.4 g/kg milk during experimental period. There were no significant differences between High BI and Low BI nor between Fat cows and Thin cows in milk protein concentration in response to differential feeding.

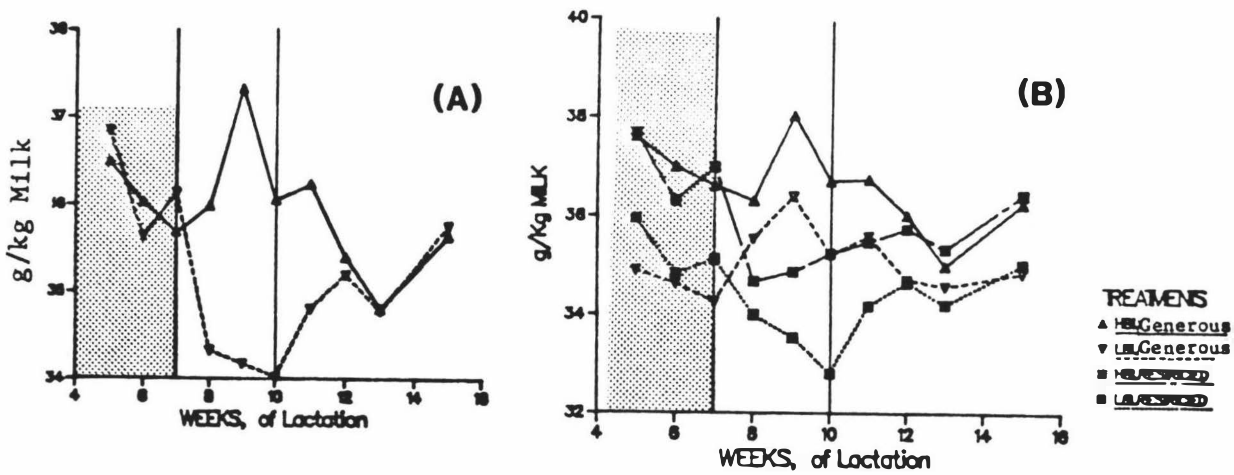


Figure 3.11: Protein concentration due to differential feeding
(A) Generous (____) and Restricted Feeding (....)
(B) For the four main treatments

(Experiemtal period week 7-10)
= Pre-experimental period.

Table 3.12: Milk protein concentration due to differential feeding, all values have been covariance adjusted except Pre-experimental results

Genotypes	High BI				Low BI			
Condition at calving	Fat		Thin		Fat		Thin	
Feeding regime	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Milk protein (g/kg milk)								
Pre-experimental	36.7	35.5	36.9	38.7	35.8	35.4	35.2	35.6
Experimental	36.4	33.4	36.3	34.5	36.3	34.8	36.7	33.3

Summary (g/kg Milk)	Generous	Restricted	Diff.
Experimental Period	36.5 ± 2.1	34.1 ± 2.4	2.4

3.2.6 FATTY ACID COMPOSITION OF MILK DUE TO DIFFERENTIAL FEEDING

Restricted feeding significantly reduced ($P<.001$) mole % of short chain fatty acids, and significantly increased ($P<.001$) mole % of the long chain fatty acids. The mole % of individual fatty acid of milk fat for the two feeding regime are given in Table 3.13 with the significant values of F and these are illustrated in Figure 3.12 . There were no significant differences between High BI cows' and Low BI cows' nor between Fat cows' and Thin cows' milk in fat composition changes in response to differential feeding. The changes in mole % of fatty acids due to differential feeding are illustrated in Figure 3.13, and mmole % of individual fatty acid are illustrated in Appendix IV. And from molecular weight % the fatty acid yields (kg/cow/day) were calculated using;

Fatty Acid Yield = (molecular % x milk fat yield)/100

The yield of fatty acid are illustrated in Figure 3.12.

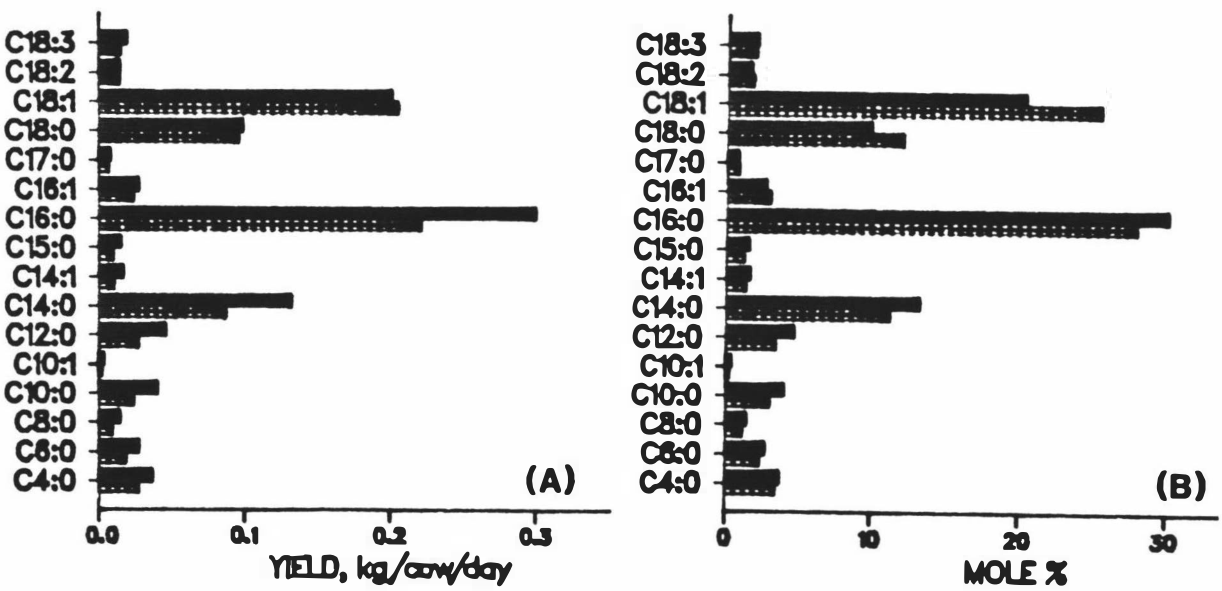


Figure 3.12: Fatty acid composition of milk due to differential feeding (A) Fatty acid yield (B) Mole % of fatty acid

Generous   Restricted

Table 3.13: Milk fat composition due to differential feeding and the significant values of F

Acids	Feeding Regimes		Significant values of F*						
	Generous	Restricted	F	B	C	FxB	FxC	BxC	FxBxC
C4:0	3.65	3.36	-	-	-	-	-	-	-
C6:0	2.65	2.32	.042	-	-	.011	-	-	-
C8:0	1.41	1.15	.012	-	-	.018	-	-	-
C10:0	3.94	3.01	.002	-	-	.024	-	-	-
C10:1	0.32	0.21	.004	-	-	.057	-	-	-
C12:0	4.61	3.40	.000	-	-	-	-	-	-
C14:0	13.25	11.20	.000	-	.050	.061	-	-	-
C14:1	1.61	1.35	.004	-	.065	-	-	.033	-
C15:0	1.50	1.20	.001	-	.017	-	-	.045	-
C16:0	30.10	28.00	.014	-	-	-	-	-	-
C16:1	2.68	2.96	.049	-	-	-	-	-	-
C17:0	0.74	0.81	-	-	-	-	-	-	-
C18:0	9.96	11.96	.001	-	-	-	-	-	-
C18:1	20.30	25.45	.001	-	-	.050	-	-	-
C18:2	1.61	1.76	.012	-	-	.024	-	-	-
C18:3	1.92	1.87	-	-	.056	.007	-	-	-
SHORT	32.94	27.20	.000	-	-	.014	-	-	-
MEDIUM	31.52	30.27	.034	-	-	-	-	-	-
LONG	33.57	41.05	.00	-	.055	.034	-	-	-

* F = Feeding, B = Breeding Index, C = Condition, x = Interaction

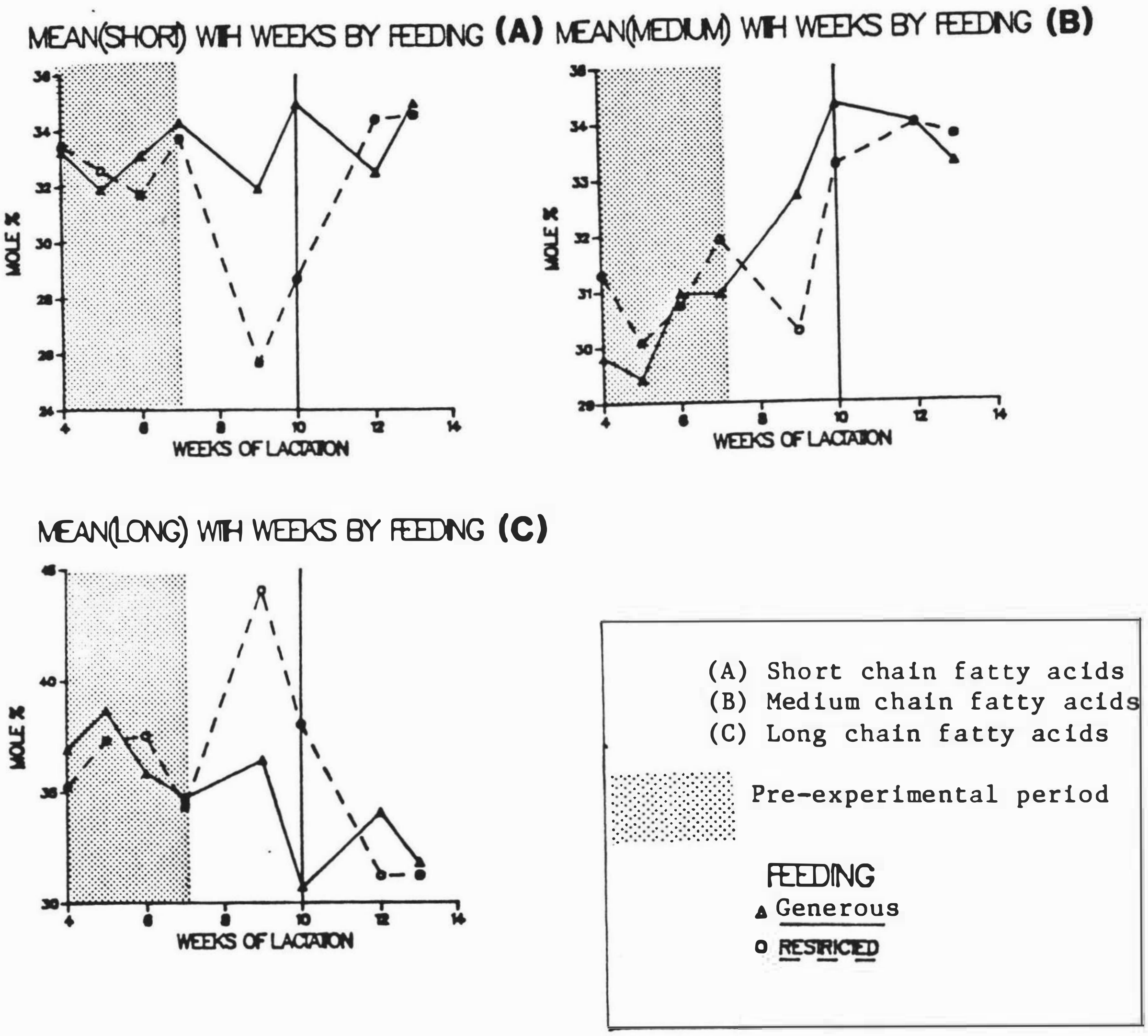


Figure 3.13: Changes of fatty acid of milk due to differential feeding.
(Vertical line indicates the finish of the experiment)

3.2.7 LIVEWEIGHT

Cows' liveweight taken at the beginning, at the end of experiment and at 14th and 18th week after the start of lactation are given in Table 3.14 together with the liveweight changes due to differential feeding. The results are illustrated in Figure 3.14A, 3.15A. Restricted feeding caused significant (P<.001) reduction in liveweight of the cows. There were significant differences (P<.05) in response in liveweight to differential feeding by Fat and Thin cows. No significant differences between High and Low BI cows in liveweight changes in response to differential feeding was found.

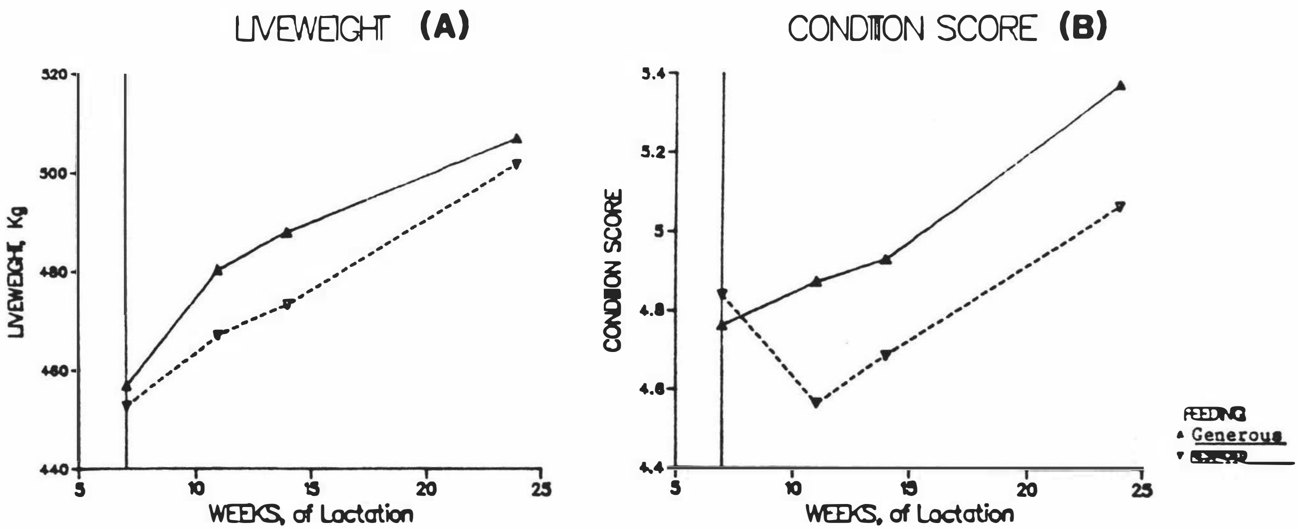


Figure3.14: (A) Liveweight and (B) Condition score due to differential feeding
(Vertical line indicates the start of experiment, Experimental period week 7-10)

Table 3.14: Cows' liveweight and liveweight changes due to differential feeding

Genotypes	High BI				Low BI			
Condition	Fat		Thin		Fat		Thin	
Feeding regime	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Week 7	429	474	429	466	541	478	472	428
Week 11	443	474	455	475	567	479	499	442
Week 14	445	477	458	478	575	490	518	450
Week 24	463	484	482	508	581	520	542	486
Changes in 3 weeks	+14.0	+0.8	+25.8	+8.8	+25.7	+0.9	+26.7	+13.4
Changes in 19 weeks	+34.0	+10.0	+53.0	+42.0	+40	+42.0	+70.0	+58.0

Summary	Generous	Restricted	Generous	Restricted
Changes in 3 weeks	+19.1	+4.6	+26.3	+7.2
Changes in 19 weeks	+43.5	+30.5	+55.0	+50.0

Grand Summary	Generous	Restricted
Changes in 3 weeks	+22.1	+6.7
Changes in 19 weeks	+49.3	+40.5

3.2.8 CONDITION SCORE

The results of the condition scores of the cows are given in Table 3.15, and illustrated in Figure 3.14B, 3.15B. Restricted feeding significantly (P<.05) caused cows to loss condition score. There were no significant differences between High BI and Low BI cows and there were no significant differences between Fat cows and Thin cows at calving in condition scores in response to differential feeding (but the Fat cows lost more condition than the Thin cows).

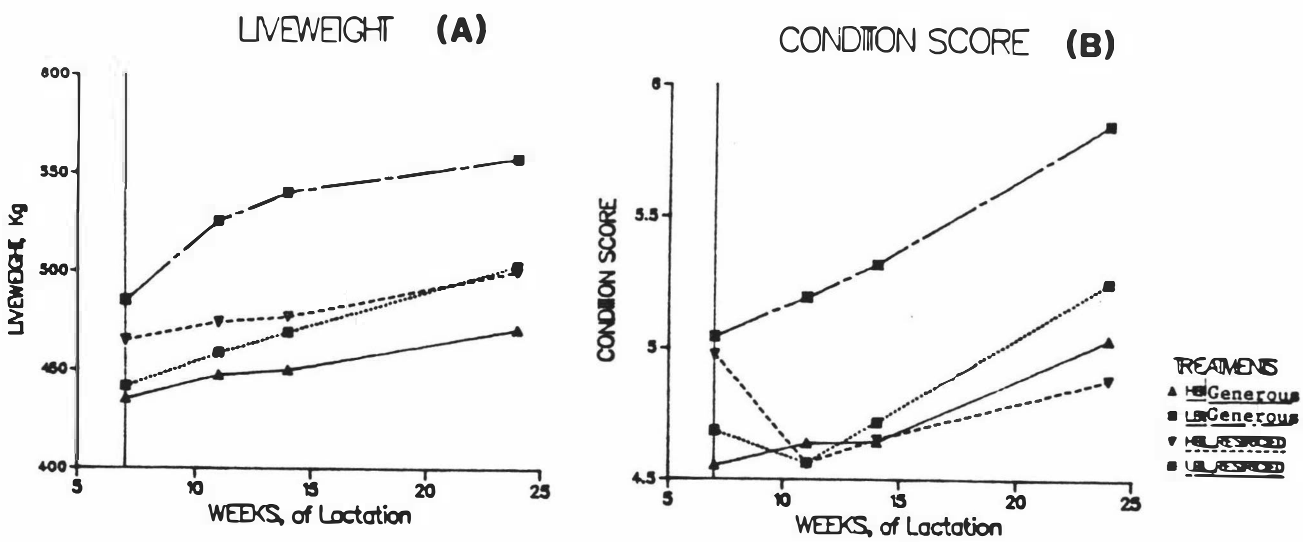


Figure3.15: (A) Liveweight and (B) Condition score due to differential feeding
(Vertical line indicates the start of experiment, Experimental period week 7-10)

Table 3.15 Cows' condition score and condition score changes due to differential feeding

Genotypes	High BI				Low BI			
Condition	Fat		Thin		Fat		Thin	
Feeding regime	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Week 7	4.85	5.38	4.21	4.45	5.83	5.09	4.62	4.27
Week 11	4.89	4.89	4.30	4.37	5.63	4.80	4.90	4.32
Week 14	4.90	4.78	4.31	4.53	5.62	4.86	5.13	4.58
Week 24	5.13	4.88	4.92	4.88	6.25	5.42	5.58	5.08
Changes in 3 weeks	-0.04	-0.49	+0.10	-0.08	-0.20	-0.29	+0.28	-0.05
Changes in 19 weeks	+0.24	-0.05	+0.71	+0.43	+0.42	+0.33	+0.96	+0.81

Summary	Generous	Restricted	Generous	Restricted
Changes in 3 weeks	+0.08	-0.29	+0.09	-0.12
Changes in 19 weeks	+0.48	+0.38	+0.69	+0.57

Grand Summary	Generous	Restricted
Changes in 3 weeks	+0.08	-0.20
Changes in 19 weeks	+0.58	+0.38

3.3 HERBAGE INTAKE

3.3.1 ESTIMATE HERBAGE INTAKE, By Sward Cutting Technique

The herbage allowances were achieved by controlling the grazing area. The herbage mass present before grazing were estimated by the sward-cutting technique. For the present thesis the herbage masses for the Restricted feeding regime groups were lower than that for the Generous feeding regime groups. These were because the herbage had been serverely grazed during the pre-experimental experiment when chromic oxide technique was also tested. The results obtained from experiment for herbage intake are given in Table 3.16. The detail of the results obtained are given in Appendix V. The results showed that 68 % reduction in herbage allowance caused 37 % reduction in herbage DM intake (estimate from sward-cutting technique).

Table 3.16: The herbage allowance, and herbage intake by grazing dairy cows in the experiment (during 15 Oct. to 5 Nov.).

Genotypes	High BI		Low BI	
Feeding regime	Generous	Restricted	Generous	Restricted
Area Allowed (m^2/cow/dy)	149	79	149	79
Herbage Mass(kg DM/ha)	3352	1980	3352	1980
Residual Herbage Mass (kg DM/ha)	2137	566	2181	589
Herbage Allowance (kg DM/cow/day)	50	16	50	16
Herbage Intake (kg DM/cow/day)	18.1	11.2	17.4	11.0

The results obtained from Sward-cutting technique were used to show the relationship between herbage intake and herbage allowance, and residual herbage mass and are illustrated in Figure 3.16. Figure 3.16 show a curvilinear relationship between DM herbage intake and herbage allowance, and a curvilinear relationship between DM herbage intake and residual herbage mass can be observed. High BI cows showed slightly higher herbage DM intake than Low BI cows.

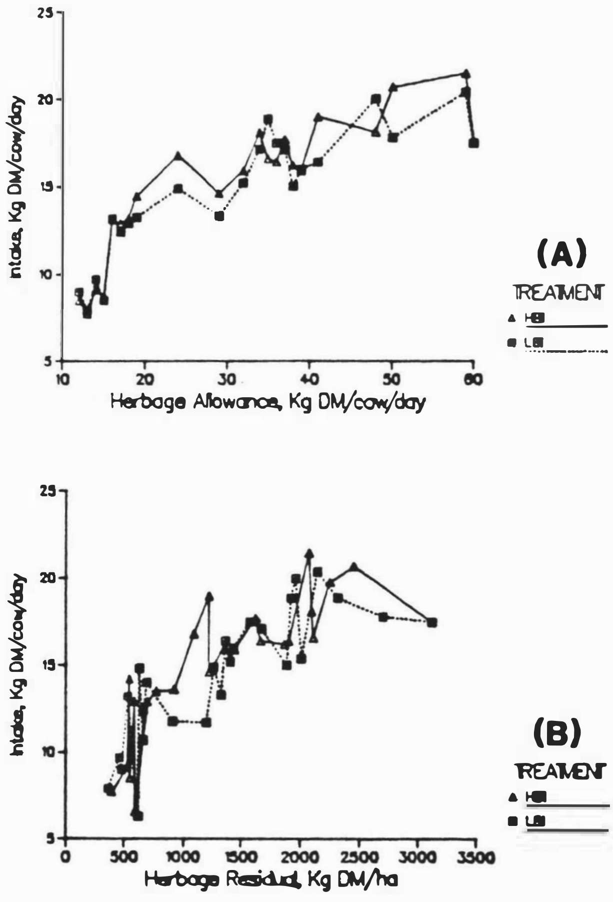


Figure 3.16: The relationships between herbage DM intake and
(A) Herbage intake
(B) Residual herbage mass.

3.3.2 HERBAGE INTAKE, Estimate by the Marker Technique

3.3.2.1 Intake Estimated Prior To Differential Feed (12 to 23 Sept.)

The experiment was the preliminary experiment, was not related directly to the grazing trial reported above. The average chromic oxide concentration in faeces was 4.75$\pm$0.61 g/kg DM faeces. From *in vivo* digestibility values from Section 3.3.3 (776 g/kg DM), the herbage intake was estimated and given in Table 3.17 and Table 3.18. The herbage herbage intake were estimated based on total recovery. High BI cows showed higher (non-significant) estimated herbage intake than the Low BI cows. Thin cows showed slightly higher (non-significant) estimate intake than Fat cows. The average soil in faeces was 0.65 kg/cow/day.

Table 3.17: Estimated herbage intake during preliminary experiment early lactation (12 Sept. - 23 Sept.)

Genotypes	High BI		Low BI	
Feeding regime	Fat	Thin	Fat	Thin
Cr_2O_3 (g/kg faeces)	4.75+.58	4.41+.66	4.98+.88	4.99+.41
Faeces (kg/cow/day)	4.26+.47	4.62+.73	4.10+.70	4.03+.34
Soil in faeces (kg/cow/day)	0.69+.26	0.61+.12	0.66+.30	0.66+.15
Herbage Intake (kg DM/cow/day)	18.3+1.9	20.0+3.2	17.7+2.9	17.3+1.4

3.3.2.2 Estimated Herbage Intake due to Differential Feeding, Preliminary Experiment, 23 Sept. to 14 Oct.

Generous feeding groups showed higher (non-significant) estimate herbage intakes than Restricted feeding groups. The High BI cows showed higher (non-significant) estimated intakes than the Low BI cows. Thin cows showed higher (non-significant) estimated herbage intakes than Fat cows but this was true only for High BI cows. There was significant difference between feeding regime in the amount of soil in faeces (P>.001), which were 0.60$\pm$.16 and 0.96$\pm$.24 kg/cow/day respectively for Generous and Restricted feeding regime. The results are given in Table 3.18.

Table 3.18: Herbage intake estimate by chromic oxide technique, when the cows were on differential feeding.

	High BI				Low BI			
	Fat		Thin		Fat		Thin	
	Gen.	Res.	Gen.	Res.	Gen.	Res.	Gen.	Res.
Cr_2O_3 (g/kg DM faeces)	5.64	5.67	4.89	5.20	5.18	5.41	5.68	5.86
Faeces (DM kg/cow/day)	3.58	3.53	4.15	3.85	3.86	3.74	3.62	3.35
Soil (kg/cow/day)	0.65	0.94	0.50	1.10	0.74	0.87	0.60	0.91
Herbage Intake (kg DM/cow/day)	15.35	14.83	18.02	16.07	16.50	15.82	15.56	14.48

The herbage intake of the cows used estimated by chromic oxide technique during this period given in Table 3.18 are summarised and also shown in Table 3.19 for comparison. The results showed that the estimate herbage intake by the two technique are in agreement for the Generous feeding regime. The estimate herbage intake by chromic oxide technique for the Restricted feeding regime were higher than the intake estimate by the sward-cutting technique.

Table 3.19: The herbage allowance, and herbage intake by grazing dairy cows estimated by the sward-cutting and chromic oxide technique, preliminary experiment

Genotypes	High BI		Low BI	
Feeding regime	Generous	Restricted	Generous	Restricted
Area Allowed (m^2/cow/day)	116	58	116	58
Herbage Mass (kg DM/ha)	3169	3169	3169	3169
Residual Herbage Mass (kg DM/ha)	1724	765	1737	853
Herbage Allowanced (kg DM/cow/day)	36.8	18.4	36.8	18.4
Herbage Intake (kg DM/cow/day)				
By Sward-cutting	16.8	13.9	16.6	13.4
By Chromic Oxide	16.7	15.5	16.0	15.2

3.3.3 IN VIVO DIGESTIBILITY VALUES

The in vivo digestibility DM values obtained during preliminary experiment was 776$\pm$26 g/kg and the value was used for the estimation of herbage intake by chromic oxide technique. The in vivo digestibility DM values obtained during experimental period was 763$\pm$ g/kg. The mean values of in vivo digestibilities obtained from in vitro digestibility were 791$\pm$39 g/kg DM and 663$\pm$37 g/kg DM respetively for the herbage obtained before and after grazing.

CHAPTER 4

C H A P T E R 4

4 D I S C U S S I O N

4.1 HIGH AND LOW BI COWS AND THEIR PERFORMANCES

The results obtained for the present thesis and the results obtained previously by Grainger (1982) and the results from Ruakura (Bryant, 1981; Bryant & Trigg, 1981) are in agreement in showing that High BI cows produce more milk over the lactation than Low BI cows. The difference in BI between High and Low BI cows was 20 BI units and was associated with a difference in milkfat yield of 23 %. This confirms the result obtained by Grainger (1982) that the agreement between expected differences (based on breeding index) and the observed differences in milkfat yield was close. Because the selection criteria for dairy cows in New Zealand aimed mainly to improve fat yield, the production advantage of High BI cows over Low BI cows were smaller for other milk components namely, 17.9 % for protein yield, 13 % for milk yield. When the lactation performances during the first 5 week of lactation namely milk, milk fat, protein yield, fat and protein concentration were plotted against the breeding index values of the cows the results are illustrated in Figure 4.1. The slopes of the linear regression lines were obtained and also given in Figure 4.1. The slope for milkfat yield was 0.00866 which means that for 1 increment in BI unit the milkfat yield is improved by 0.00866 kg/cow/day. The expected different in milkfat yield is 20x0.00866 = 0.173 kg/cow/day which is close to the mean yield difference (0.85 - 0.69 = 0.16 kg/cow/day). The change in difference between genotypes in milkfat yield as lactation progressed has been observed to be variable and non-significant by Bryant & Trigg (1981), Grainger (1982). The declines of milkfat yield were similar as lactation progressed for both genotypes for the present thesis (Figure 3.2A, Appendix II). It must be therefore assumed that the difference between genotypes in milkfat yield remains constant throughout lactation. High BI cows′ milk contain more milkfat than Low BI cows′ milk, their protein concentrations were similar.

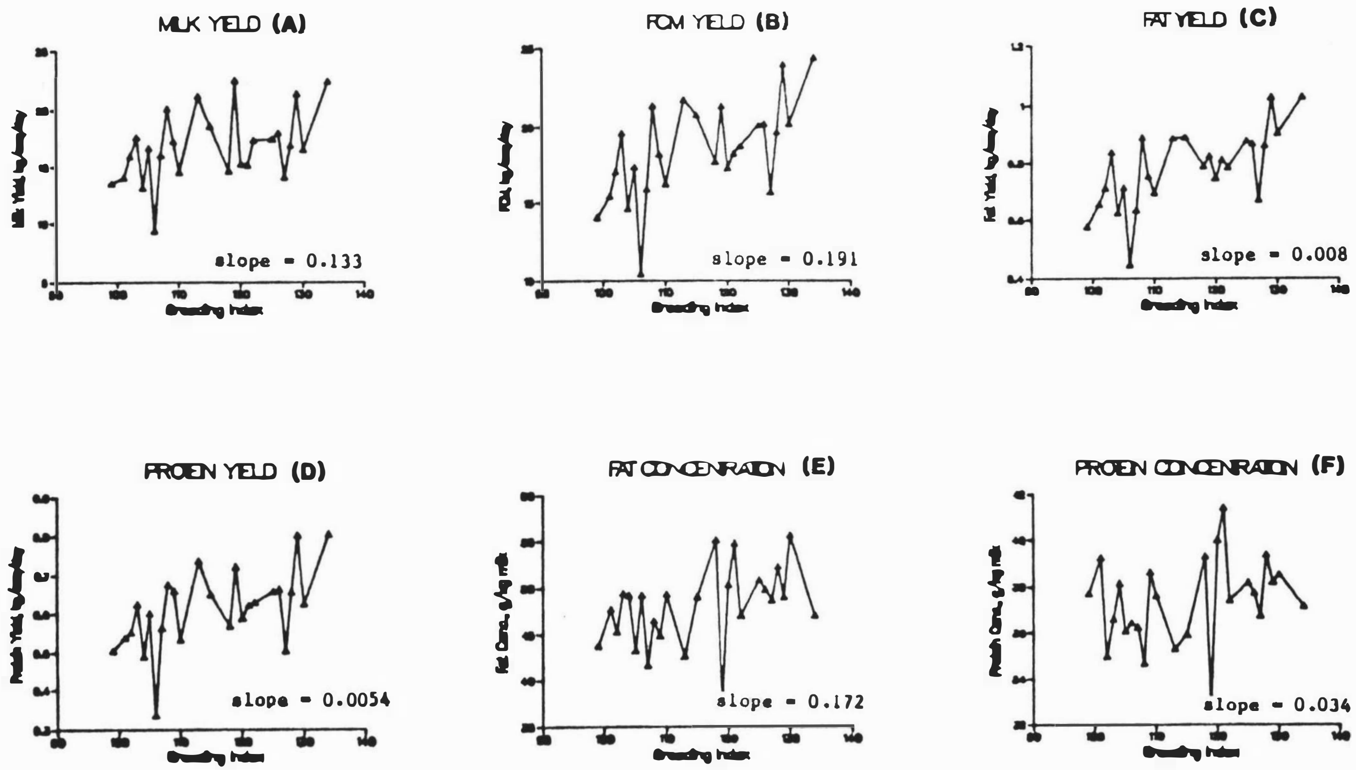


Figure 4.1 The relationships between BI values and (first 5 week) (A) Milk, (B) FCM , (C) Fat yield, (D) Protein yield (E) Fat concentration (F) Protein concentration.

The results obtained for the present thesis showed that High BI cows' and Low BI cows' milk had similar in milkfat composition. Milk fat composition was found to reflect more from nutritional status and from cows' body condition rather than genotypes.

The results showed that Low BI cows had higher condition score and were heavier than High BI cows, this confirms the results obtained by Grainger (1982), The liveweight gain by Low BI cows was slightly higher than High BI cows. Because Low BI cows partition less nutrients for milk production but they partition more to liveweight gain than High BI cows (Grainger, 1982). When the liveweight changes due to differential feeding (Table 3.14, 3.15) were plotted against the respective condition score changes. The relationship is illustrated in Figure 4.2. From the relationship, 1 condition score change was equivalent to 37.4 kg liveweight change which is agreed with 35 kg liveweight used by Holmes et al. (1981).

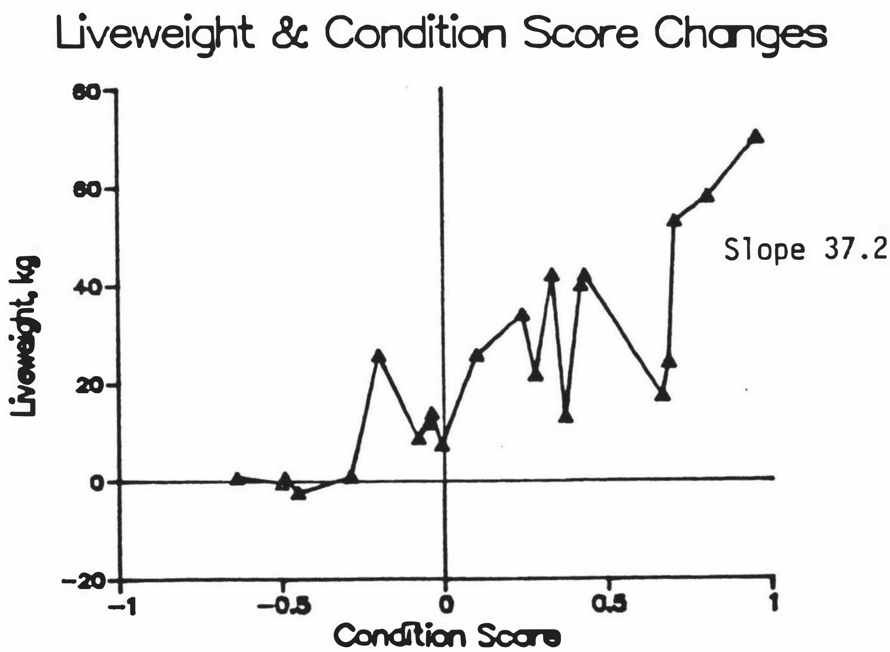


Figure 4.2: The relationship between cows' liveweight and condition score changes.

4.2 FAT AND THIN COWS AND THEIR LACTATION PERFORMANCES

The Fat cows were calved at mean condition score of 5.7 while the Thin cows calved at mean condition score 3.8. Improving body condition at calving increased milk production, Fat cows produced 12.4 % more milkfat than Thin cows. The results (Figure 3.2B) show larger difference between Fat and Thin cows in early lactation than later but Appendix II shows that this is true only for High BI cows. The fat concentration of milk of the Fat cows were higher than the milk of Thin cows during the first 10 weeks of lactation, suggesting that Fat cows mobilsed more of body fat for milkfat production, thereafter their fat concentration were similar. This is consistent with the fact that Fat cows lost their body weight and condition scores during early lactation. Fat cows' milkfat contained higher (P<.05) long chain fatty acids but lower mole % (P<.05) than Thin cows early lactation, indicated also that Fat cows mobilised more of their body reserves than Thin cows. Bryant (1979) also indicated that cows calve 1 condition score higher results in milk contains fat an extra 1.5 g/kg milk. Protein concentration of milk of the Fat cows were slightly lower and this is also in agreement with Bryant (1979) that an increase in live weight at calving causes a decrease in milk protein concentration, the effects were smaller than those of fat concentration.

Holmes (1982) suggested that the production achieved by a cow will increase by about 8 to 10 kg milkfat for an increase of 1 condition score in her body at calving provided that their condition scores are in the range 3 to 6. The results obtained for the present thesis showed that the production achieved by a cow inceased by 10.5 kg milkfat for an increase of 1 condition score (Table 4.1). But the results showed that Low BI improved the milk fat production more than High BI cows due to improving their body condition at calving. For the present thesis, although Fat cows produced more milkfat, but because of Low BI cows produced less than High BI, Table 4.1 showed that Fat Low BI cows produced less milkfat than Thin High BI cows. However, the gain of 1 condition score required 221 kg DM during dry period (Ngarmsak, 198~~4~~2). The equivalent response to this amount of herbage DM is 21.0 kg DM to produce 1 kg milkfat (see the calculation).

Table 4.1: Production of High BI and Low BI cows calving at two levels of body condition.

	High BI		Low BI	
	Fat	Thin	Fat	Thin
Condition Score				
At calving	5.6	3.8	5.7	3.7
At 24th Weeks	4.9	5.0	6.1	5.7
Milkfat Yield kg/cow	219	208	183	152

			Average
Differences (Fat - Thin)			
Milkfat yiled (kg)	11	31	20
Condition score	1.8	2.0	1.9
Extra feed DM/kg milkfat yield	36	14	21

Calculation:

The average Fat cows had 1.9 unit condition score than Thin cows this associated with the milkfat yield of 20 kg higher.

Therefore;

Increase 1 condition score improves 20/1.9 = 10.5 kg milkfat.

The gain of 1 unit condition score required 221 kg DM.

Feed required to increase condition score = 1.9x221 kg DM.

Extra feed required = (1.9x221)/20 = 21 kg DM/kg milkfat

4.3 HERBAGE INTAKE

The results obtained from both sward-cutting and chromic oxide technique showed that High BI cows consumed slightly (not significant but consistent) more herbage DM than Low BI cows. The results were agreed with Grainger (1982) and Bryant (1981) who also obtained consistent higher herbage intake for High BI cows than Low BI cows. Grainger (1982) postulated that higher milk and milkfat production of High BI compared with Low BI cows can be almost completely explained by the higher intakes and the utilisation of a greater proportion of metabolisable energy intake for the synthesis of milk and a smaller proportion for the synthesis of body tissue. But the herbage intake differences between High BI and Low BI cows were not significant for the present thesis and thus can not explain entirely the sigificantly higher milkfat yield for High BI cows than Low BI cows. However the reason for the higher herbage DM intake for High BI to date is not clear (Grainger, 1982). Forbes (1980) reiterated the concept that food is eaten in order to preserve an equilibrium between energy flow into and out of the body. In support to this theory Bryant (1980) indicated that differences between genotypes in intake that occured during lactation were not present during dry period. Factors associated with lactation therefore may responsible for the differences between genotypes in herbage DM intake. Whether these factors arise from the mammary gland itself, digestion end-products or hormonal status is unclear (Grainger, 1982).

From chromic oxide technique, the results showed that Thin cows consumed slightly (not significant) more herbage DM than Fat cows in both Generous and Restricted feeding regimes. But the chromic oxide technique is critisism, the results obtained for the present thesis agreed with Carruthers & Bryant (1983) that the technique is unsuitable for detection of small but real differences in intake between groups of animals.

Curvilinear relationships between herbage allowances, and between residual herbage mass and the herbage DM intake were found (Figure 3.16). These curvilinear relationships have been demonstrated previously (Ngarmsak, 1982) and have generally been demonstrated by others workers such as Combellas & Hodgson (1979) for grazing dairy cows, Trigg & Marsh (1980) for young beef cattle, Rattray (1978) for sheep, Glassey (1980) for lactating dairy cows. Bryant (1980) suggested that for these curvilinear relationship there is considerable flexibility in the level of feed offered to the grazing cows. In some situations, there may be scope for reducing the amount of herbage offered without significantly reducing herbage DM intake or milk production and Glassey (1980) has demonstrated this to be true for his results. And for the present thesis reduction in herbage allowance by 68 % caused a reduction in herbage DM intake by only 37 % and the milkfat yield reduced by only 15 % during period of restriction.

4.4 THE EFFECTS OF UNDERFEEDING DURING EARLY LACTATION

4.4.1 The Effect of Underfeeding on Milk Yield And Milk Composition

Restricted feeding significantly reduced milk yield by the cows and slighlty increases in fat concentration and significantly reduced protein concentration in milk. These were in agreements with previous results reviewed by Burt (1957) and Rook (1961), in Bryant (1979) and results obtained by Huber & Bowman (1966), Thomas & Kelley (1976). The results for present thesis showed that milkfat concentration was increased but more variable. Restricted on herbage intake caused the reduction in milfat and milk protein yield but mainly during period of restriction.

For milkfat yield Mackenzie (1984) indicated that early lactation a proportion of milkfat is synthesised from fat mobilised from body reserves. During underfeeding this mobilisation continue or may even be stimulated which buffers the fat yield against falling as much as the milk yield. Consequently the concentration of milkfat generally rises. Sutton (1979) also indicated, the effect of level of intake on milkfat yield is complex depending on whether the increase in fat concentration due to decreasing level of intakes outweighs the decrease in milk yield that usaully accompanies it.

4.4.2 The Effect of Underfeeding on Fatty Acid Composition of Milk

For the present thesis, restricted feeding caused increases (P<.001) in mole % of long chain fatty acids by 22 % indicated that cows were mobilised their body fat reserved for milk production, the results obtained were in agreement with Bartsch et al. (1981). The results showed that Restricted feeding reduced (P<.001) mole % of short chain fatty acids by 17 % and reduced (P<.05) mole % of medium chain fatty acids by 4 %. From mole % of individual fatty acids changes, restricted feeding reduced C4:0 to C16:0 and increased C16:1 to C18:2 which illustrated in Figure 3.15A and summarised in Figure 4.3. The decrease in the short chain and medium chain fatty acids (C6 to C16) and the increase in the long chain C18 saturated and unsaturated fatty acids are consistent with the mobilisation of body reserves (Stobbs & Brett, 1974). C16 and C18 fatty acids were reported to related negatively to liveweight changes (see Storry et al., 1979 for references). Changes in fatty acid composition of milk due to under feeding can be detected with 24 hours. A restriction in grazing for 24 hours has been shown to increase the proportions of unsaturated C18 fatty acids in milk (Munford et al., 1964). Bartsch et al. (1981) reported that 12 to 18 hours after the commencement of the restriction of feed significantly differences existed between the treatment groups in the proportion of fatty acids in the milk.

The yield of fatty acids (kg/cow/day), restricted feeding reduced the yield (P<.001) of short chain and medium chain fatty acids (Figure 3.15B). But the yield of long chain fatty acids were unchanged because the decreases in milkfat yield were outweighed by the increases in mole % of these acids, are given in Figure 4.3B. Underfed cows able to maintain yield of long chain fatty acids by mobilizing tissues. The changes in fat composition reflect the relative proportion of fatty acids in fat which Mackenzie (1984) were;

(1) derived directly from the intestine,

(2) released from the adipose tissue,

(3) synthesised in the mammary gland.

Acids containing from 4 to 10 carbons atoms are synthesised within the mammary gland from acetate and B-hydroxybutyrate, long chain acids containing 18 or more carbon atoms are transfered from blood plasma triglycerides, fatty acids of intermediate chain length can be derived from both sources. In broad terms Oldham & Sutton (1979) pointed out that about one-half of the fatty acid of milk is synthesised in the udder from short chain precursors and one-half is transfered directly from blood. But the relative contribution of these two sources to the total yield of fatty acids and to the yield of those acids of intermediate chain length is affected by a variety of dietary and non-dietary factors (Storry, 1970).

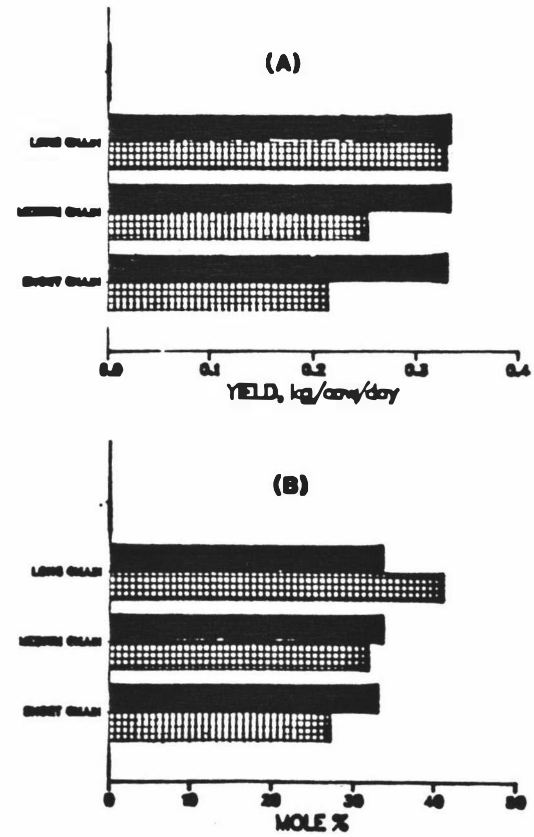


Figure 4.3: Fatty acid composition of milk due to differential feeding (A) Fatty acid yield (B) Mole % of fatty acid

Generous Restricted feeding

4.5 RESPONSE TO FEEDING

4.5.1 Milk Production

It was the aim of the present thesis to study the responses of cows differing in breeding index to differing feeding levels and of these cows of differing condition at calving. The response to feeding calculated from the performances of the animals under different feeding level namely Generous and Restricted feeding regimes. The milkfat yield in response to the two level of feeding are summarised in Table 4.2. No differences in this respect were found between High BI and Low BI cows nor between Fat and Thin cows. The summarised of the responses of these cows to differential feeding are given in Appendix VI.

Table 4.2: Effect of feeding level during 3 weeks early lactation on milkfat production and body condition score

	Generous	Restricted	Diff.
Immediate (during 1-3 weeks)			
Herbage DM intake (kg)	373	233	140
Fat Yield (kg/cow)	21.0	17.9	+3.2
Condition Score Changes	0.08	-0.20	+0.28
Total in 19 weeks			
Fat Yield kg/cow	95.9	92.3	3.6
Condition Score Changes	0.58	0.38	0.20

In the calculation, 221 kg DM herbage required by dairy cows to gain 1 condition score (Ngarmsak, 1982) was used, and calculated as follows;

Immediate Effects 3 weeks

Extra 140 kg DM eaten produced 3.2 kg milkfat + 0.28 condition score

To produced extra 0.28 condition scores required:

0.28 x 221 = 62 kg DM herbage.

Therefore extra herbage DM available for fat production is:

140 - 62 = 78 kg DM herbage.

Therefore:

To produced extra 1 kg fat required 78/3.2 = 24.4 kg DM herbage.

Long Term Effects 19 weeks

Extra 140 kg DM eaten produced 3.6 kg milkfat + 0.20 condition score

To produced extra 0.20 condition scores required:

0.20 x 221 = 44 kg DM herbage.

Therefore extra herbage DM available for fat production is:

140 - 44 = 96 kg DM herbage.

Therefore:

To produced extra 1 kg fat required 96/3.2 = 26.7 kg DM herbage.

Residual Effects

The residual effect was (3.6 - 3.2)/3.6 = 0.11

The immediate effects over the 3 weeks of differential feeding was the production of an extra 3.2 milkfat from 140 kg DM. But when the gain in condition score was also taken into the calculation, the herbage DM actually avialable for milkfat production was 78 kg DM. The response was 24.4 kg DM required to produce 1 kg milkfat.

The Generous cows produced extra 0.4 kg milkfat after both groups had returned to the same level of feeding, and the total effect was the production of 3.6 kg milkfat and 0.20 condition score. Thus in the long term effect was 26.7 kg DM required to produce 1 kg milkfat. this is extremely high compared to 15 kg DM required obtained by Grainger et al. (1982). This is because the residual effect was very small for the present thesis was 0.11 time immediate effect. This is likely and according to Davey (1983), the size of residual effect varies and can be small particularly where comparatively short periods of underfeeding take place. The duration of underfeeding for the present experiment and only 3 weeks (21 days) and only moderately restriction on the intake of the Restricted feeding regime and was 63 % (or restriction of 37 % on intake) of the Generous feeding regime. And the results obtained however confirm the conclusion made by Bryant & Trigg (1982) that the residual effects of underfeeding in early lactation are 0.50 or less than immediate effects and they are confined to the few weeks immediately following underfeeding. For the present thesis, a restriction of 37 % on intake imposed for 3 weeks early lactation caused a reduction of fat yield by 15 % during underfeeding. The time taken to recover from underfeeding effects for the present experiment was approximately 14 days (Figure 4.4). The results obtained for the present Thesis were in agreement with Bryant (1982b) that cows well fed throughout or had about a 25 % restriction on intake imposed for 3 and 6 weeks early lactation caused reduction in fat yield by 12 and 22 % during underfeeding. This effects were reported to have largely disappeared within 6 weeks of returning to full feeding. For the small residual effects resulting from underfeeding, it is suggesting that calculating long term response to the feeding longer than the time when full recovery of production can be miss-leading. Because the causes of variation in production can not explain entirely by the previous feeding regime, Figure 4.4 confirms this. From Figure 4.4, the period beyond weeks 15 of lactation groups of cows showed large variation in their milkfat production. It is for the present thesis, long term responses for milk production calculated for 19 - 20 weeks after returning to full feeding as have been done normally (Bryant & Trigg, 1979; Grainger et al., 1982) had not been undertaken. From Figure 4.4 some groups of cows especially Fat Low BI cows appeared to have large residual effects but because of there were no significant effect of differential feeding effects were found. The lower production of the Fat Low BI cows Restricted groups during post-experimental period can not be entirely residual effects. The same agruement is given for the Fat High BI cows Restricted groups (Figure 4.4A) which showed higher milkfat production during post-experimental period.

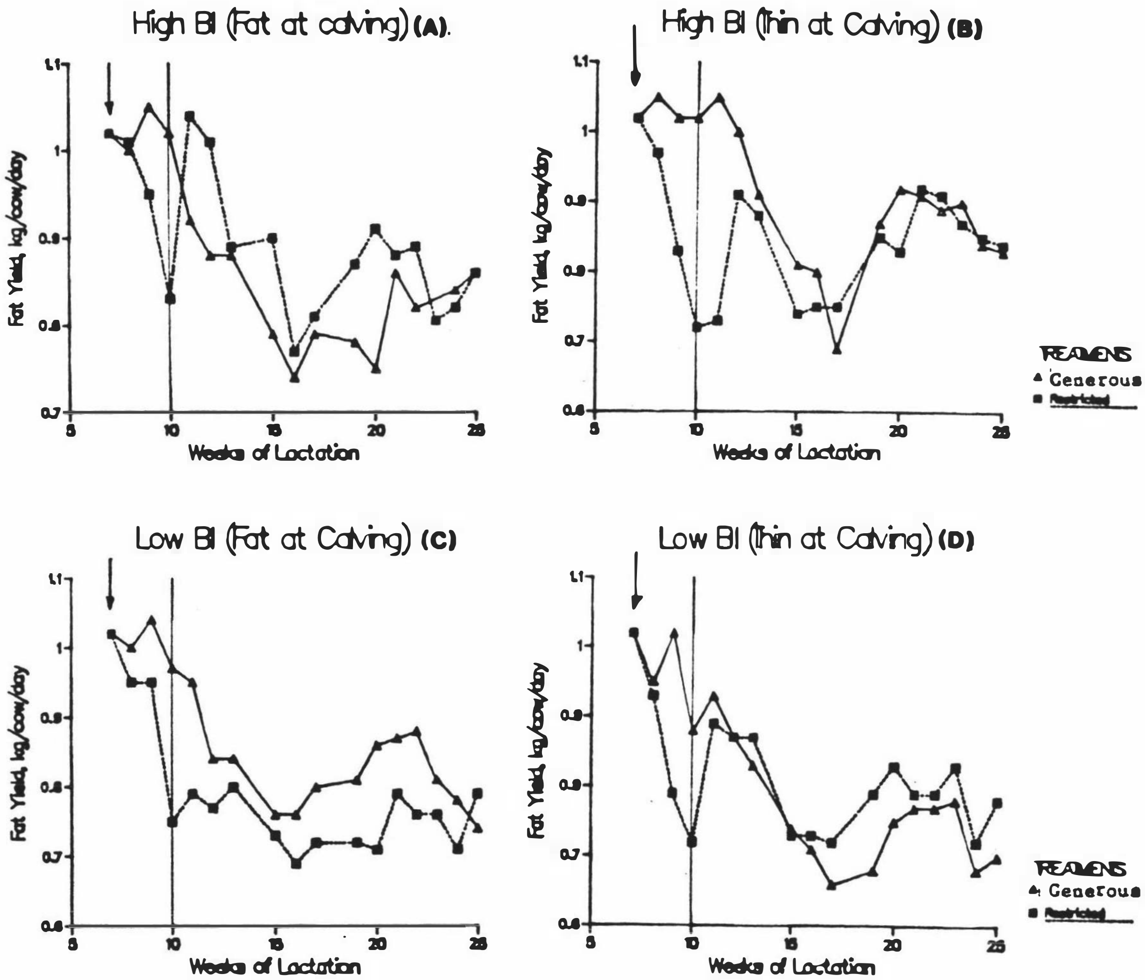


Figure 4.4 The covariance adjusted milk yield due to differential feeding (↓) start (vertical line) finish.

For the present thesis, High BI cows had slightly greater marginal efficiencies than Low BI cows, and Thin cows had slightly greater marginal efficiencies than Fat cows (Appendix VI). But no significant differences between the cows of differing genotypes nor between the cows of differing condition at calving in response to differential feeding were found. The results confirmed the results obtained by Grainger (1982) who found that High BI cows had greater marginal efficiencies than Low BI cows, but the differences between genotypes were not significant. Bryant (1981) also found that marginal efficiencies did not differ between genotypes. It is therefore concluded that when the feeding level is increased the extra milkfat produced will be similar for cows differing in genotypes, and for cows differing in body condition at calving.

4.5.2 Effect on liveweight and condition score

In response to underfeeding, Restricted feeding regime has caused a significant ($P>.05$) decrease in liveweight gain by the cows and has caused significantly ($P>.001$) cows to loss condition score during the restriction of feed. The residual effects on liveweight and condition scores were high. From the results Restricted feeding regime groups gained liveweight at slightly higher rates than the Generous feeding regime groups when they returned to the same level of feeding. Bryant & Trigg (1982) commented that whether the higher rate of liveweight gain is at the expenses of milk yield is unknown. But their liveweights were not regained to the same liveweight as the Generous feeding regime groups by 19 weeks of the experiment. For the residual effects on liveweight, Broster & Thomas (1981 see page 28) also pointed out the effect of lower liveweight achieved by the restricted groups.

The rates of condition score gain when both groups were on the same level of full feeding were similar. By 19 weeks after the start of the experiment condition score of the Restricted feeding regime groups were less than those of the Generous feeding regime. From Figure 3.16B, showed that the Restricted feeding regime have not regained their condition scores in compared to Generous feeding regime. And from the results obtained for the cows' condition score at the end of lactation (3-4 May) showed that the Restricted groups had not regained their body condition and their average condition score was 4.8 compared to 5.3 for the Generous groups.

4.6 GENERAL CONSIDERATION

Because feed is the major cost and must be utilised to obtain the greatest responses in term of milk production. It is obvious that the better feeding strategy for milk production needed the understanding of the responses to feeding by dairy cows both before and after calving to be clarified. Early lactation is the period in which cows respond best to feeding (Broster & Thomas, 1981; Holmes, 1982). The key factor in determining the benifit of good feeding in early lactation is whether a residual effect occurs thereafter (Grainger & Wilhelms, 1979). Davey (1983) also stressed that the extent of the residual effect is important in assessing the economics of supplementation. The present thesis agrees with the works done previously in Australia and New Zealand (Grianger & Wilhelms, 1979; Grainger et al., 1982; Bryant and Trigg, 1979; Glassey et al., 1980) that the effect of short period of underfeeding in early lactation is small and confined to the few weeks after the returning to full feeding. And inspite of the finding of the small effect of short period underfeeding, it is generally believed and recommended to feed cows well in early lactation and feed the cows pre-calving so that they calve in good condition. As stated by Bryant (1982b), it is unquestionable that underfeeding in early lactation reduces cow performance and the problem should be minimise.

Conversly, for full feeding in early lactation under Australia and New Zealand dairying needed feed planning and difficult to attain. Well fed early lactation may mean feeding in Autumn and Winter have to be sacrificed thus cows may calve in poorer condition (Bryant, 1982a), vice versa. In order to feed cows well in early lactation, generous amounts of herbage must be offered and this means that considerable amounts of residual herbage remain ungrazed. But as herbage allowance increases, milk production increases but at a decreasing rate. Cow with better body condition at calving produces more milk than thin cow it is also the general recommandation to calve a in reasonable condition score (Bryant 1982b). It is recommended the minimum condition score for a cow at calving at 4 condition score and higher than this figure for heifers (Holmes, 1982).

It is obvious that under condition prevailing in New Zealand, feeding the dairy cows in early lactation does not aim for the maximum peak yield by the cows, but to utilise feed wisely for the maximum responses and to minimise the long term effects of underfeeding during this period in both animal performances and pasture quantities and qualities. From the finding for the present thesis provides some quide to farmer for the flexibility of management especially in early lactation when the herbage are shortage. Moderately restricted herbage intake of lactating cows early lactation for 3 weeks will be mainly an immediate effect. The cows will regain their former level of production when their level of feeding return to full feeding with 2 weeks. The present thesis also provides evidences that cows which calve in better body condition will produce more milk than which calve in poorer body condition. There are no differences between the genotypes nor between condition of the cows at calving in responses to feeding.

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APPENDICES

6 APPENDICES

APPENDIX I: Lactation Performances of High and Low BI Cows 1982/83

	BI VALUES	WEIGHT AT CALVING	WEIGHT AT WEEK 24	CONDITION AT CALVING	CONDITION AT WEEK 24	CALVING DATE	LACTATION WEEKS	LACTATION PERFORMANCES: PRODUCTION TOTAL: MILK	FCM	FAT	PROTEIN	AVERAGE OVER LACTATION: FCM	FAT	PROTEIN	AVERAGE FAT & PROTEIN CONTENT: FAT	PROTEIN
HIGH BREEDING INDEX COWS																
THIN AT CALVING								------ (Kg/cow) ---				----- (Kg/cow/day) ------			--- (g/Kg Milk) --	
149	119	453	549	4.0	5.4	28/8*	35	5545	5285	204	180	22.0+5.1	0.81+.12	0.72+.13	38.3+6.1	33.4+3.7
156	126	453	491	3.4	5.0	21/8*	35	3996	4612	201	154	15.8+6.5	0.80+.23	0.61+.21	54.7+11.0	40.6+6.2
159	126	481	517	4.2	5.1	11/9*	33	3269	3745	163	130	13.7+2.4	0.69+.10	0.55+.07	50.7+5.1	40.2+3.4
169	118	333	403	3.0	4.9	27/8*	35	3621	4403	196	142	14.3+3.8	0.78+.16	0.56+.12	55.7+7.5	39.8+4.2
171	126	412	521	3.9	4.9	27/8*	35	3974	4550	198	145	15.8+4.9	0.78+.17	0.57+.15	51.7+7.0	37.4+4.5
178	128	424	489	3.8	5.0	28/8*	35	4076	4550	209	159	18.0+4.4	0.86+.10	0.65+.10	52.8+8.5	39.6+4.5
182	129	473	551	3.8	4.9	10/8	33	5487	5831	261	212	23.3+5.4	0.97+.21	0.80+.19	48.9+6.9	39.6+4.7
195	125	388	465	3.9	4.9	17/8	36	4461	5016	223	172	19.9+4.6	0 86+.19	0.67+.17	50.6+5.2	38.9+3.0
200	126	483	541	4.3	4.7	30/8	34	4260	4707	215	165	20.1+4.3	0.88+.17	0.68+.16	51.9+7.6	39.7+3.8
Average		433	503	3.8	5.0		34.5	4299	4744	208	162	18.1	0 83	0.65	50.6	38.8
+SE		+50	+48	+.4	+.2			+711	+587	+26	+24	+3.4	.09	+.08	+5.1	+2.2
FAT AT CALVING																
154	126	433	463	5.0	5.1	25/8	35	4930	5618	242	177	22.2+4.4	0.96+.18	0.74+.14	49.7+4.4	36.4+4.2
163	120	424	464	4.9	4.8	31/7	37	3975	4178	195	155	16.6+6.3	0.73+.27	0.58+.21	50.9+6.4	40.6+4.9
168	122	402	437	5.2	4.7	17/8	36	4447	4683	203	164	18.6+4.9	0.78+.19	0.64+.17	47.3+5.4	38.1+3.9
176	134	513	533	6.5	4.9	12/9*	33	5032	5680	234	191	23.9+4.9	1.01+.17	0.81+.16	47.8+6.1	38.3+5.4
180	126	435	457	6.3	4.7	29/8*	35	4618	4936	205	169	20.1+7.3	0.84+.29	0.69+.25	46.4+7.1	37.8+4.5
190	121	395	415	5.9	5.4	23/8*	35	3626	4403	196	149	17.4+4.6	0.78+.19	0.59+.16	55.7+6.3	41.9+3.6
191	126	489	484	5.7	4.7	28/8	35	4794	5393	232	174	22.1+5.2	0.95+.22	0.71+.17	48.8+5.7	36.7+3.4
193	130	391	425	5.0	4.6	4/8	37	4306	4919	238	164	19.5+5.9	0.90+.26	0.62+.18	56.2+4.6	39.1+3.7
196	126	433	451	6.1	4.3	30/8*	34	4087	4725	205	153	20.1+4.3	0 84+.18	0.62+.14	51.7+8.6	38.6+5.0
207	115	481	519	5.7	5.9	3/8	37	4904	5154	235	171	20.4+6.8	0.88+.28	0.65+.19	49.0+6.0	36.3+4.6
Average		440	465	5.6	4.9		35.4	4472	4968	219	167	20.1	0.87	0.67	50.4	38.4
+SE		+42	+46	+.4	+.5			+468	+500	+19	+13	+2.2	+.09	+.07	+3.4	+1.8

	BI VALUES	WEIGHT AT CALVING	WEIGHT AT WEEK 24	CONDITION AT CALVING	CONDITION AT WEEK 24	CALVING DATE	LACTATION WEEKS	LACTATION PERFORMANCES: PRODUCTION TOTAL: MILK	FCM	FAT	PROTEIN	AVERAGE OVER LACTATION: FCM	FAT	PROTEIN	AVERAGE FAT & PROTEIN CONTENT: FAT	PROTEIN
LOW BREEDING INDEX COWS																
THIN AT CALVING																
151	110	515	673	5.1	6.0	9/8	37	3786	3887	173	139	15.9+5.0	0.67+.20	0.52+.15	46.6+7.7	37.6+4.3
153	106	390	597	3.8	7.9	8/8	29	1798	1848	84	66	9.6+4.6	0.41+.19	0.32+.16	48.2+7.6	36.7+2.2
160	109	431	539	2.4	4.3	29/8*	35	4135	4473	187	160	20.3+3.0	0.74+.11	0.64+.12	46.4+6.7	39.4+3.3
174	110	385	507	4.0	5.5	19/8	35	3532	4041	174	132	15.6+5.2	0.69+.18	0.57+.20	51.2+6.9	38.5+4.7
181	107	408	473	4.3	5.1	23/8*	35	4485	4183	167	153	17.1+3.6	0.66+.12	0.61+.12	38.7+6.8	35.1+4.4
187	101	401	535	3.9	5.0	27/8*	35	3494	3861	162	134	15.2+3.9	0.64+.15	0.53+.13	48.0+5.2	39.6+3.7
188	99	453	567	3.4	6.4	21/8*	27	2166	2111	84	77	11.3+4.1	0.44+.16	0.41+.16	39.7+7.2	35.9+2.1
189	104	455	533	3.3	5.0	30/8*	34	3345	3612	151	125	14.7+3.8	0.62+.14	0.51+.14	47.2+7.9	38.7+4.5
204	102	329	419	3.3	4.8	2/9*	34	3819	4128	174	134	16.8+3.2	0.71+.12	0.55+.10	45.8+4.7	35.5+3.5
209	104	362	481	3.6	5.7	14/8	37	3301	3569	161	125	14.1+4.2	0.61+.18	0.47+.14	50.2+6.8	38.8+3.8
Average		413	532	3.7	5.8		33.8	3386	3571	152	125	14.1	0.62	0.51	46.2	37.6
+SE		+53	+71	+.7	+1.0			+828	+882	+37	+30	+5.2	+.11	+.09	+4.1	+1.7
FAT AT CALVING																
158	103	526	517	5.5	6.0	29/8*	35	4784	4473	208	167	20.3+5.1	0.84+.20	0.67+.17	44.1+5.8	36.5+4.6
164	107	533	608	5.9	6.8	8/9	30	2568	2979	119	98	13.0+4.7	0.65+.20	0.45+.17	47.7+8.1	39.1+3.9
170	99	560	619	6.2	7.3	30/7	37	4581	4041	177	152	15.6+5.2	0.66+.20	0.57+.20	47.3+6.9	40.0+4.2
184	113	478	543	5.0	5.3	31/8*	34	4908	5066	207	172	20.7+4.4	0.85+.16	0.70+.14	43.7+5.0	36.2+4.7
202	105	455	519	6.3	7.9	25/8*	34	4121	4151	168	146	17.0+2.8	0.68+.11	0.60+.13	41.3+3.5	35.7+2.8
203	108	448	499	5.8	4.7	30/8	34	4531	4928	207	156	20.1+5.4	0.84+.19	0.64+.21	48.3+8.4	35.4+4.8
205	105	424	454	5.3	4.7	28/8*	35	4112	4444	185	153	17.6+3.5	0.74+.14	0.61+.11	45.8+5.4	37.9+4.7
206	103	465	519	5.9	5.7	-	34	3485	4262	191	130	17.9+3.9	0.81+.16	0.55+.13	56.7+7.6	38.2+4.0
Average		486	535	5.7	6.1		34.1	4136	4293	183	147	17.8	0.76	0.60	46.9	37.4
+SE		+48	+55	+.45	+1.2			+779	+640	+29	+23	+2.6	+.10	+.08	+4.6	+1.7

* Induced Calving

APPENDIX II Milk, Fat and Protein Yield (kg/cow/day); and Fat and Protein Concentration (g/kg milk) of High BI (HBI) and Low BI (LBI) cows 1982/83 season

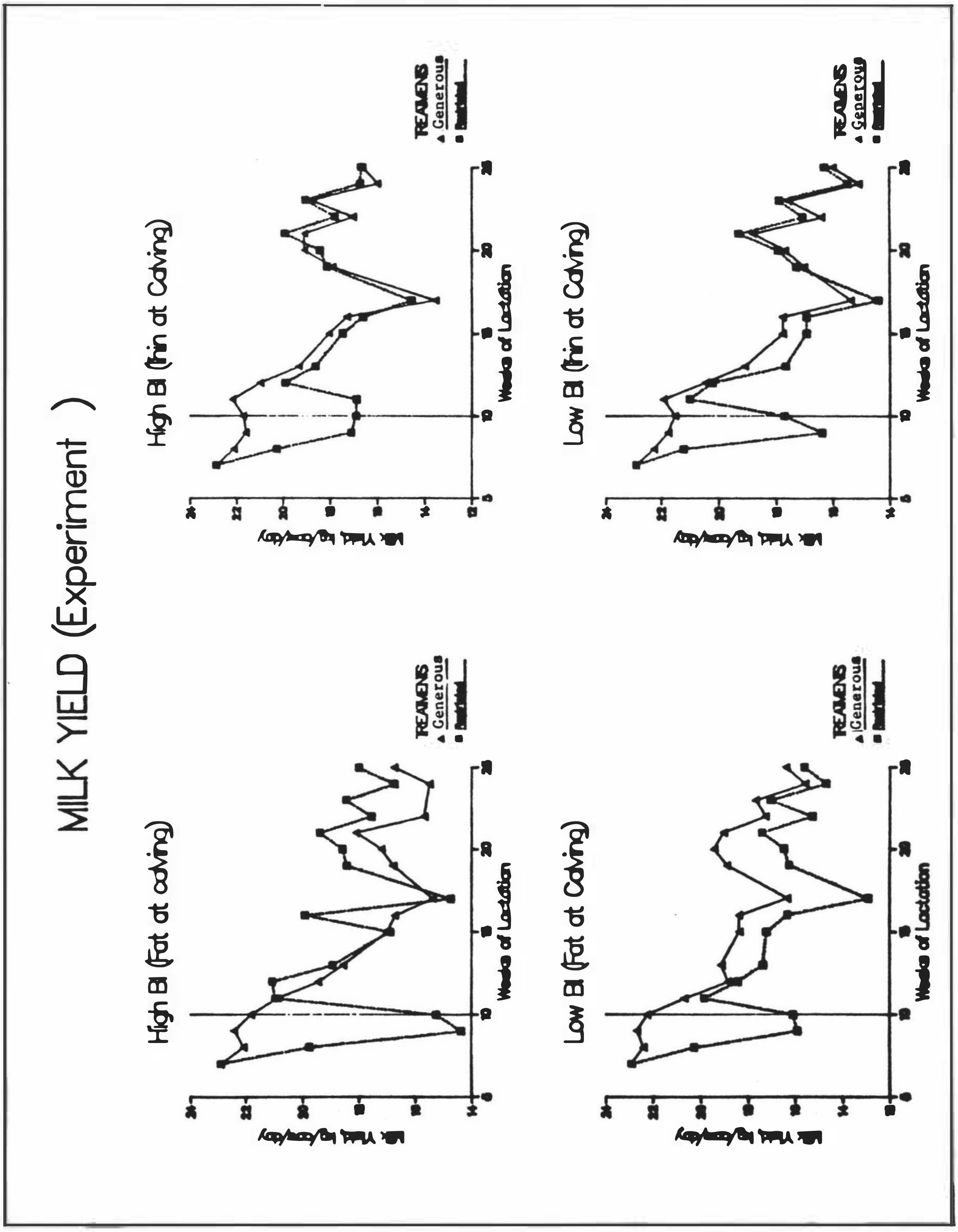
Weeks	Milk Yld		Fat Yld		Protein Yld		Fat Con.		Protein Con.	
	HBI	LBI	HBI	LBI	HBI	LBI	HBI	LBI	HBI	LBI
2	22.6	18.8	0.95	0.74	0.91	0.78	43.3	40.0	40.1	41.1
3	23.5	20.7	1.05	0.83	0.87	0.77	44.4	40.6	37.3	37.5
4	23.3	20.9	1.02	0.84	0.84	0.74	44.2	41.1	36.9	36.1
5	22.5	20.2	1.04	0.84	0.82	0.70	46.7	42.1	36.7	35.4
6	22.8	20.3	1.03	0.85	0.80	0.69	45.9	42.9	35.3	34.4
7	22.5	20.3	1.03	0.86	0.80	0.69	46.3	42.4	35.8	34.6
8	21.4	19.7	1.04	0.85	0.76	0.69	48.9	43.7	35.6	35.2
9	19.7	17.8	0.96	0.81	0.72	0.63	49.3	46.1	36.6	35.4
10	20.1	17.8	0.94	0.76	0.73	0.62	47.2	43.4	36.1	34.4
11	20.8	19.2	0.93	0.80	0.74	0.67	44.9	41.7	36.0	35.1
12	20.4	18.1	0.95	0.76	0.72	0.62	46.7	42.7	35.7	35.1
13	19.0	16.5	0.91	0.73	0.65	0.56	48.0	44.5	34.6	34.4
15	18.1	16.3	0.81	0.69	0.65	0.57	45.2	42.2	36.0	35.1
16	17.2	15.6	0.78	0.64	0.65	0.57	45.7	41.2	37.7	36.9
17	14.5	12.8	0.76	0.65	0.53	0.46	51.7	50.9	36.5	36.0
19	17.8	15.3	0.84	0.66	0.61	0.52	47.1	43.2	34.4	33.8
20	18.3	15.6	0.85	0.68	0.63	0.52	46.8	42.9	34.7	33.3
21	19.0	16.3	0.91	0.72	0.68	0.57	48.1	44.5	35.9	34.8
22	17.1	14.9	0.87	0.69	0.61	0.53	51.9	46.7	35.9	35.9
23	18.8	15.6	0.87	0.68	0.65	0.53	46.9	44.6	35.4	34.2
24	16.4	13.3	0.83	0.62	0.57	0.45	51.1	46.9	34.7	34.3
25	16.9	14.6	0.83	0.68	0.59	0.50	49.9	46.4	35.0	34.6
26	14.5	11.6	0.72	0.55	0.53	0.41	50.6	48.6	36.9	35.7
27	12.4	11.3	0.66	0.56	0.50	0.44	53.8	50.8	40.7	39.9
28	11.8	10.9	0.62	0.53	0.46	0.42	54.6	51.1	40.0	39.2
29	11.1	10.3	0.60	0.52	0.44	0.40	55.3	51.9	40.7	39.6
30	11.0	9.0	0.60	0.51	0.47	0.41	56.1	54.4	43.0	43.2
31	12.8	11.5	0.66	0.58	0.57	0.50	52.1	51.2	44.8	43.3
32	12.1	10.6	0.64	0.54	0.54	0.46	52.4	50.8	44.4	44.1
*										

* some cows had been dried off by week 33, thus the data thereafter were not given in the Appendix II.

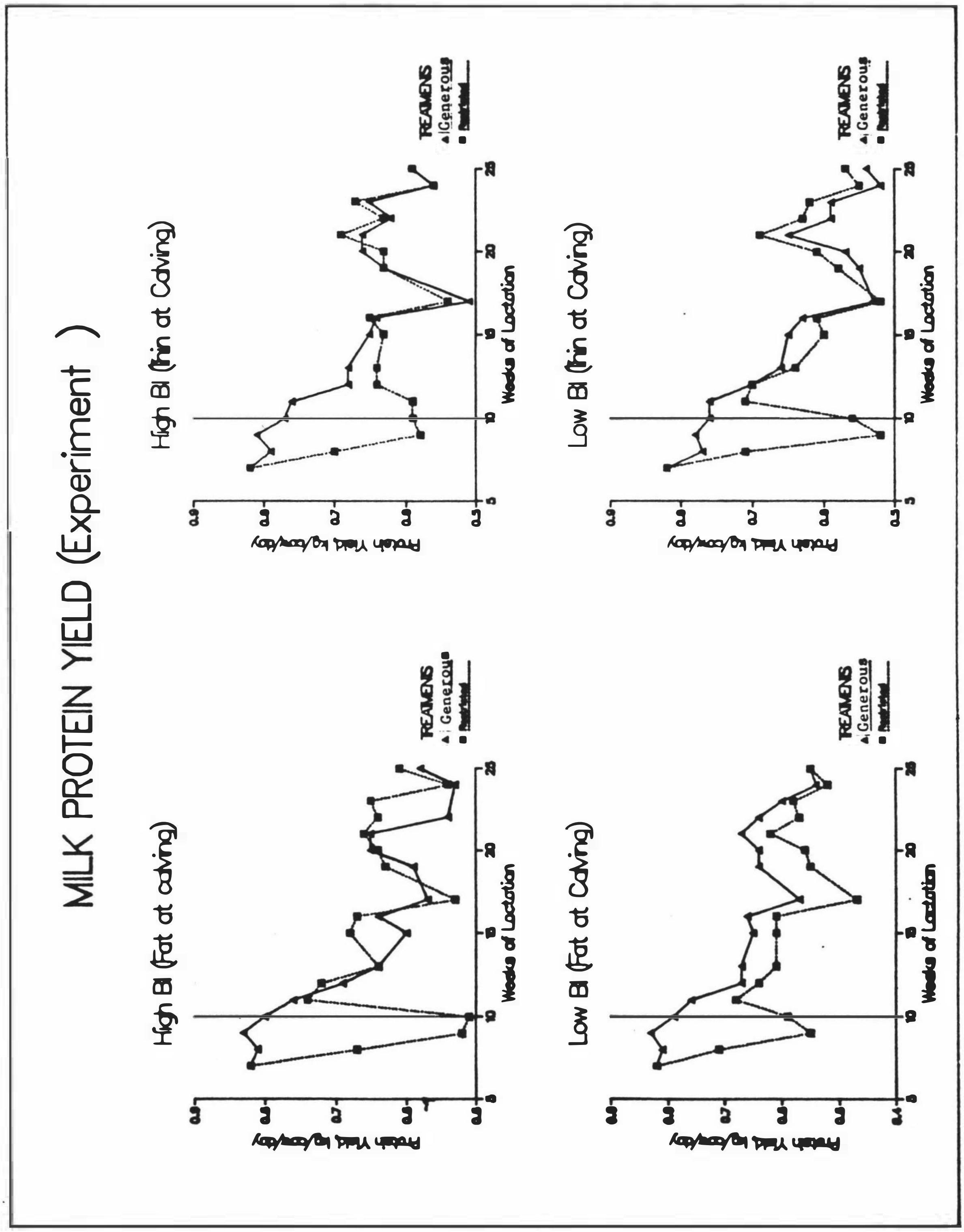
APPENDIX IIA. Fat Yield (kg/cow/day), Fat Concentration (g/kg milk of High BI and Low BI cows differing in body condition at calving

Weeks	Fat Yield				Fat Concentration			
	High BI		Low BI		High BI		Low BI	
	Fat	Thin	Fat	Thin	Fat	Thin	Fat	Thin
2	1.05	0.87	0.89	0.66	45.8	38.7	40.2	39.8
3	1.15	0.96	0.95	0.75	47.2	41.5	40.5	40.7
4	1.56	0.96	0.96	0.76	46.9	41.1	40.5	41.9
5	1.15	1.00	0.96	0.76	49.0	44.2	42.8	42.1
6	1.12	1.00	0.97	0.77	47.3	44.8	43.9	42.2
7	1.10	1.03	0.97	0.78	47.0	45.8	42.4	42.5
8	1.11	1.05	0.94	0.80	48.6	49.3	44.9	43.0
9	1.04	0.97	0.87	0.79	50.7	48.9	45.0	47.1
10	1.02	0.91	0.85	0.70	48.2	46.0	44.8	42.4
11	1.00	0.92	0.84	0.78	44.5	45.9	41.3	42.1
12	0.99	0.97	0.80	0.75	45.5	47.8	41.7	43.6
13	0.96	0.92	0.78	0.69	47.5	49.1	43.8	45.3
15	0.87	0.81	0.75	0.64	45.1	45.7	42.1	42.2
16	0.81	0.81	0.73	0.59	45.7	46.7	41.4	41.1
17	0.84	0.76	0.74	0.59	52.8	52.8	50.9	51.3
19	0.88	0.87	0.75	0.60	47.0	47.9	42.9	43.4
20	0.89	0.90	0.76	0.62	46.7	47.5	42.6	43.1
21	0.96	0.94	0.79	0.68	48.1	49.1	43.9	44.9
22	0.92	0.90	0.77	0.64	51.9	53.2	47.3	46.9
23	0.90	0.91	0.77	0.63	46.2	48.2	44.2	45.1
24	0.88	0.85	0.71	0.56	51.7	52.0	47.2	46.8
25	0.90	0.86	0.75	0.63	50.0	51.0	47.0	46.2
26	0.77	0.73	0.62	0.50	50.7	51.8	47.9	49.4
27	0.67	0.68	0.64	0.51	53.8	55.3	50.2	51.4
28	0.61	0.67	0.61	0.47	53.3	57.2	50.1	52.0
29	0.59	0.63	0.57	0.48	53.2	59.1	50.8	53.1
30	0.61	0.65	0.58	0.46	54.5	59.7	54.4	54.5
31	0.68	0.68	0.65	0.53	52.0	53.6	52.4	49.5
32	0.63	0.66	0.56	0.53	52.5	52.9	50.3	51.0

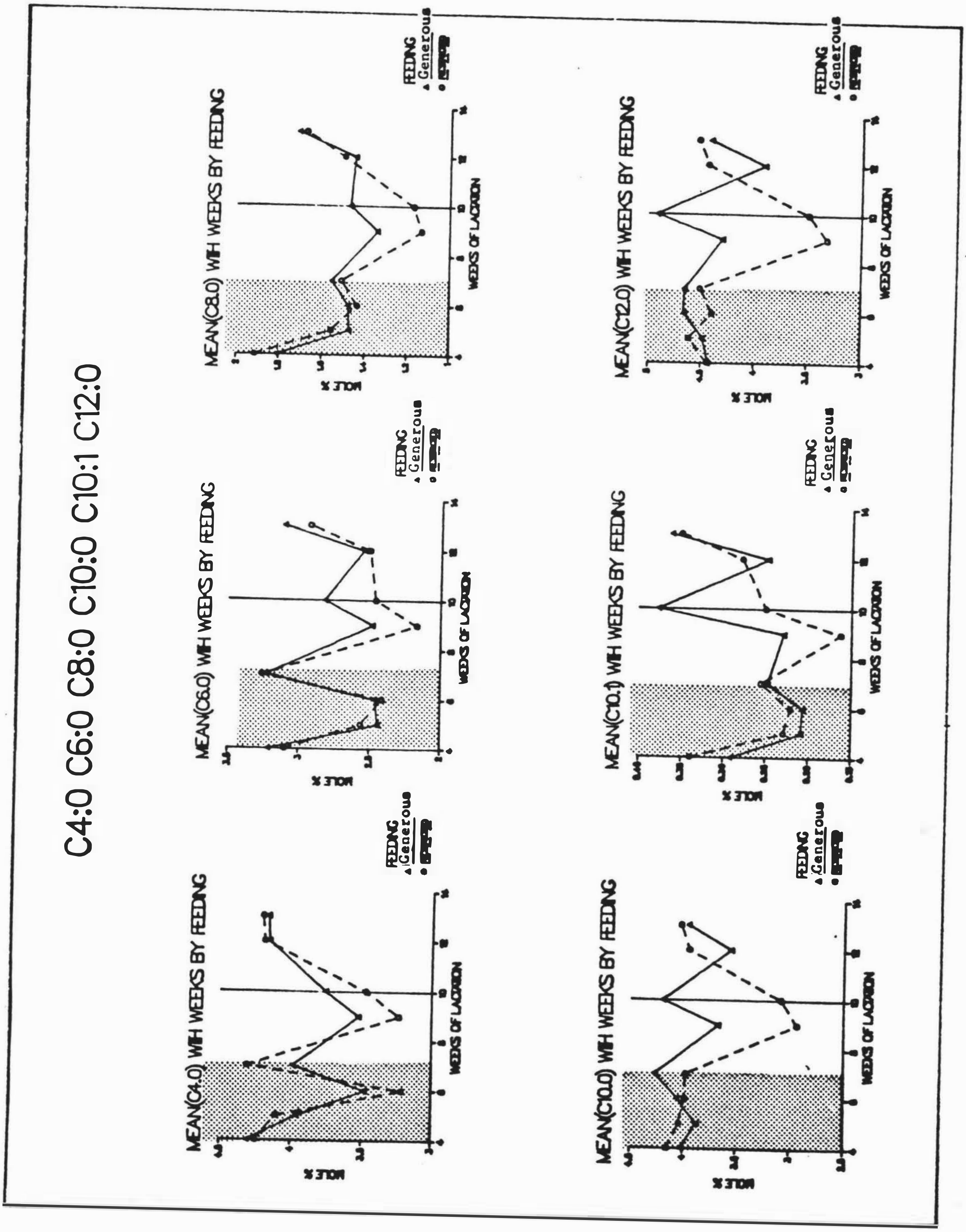
APPENDIX III: Covariance adjusted milk yield due to differential feeding (week 7-10 of lactation)

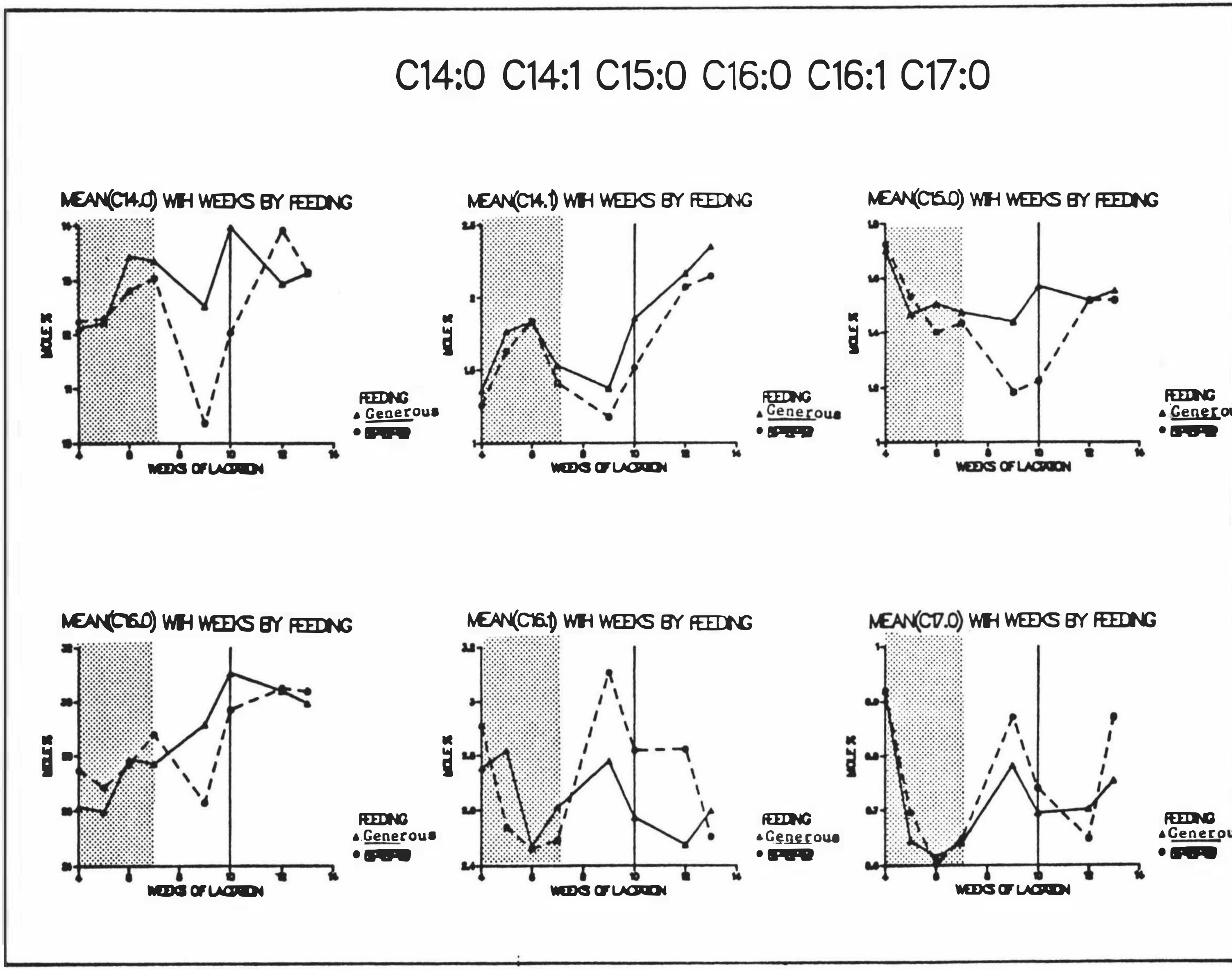


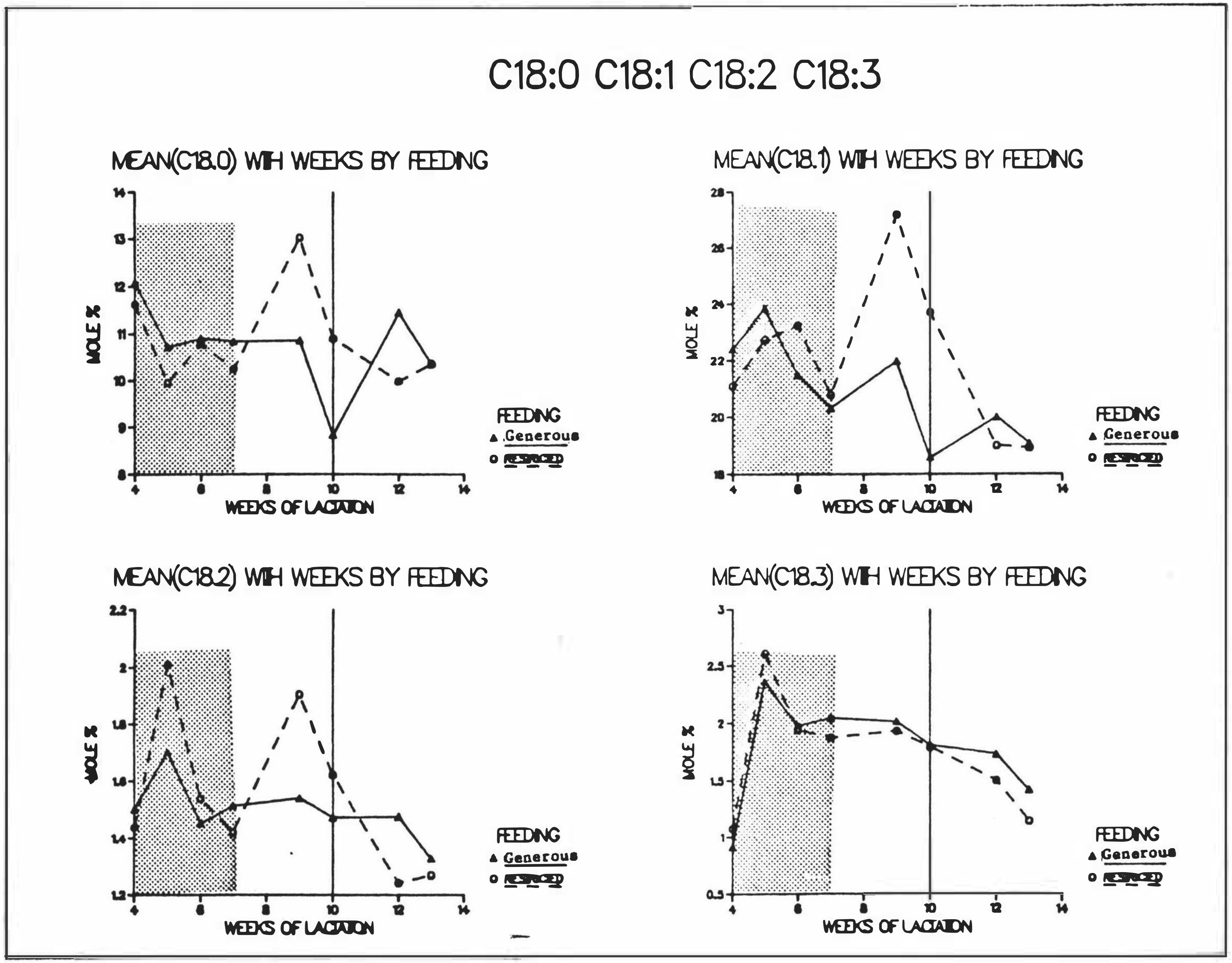
APPENDIX III (cont.) <u>Covariance adjusted protein yield due to differential feeding (week 7-10 of lactation)</u>



APPENDIX IV: Fatty acid composition of milk changes due to differential feeding (week 7-10 of lactation).




C14:0 C14:1 C15:0 C16:0 C16:1 C17:0
MEAN(C14:0) WITH WEEKS BY FEEDING
MEAN(C14:1) WITH WEEKS BY FEEDING
MEAN(C15:0) WITH WEEKS BY FEEDING
MEAN(C16:0) WITH WEEKS BY FEEDING
MEAN(C16:1) WITH WEEKS BY FEEDING
MEAN(C17:0) WITH WEEKS BY FEEDING
MOLE %
WEEKS OF LACTATION
FEEDING
Generous
[redacted]


C18:0 C18:1 C18:2 C18:3
MEAN(C18.0) WITH WEEKS BY FEEDING
MOLE %
WEEKS OF LACTATION
FEEDING
Generous
MEAN(C18.1) WITH WEEKS BY FEEDING
MOLE %
WEEKS OF LACTATION
FEEDING
Generous
MEAN(C18.2) WITH WEEKS BY FEEDING
MOLE %
WEEKS OF LACTATION
FEEDING
Generous
MEAN(C18.3) WITH WEEKS BY FEEDING
MOLE %
WEEKS OF LACTATION
FEEDING
Generous

APPENDIX V: Results for Sward-Cutting When Cr_2O_3 Technique Was Test

Pad No.	Days	Feed	BI	Area m^2/cow/ day	Pasture Mass kgDM/ha	Residual Mass kgDM/ha	Allowance kgDM/cow/ day	Intake kgDM/cow/ day
18	4	Ad	HBI	117	3256	1870	38	16.2
			LBI	117	3256	1891	38	16.0
		Res	LBI	58	3256	925	19	13.6
			HBI	58	3256	1200	19	11.7
20	3	Ad	HBI	117	3070	1668	36	16.4
			LBI	117	3070	1574	36	17.5
		Res	HBI	59	3070	776	18	13.5
			LBI	59	3070	694	18	14.0
11	4	Ad	HBI	117	2706	1350	32	15.9
			LBI	117	2706	1407	32	15.2
		Res	HBI	58	2706	545	16	13.1
			LBI	58	2706	532	16	13.2
16	3	Ad	HBI	119	3118	1628	37	17.7
			LBI	119	3118	1676	37	17.1
		Res	HBI	60	3118	545	19	15.3
			LBI	60	3118	628	19	14.8
12	4	Ad	HBI	93	3672	1910	34	16.4
			LBI	93	3672	2013	34	15.4
		Res	HBI	47	3672	-	17	-
			LBI	47	3672	-	17	-
10	3	Ad	HBI	140	3393	2098	48	18.1
			LBI	140	3393	1965	48	20.0
		Res	HBI	70	3393	1090	24	16.8
			LBI	70	3393	1268	24	14.9
13	1	Ad	HBI	120	2437	1224	29	14.6
			LBI	120	2437	1330	29	13.3
		Res	HBI	60	2437	661	15	10.7
			LBI	60	2437	665	15	10.7

APPENDIX VA: Results for Sward-Cutting Technique for the Estimate of Herbage DM Intake (15 Oct. to 5 Nov. 1982).

Pad No.	Days	Feed	BI	Area m^2/cow/ day	Pasture Mass kgDM/ha	Residual Mass kgDM/ha	Allowance kgDM/cow/ day	Intake kgDM/cow/ day
13	3	Ad	HBI	160	2437	1442	39	15.9
			LBI	160	2437	1435	39	16.0
		Res	HBI	70	2437	590	17	12.9
			LBI	70	2437	666	17	12.4
18	3	Ad	HBI	135	4417	3119	60	17.5
			LBI	135	4417	3123	60	17.5
		Res	HBI	140	1072	595	15	6.6
			LBI	140	1072	622	15	6.3
17	4	Ad	HBI	180	3272	2075	59	21.5
			LBI	180	3272	2147	59	20.4
		Res	HBI	50	3272	701	18	12.9
			LBI	50	3272	912	18	11.8
16	3	Ad	HBI	120	4176	2452	50	20.7
			LBI	120	4176	2696	50	17.8
		Res	HBI	87	1570	528	14	9.1
			LBI	87	1570	459	14	9.7
20	3	Ad	HBI	146	3609	2252	34	19.8
			LBI	146	3609	2316	34	18.9
		Res	HBI	80	1352	393	12.6	7.7
			LBI	80	1352	361	12.6	7.9
11	3	Ad	HBI	120	2947	2114	35	16.6
			LBI	120	2947	1925	35	18.9
	5	Res	HBI	66	1839	552	12	8.5
			LBI	66	1839	478	12	9.0
12	2	Ad	HBI	180	2278	1221	41	19.0
			LBI	180	2278	1365	41	16.4

APPENDIX VI: The response to feeding by High and Low BI cows and by Fat and Thin cows.

	Breeding Index*		Condition**		
	HBI	LBI	FAT	THIN	
Amount of herbage DM required to produce 1 kg milkfat (kg DM/kg milkfat)					
Immediate	21.3	26.8	28.4	24.4	
Long term	55.0	21.9	27.2	40.1	
Residual Effects	-0.34	0.33	0.21	-0.47	

* Herbage intake obtained from the sward-cutting technique
** Assumed Fat and Thin cows had similar herbage DM intake