EFFECT OF CONCENTRATE SUPPLEMENTATION ON HERBAGE CONSUMPTION, MILK PRODUCTION AND COMPOSITION, AND ON LIVEWEIGHT AND CONDITION SCORE CHANGE IN EARLY LACTATION

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ABSTRACT

Each of 15 sets of identical twins was allocated to two grazing treatments, the pasture fed treatment (PF) and the concentrate fed treatment (CF). Cows in PF treatment were fed pasture only and those cows in CF treatment were supplemented with concentrates. The swards used were predominantly of perennial ryegrass. The experiment was carried out for 14 weeks (14th September-21st December 1987) of the early grazing season of 1987.

The experiment was carried out in two periods, Period I with an allowance of 20 kgDM/cow/day from 13th to 27th October 1987 and Period II with an allowance of 25 kgDM/cow/day from 21st to 30th November 1987. Milk yield, milk composition, animal liveweight and condition score were measured.

Herbage intake was estimated by sward cutting technique and was 10.0 and 9.0 kgDM/cow/day for supplemented cows, and 11.8 and 12.2 kgDM/cow/day for unsupplemented cows in Periods I and II respectively. Supplemented cows consumed 6.7 kgDM/cow/day concentrates in both periods.

There was a significant increase in milk yield due to concentrate supplementation. The average response was 0.40 kg milk/kg concentrate DM eaten or 0.68 kg milk/kg extra feed DM eaten. Yields of milk constituents were increased except for fat in Period II.

Concentrate feeding had no effect on milk fat and milk lactose concentrations but milk protein concentration was increased. Supplemented cows gained more liveweight and condition score than unsupplemented cows.

Concentrate supplement increased total intakes by 0.65 kgDM/kgDM concentrate eaten and 0.69 MJME/MJME concentrate eaten. Herbage intake was decreased by an average 0.34 kgDM/kgDM concentrate eaten. Residual herbage mass was increased by concentrate supplementation.

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CHAPTER 1: INTRODUCTION

INTRODUCTION

In New Zealand dairy farmers rely on grazed pasture as the main source of feed for their dairy stock, and through their management attempt to match annual demand with pasture supply. However, in some years, significant pasture deficits can occur due to exceptionally cold or wet winters reducing pasture growth rates particularly on those farms with early calving. In such situations farmers are forced to use supplements such as hay, silage and meal concentrate in order to fill the temporary 'gap' in pasture supply.

The present study was designed and initiated to examine the effect of concentrate supplement on animal performance when pasture allowance was restricted, as in the above examples, and when allowance was adequate.

Although several experiments (Jennings and Holmes,1984; Arriga-Jordan and Holmes,1986; Grainger,1987) have shown relatively poor and uneconomic responses to concentrate feeding, these have generally been relatively short-term studies. Because many factors, such as level of feeding, feed quality and the animal itself, can affect the response of grazing cows to supplements, it is possible that longer-term concentrate feeding may show different and even more favourable effects.

The present study also attempts to detail the major factors concerned with the response of cows to supplementary feeding and also the factors influencing herbage intake by grazing dairy cows.

CHAPTER 2: REVIEW OF LITERATURE

2 REVIEW OF LITERATURE

2.1 EFFECTS OF SUPPLEMENTARY FEED GIVEN TO GRAZING COWS.

2.1.1 Effects on Feed Intake and Substitution.

There is general agreement that when supplements are fed with unrestricted pasture of good quality, cows consume less pasture although total feed intake is often increased (Hutton and Parker,1966; Bryant,1978; Stockdale et al.,1981; King and Stockdale,1981; Bryant and Trigg,1982; Meijs and Hoekstra,1984; Stockdale and Trigg,1985; Stakelum,1986a,b,c; Grainger,1987; Wills,1988). The term 'substitution rate' is used to describe the amount of reduction in pasture DM intake when 1 kgDM supplement is consumed. The substitution rate and the amount of total DM intake can be influenced by the type of supplements, the feeding level of herbage and supplements, the quality of herbage and supplements, physiological state of animals and probably the interaction between these factors.

2.1.1.1 Type of supplements

Supplementary feeds are usually used to supplement grazing particularly when herbage is in short supply. The effects of type of supplement on substitution rate are variable (Umoh and Holmes,1974; Bryant and Trigg,1982), probably owing to the confounding effect of feeding level, relationship with pasture quality or balance of the whole diet. However, supplementation with a particular nutrient which is deficient in the diet can increase the intake of pasture resulting in a reduction in substitution rate. Protein supplementation, for instance, can increase pasture intake when the diet is deficient in protein (Kempton,1983). The range of substitution rate for various feeds at various physiological state can be considered to be similar to those reported by Leaver et al.(1968), Journet and Demarquilly (1979), Bines (1979), Meijs (1981) and Leaver (1985).

Total DM intake is usually increased with supplementation to grazing cows. At restricted herbage allowance, offering grass silage as a buffer feed leads to a large increase in total DM intake (Rogers,1979; Bryant,1978; Phillips and Leaver, 1985b).

2.1.1.2 Level of feeding

The extent to which herbage DM intake is reduced in response to supplementary feeding under grazing condition is largely dependent on level of herbage allowance (Meijs and Hoekstra,1984). Regardless of the type of supplements, the substitution rate is increased with increasing HA. Meijs and Hoekstra (1984) with concentrate supplementing to grazing cows, found that the substitution rate was shown to decrease from 0.50 at a high HA to 0.11 at a low HA. Similar relationship was also observed with hay supplement (Eldridge and Kat,1980; Wills and Holmes,1988) and silage supplement (Phillips and Leaver,1985b).

The relationship between the amount of supplement consumed and substitution rate has been shown to be inconsistent. In reviewing 11 zero grazing experiments covering the range 0-5.2 kg concentrate DM, Meijs (1981) showed a mean substitution rate of 0.45. For a further increment of concentrates over the range 2.7-6.9 kg concentrate DM in the same experiments, the mean substitution rate was 0.60. This indicated the curvilinear relationship, however, this has not been confirmed in grazing trials with lactating cows (Meijs and Hoekstra,1984), with beef cattle (Umoh and Holmes,1974) and indoor trials (Taparia and Davey,1970; Tayler and Wilkinson,1972). Sarker and Holmes (1974), Combellas et al.(1979), and Stockdale and Trigg (1985) even found a decreasing substitution rate at higher concentrate intakes by grazing dry cows, heifers and lactating cows respectively.

It is simply that at high level of feeding, either high HA or high supplement intake, substitution rates are increased but HA is more likely to play a major determinant in influencing the magnitude of substitution rates.

2.1.1.3 Quality of feeds

The substitution rate can be affected by the quality of supplement. Meijs (1986) compared a high starch with a high fibre supplement (12.4 and 11.7 MJME/kgDM respectively) for grazing dairy cows and concluded that the high starch supplement caused higher reduction in the consumption of pasture (0.45 kgDM/kgDM as concentrate) than the low starch supplement (0.21 kgDM/kgDM as supplement). He suggested that change in substitution rate was related to the rumen fermentation, where the high starch concentrate tended to decrease the rumen pH, affecting the cellulolytic activity of microbes. Similar results were observed by Jennings and Holmes (1984) with concentrates of high or low quality (13.6 and 12.0 MJME/kgDM respectively). With forage supplementation, there is not much information related to the different quality. Stockdale et al.(1981) and King and Stockdale (1981) suggested that the relative quality of hay compared with pasture determined the ability of the supplement to counteract the effects of underfeeding, although they did not compare supplements of different digestibility.

2.1.1.4 Physiological state

Information about the effect of stage of lactation on DM substitution rate is contradictory (Jennings and Holmes,1984; Phillips and Leaver,1985a,b).

2.1.2 Effect on Residual Herbage Mass

Supplementation can reduce the severity of grazing. Bryant and Trigg (1982) concluded from many experiment that for each 1 kgDM of supplement consumed, residual herbage mass is increased by 100-200 kgDM/ha. Considering that when supplements are fed cows eat less pasture, an increase in residual herbage mass is presumably due to the substitution rate of supplements for herbage (Wills,1988). The extent of variation in increased residual herbage mass is probably due to the differences in herbage mass, herbage allowance, level of supplement feeding and the substitution rate.

2.1.3 Effect on Milk Yield and Composition.

The effect of supplementary feeding on milk yield and milk composition was reviewed by Bryant and Trigg (1982) who concluded that the average response was an extra 0.5 kg of milk or 21 grm of milk fat for each additional 1 kgDM of supplement consumed, with a range of -0.2 to 1.4 kg and -6 to 63 grm of milk and milk fat respectively. Leaver _et al_.(1968) reviewed average response of 0.32 kg milk/kg supplement eaten whereas Journet and Dermarquilly (1979) concluded an average response of 0.4 kg milk/ kg supplement consumed. The variations in such response can be attributable to differences in the type of supplements, in ME concentration per kgDM of supplement, in the amount and quality of both pasture and supplements consumed, in stage of lactation, in level of production and probably the combination of these factors affecting the response.

2.1.3.1 Type of supplement

Most evidence has shown that when supplements were fed, regardless of the type of diet, yields of milk and its constituents generally increased. Based on the limited data reviewed by Bryant and Trigg (1982), there is no convincing evidence that production response was affected by the type of supplements. Those factors including quality and quantity of supplement, frequency of feeding and interactions among these factors in association with pasture factors rather than the type of supplement itself affect animal production response. In Ireland, Walsh (1969), for example, fed grazing dairy cows with concentrate or hay ad libitum and observed different response to both supplements. He suggested that the digestibility, not the type, of supplements affected different response per kgDM supplement. This implied that as the two supplements contained different ME concentration, the ME intake of the cows were also different and hence the cows showed different response. When comparisons have been made between energy and protein concentrates, Rogers et al.(1983) shown that significantly greater responses to protein than energy supplements occurred in only 4 out of 8 experiments. One of the experiment showed increase in the yield of milk, fat and protein by 16%, 19% and 5% respectively. Concentration of fat was increased whereas protein concentration was depressed.

Although the type of supplements was unlikely to affect production response, it did affect concentration of milk constituents. Milk fat concentration was depressed by concentrate supplementation but it was increased by silage supplementation (Jennings and Holmes,1984; Stockdale and Trigg,1985; Phillips and Leaver,1985b; Arriga-Jordan and Holmes,1986; Stakelum,1986a). However, fat concentration was unlikely to be affected by hay supplementation although it tended to be increased (Stockdale *et al.*,1981; Phillips and Leaver,1985a). The reduction in milk fat concentration by concentrate supplementation has been suggested to be due to a high production of propionic acid and a low production of acetic and butyric acids in the rumen, depressing the secretion of milk fat (Rook and Thomas,1983). Milk protein concentration was increased by concentrate supplementation (Stockdale and Trigg,1985; Stakelum,1986a,b) Hay supplements had no effect on milk protein concentration but silage tended to reduce concentration of milk protein (Phillips and Leaver,1985b). Milk lactose concentration was unlikely to be affected by the type of supplements.

2.1.3.2 Level of feeding

The effect of supplementation on animal performance (kgFCM/kgDM supplement) decreased as the overall feeding level increased (Leaver *et al.*,1968; Bryant,1978; Stockdale *et al.*,1981; Bryant and Trigg,1982; Stockdale and Trigg,1985; Phillips and Leaver,1985a,b; Stakelum,1986a; Grainger,1987).

With concentrate supplement, Stockdale and Trigg (1985) observed that increases in total DM intake from 8.0 to 14.9 kg resulted in decreases in milk response from 1.6 to 0.55 kg/kg supplement eaten but increases in liveweight gain.

At comparable supplement intake, response was greater at low allowance than at high allowance and this usually occurred in association with the lower substitution rate of supplement for herbage (Phillips and Leaver,1985a; Stockdale and Trigg,1985; Stakelum,1986a; Grainger,1987). Gordon (1979), and Le Du and Newberry (1982) even reported overall responses of 1.2, and 2.9-3.5 kg milk/kg concentrate consumed, to severe restriction.

The effect of level of supplement intake on yield response was very small. Such effect tended to depend largely on the overall feeding level and the amount of pasture intake rather than the level of supplement itself. Many experiments have shown a tendency of decreasing response in yields of milk and its constituents with increasing the level of supplement consumed (Bryant and Trigg,1982; Phillips and Leaver,1985b; Stockdale and Trigg,1985).

Milk compositions were affected not only by the type of supplement but also by the level of supplementation. Experiments in which the effects of altering the ratio of roughage to concentrates had been studied (Broster et al.,1979; Sutton et al.,1980). When the ratio of roughage to concentrates was reduced, milk fat concentration fell in both experiments. The fall in milk fat concentration was due to the combined effects of an increase in milk yield and a decrease in fat secretion. There was also some evidence that a different response occurred when different types of concentrates were used (Sutton,1981). Concentrates containing a high proportion of starch such as cereal grains led to depression in milk fat concentration. Maize and sorghum produced a higher milk fat concentration than those cereal grains containing high starch (Sutton,1981).

2.1.3.3 Quality of feeds

The effect of supplementation on the digestibility of the whole diet is unclear. A depression in digestibility in the diet of grazing cows supplemented with concentrate (-0.4%/kgDM concentrate) has been shown by Arriga-Jordan and Holmes (1986). This was probably due to a reduction in gastro-intestinal pH which resulted in a reduction in the digestibility of starch and cell wall carbohydrate (Reid et al.,1980). Eldridge and Kat (1980) did, however, not find that depression in non-lactating cows supplemented with hay. The absence of the effect of hay supplement on the digestibility of the diet observed by them can be attributed that such effect would depend on the digestibility of the hay and of the pasture rather than the digestibility of the hay alone.

Milk yield was unlikely to be affected by the quality of the supplements itself. It reflected the difference in herbage intake caused by difference in quality (digestibility or ME concentration) of supplement. Meijs (1986) compared a high starch with a high fibre supplement (12.4 and 11.7 MJME/kgDM respectively) for grazing dairy cows and concluded that a high milk production from high fibre supplement than high starch supplement was due to a higher herbage intake in high fibre treatment. The fat concentration of the milk was also higher with the fibrous concentrates due to decreased molar proportions of propionic acid in the rumen. Another grazing comparison between high quality and low quality concentrate supplementation (13.6 and 12.0 MJME/kgDM respectively) has been made by Jennings and Holmes (1984). No significant difference in milk yield of cows fed either high or low quality concentrate supplements was observed but milk fat concentration was depressed when cows were fed the high quality concentrate.

Although Hutton and Parker (1965), Parker (1966) and Stockdale et al. (1981) all have shown pasture-hay diets to have lower nutritive value when compared with pasture only, King and Stockdale (1981) found the relative nutritive value of the hay, in terms of production and body condition, was similar to that of pasture. The former authors used hay having the DM digestibility of 53, 60 and 63% respectively, whereas the latter authors reported the DM digestibility of hay of 70%. In addition, the DM digestibilities of pasture offered in these studies was higher than hay except in the trials of King and

Stockdale (1981) that hay was higher in digestibility than pasture (70 and 63% respectively). These seemed to indicate that the response to a supplement is unlikely to depend on the relative digestibility of the supplement and pasture and the proportion of these components in the diets. The effect of silage quality which is supplemented to stall feeding cows on milk production has been recently examined (Rogers,1985). The average digestibility of high (early closure; September,23) and of low (late closure; October,10) quality silages were 72.5 and 67.6% respectively. The cows fed high quality silage produced 1.15 kg FCM of milk greater than those cows fed low quality silage, but the liveweight changes were similar.

2.1.3.4 Stage of lactation and level of production

Response in milk output to increased supplement input has been suggested to decline as lactation advance (Broster and Thomas,1981) since more energy intake is partitioned towards the liveweight and less to milk with advancing lactation. Recent works by Phillips and Leaver (1985a) and Stockdale et al.(1985) also reported a decrease in milk yield per kgDM supplement eaten as lactation advance. However, this effect was not observed by Jennings and Holmes (1984) and Phillips and Leaver (1985b) supplementing with concentrate and silage respectively.

Marginal response (kg FCM/kgDM supplement) can be increased by the milk potential of the cows. Coulon et al.(1987) reported a marginal response of 0.6, 1.2 and 1.6 for cows of a potential of milk yield of 26 kg, 26-29 kg and >29 kg respectively. High yielding cows showed a greater response not only in milk production but also in liveweight gain to supplementation than low yielding cows (Phillips and Leaver,1985a).

2.1.4 Effects on Liveweight and Body Condition Score.

Many trials have shown that on most occasions, supplements reduced liveweight loss or even increased liveweight gain depending on those factors outlined in the previous topics (2.1.1 and 2.1.3). Bryant and Trigg (1982) reviewed many short term trials and showed the benefit for 1.0 kgDM of supplement consumed of 150 grm/kgDM reduction in liveweight loss in early lactation.

The effect of supplementation on liveweight changes is not always reported. However, Hutton and Parker (1966), King and Stockdale (1981) and Bryant and Trigg (1982) have observed a corresponding tendency for greater increases in liveweight gains due to supplements, when the overall level of feeding increased.

Type of supplement is unlikely to affect the response in liveweight change. Its quality and quantity rather than its type do affect liveweight and condition score change. The absence of positive effect on liveweight change per unit consumed as hay at very high HA in the trials of Stockdale *et al*.(1981) was mainly due to the relatively low digestibility of hay compared with pasture offered and to very high substitution rate as well.

Any effect of supplementation on milk response is likely to be adversely affected by liveweight gain because the partition of energy consumed between milk and liveweight has a negative relationship. In early lactation, for example, more energy intake is partitioned to produce milk and less to liveweight gain but as lactation advance this shows reverse effect.

2.2 EFFECTS OF LEVEL OF FEEDING IN EARLY LACTATION.

At a given level of feeding in early lactation, cows lower in liveweight or body condition score at calving produce less milk than cows calving at higher liveweight or condition score (Grainger et al.,1982). The liveweight or body condition at calving rather than the rate of change in liveweight or condition score prior to calving is the more important factor affecting future production (Rogers et al.,1979; Grainger et al.,1982; King et al.,1985). Neither the type of diet nor the level of feeding precalvimg had a measurable influence on subsequent milk yield, milk composition or liveweight if the cows calve at similar weight or condition score (Hutton,1972; Rogers et al.,1981).

Changes in level of feeding are reflected in both milk output of the cow and in changes in body weight. Underfeeding in early lactation, for example, resulted in a reduction in milk yield, liveweight and condition score, and in an alteration of milk composition, not only during the time of underfeeding (immediate effect) but the later stage after underfeeding (carryover effect) (Broster,1971,1972; Grainger et al.,1982; Broster and Broster,1984; Broster et al.,1984; Stockdale et al.,1987).

2.2.1 Effects on Milk Yield and Composition.

2.2.1.1 Immediate effect

Underfeeding in early lactation reduced yield and altered the composition of milk. Bryant and Trigg (1982) summarised several trials from Australia and New Zealand and concluded that on average a 38% restriction of DM intake resulted in a 24% reduction in milk fat yield. This can be expressed in quantitative terms that a decrease in DM intake 1.0 kg caused a decrease in 39 grm milk fat. The extent of this decrease is proportional to the duration and severity of underfeeding (Bryant and Trigg,1979; Grainger and Wilhelms,1979). In addition, the response to change in level of feeding in milk yield is greater at low levels of feeding than at higher levels, is greater in higher than in lower yielding cows and is lower in mid-late lactation than in early lactation (Broster *et al*.,1981; Broster and Broster,1984). Of interest is however that good feeding after calving will not entirely compensate for poor feeding prior to calving if the cows calve in low body condition score (Bryant,1980; Grainger *et al*.,1982; Treacher *et al*.,1986). Although a positive interaction between body condition at calving and feeding level in week 1-5 for milk and milk fat yield (20 weeks) was observed by Grainger *et al*. (1982).

Immediate effects of feeding level on milk composition are small, however, considering that those summarised by Bryant and Trigg (1982) are the result of about a 40% reduction in DM intake. These authors also concluded that underfeeding in early lactation had an unpredictable effect on the concentration of fat, but generally reduced the concentration of protein and solid-not-fat in milk.

2.2.1.2 Carryover effect

The effect of underfeeding in early lactation on subsequent milk yield and composition have been reviewed (Broster,1972; Bryant and Trigg,1982; Broster and Broster,1984).

Recent works in New Zealand, Hutton and Parker (1973), Bryant and Trigg (1979) and Glassey _et al_. (1980) all found no significant residual effect on yields of underfeeding in early lactation. However, from New Zealand and Australian trials, Bryant and Trigg (1982) reported an average residual effect which was 0.5 times, or less, the immmediate effect of underfeeding in early lactation. Compared with recent works in the UK and Scotland, no residual effect (Combellas and Hodgson,1979; Blair _et al_.,1981; Baker _et al_.,1982), small and moderate carryover effect, up to 0.5-0.7 times the immediate effect (Wood and Newcomb,1976; Johnson,1977; Le Du _et al_.,1979) were observed.

These results contrasted to the early information from New Zealand (Wallace,1957; Patchell,1957) and the UK (Broster,1972) which carryover effect was three or more times the immediate effect. The contrasting results may be attributed to the variation in the duration and severity of underfeeding, genetic merit, cow condition and more important the subsequent level of feeding.

Data on subsequent effects on milk composition have been shown to be inconclusive. Flux and Patchell (1957) reported a residual fall in milk fat concentration following underfeeding in early lactation whereas Grainger and Wilhelms (1979) did not find this, despite an apparent effect from current feeding. Broster (1972) summarised some early evidence showing residual effect on protein and lactose concentrations in the milk. More recent works (Steen and Gordon,1980a,b; Glassey et al.,1980) indicate no residual effect on milk composition.

2.2.2 Effects on Liveweight and/or Body Condition Score.

2.2.2.1 Immediate effect

Underfeeding in early lactation generally reduced body weight and condition score (Bryant and Trigg,1979; Grainger _et al_.,1982). An average of 174 grm extra liveweight, with a range of 27-570 grm, was associated with an extra 1 kgDM intake in Australian and New Zealand trials summarised by Bryant and Trigg (1982). The variability of response may be attributed to differences in the extent of partitioning of feed between milk and body gain. Cows calving in low body condition, for example, will use a greater proportion of the feed for liveweight gain but a small proportion for milk production than those with higher body condition at calving. Also as a cow approaches its potential milk production therefore an increasing proportion of the extra feed consumed will be partitioned towards liveweight gain and thus more feed will be required to produce an extra milk production.

It should also note that at a given level of intake the greater the yield potential of the cow the smaller the body gain and in conformity with this, the greater the partition of additional nutrients to milk than to body by the high yielding cow (Broster _et al_.,1975).

2.2.2.2 Carryover effect

The previous less generously fed cows in early lactation gained more weight in mid lactation than did the previously better fed cows (Bryant and Trigg,1979; Grainger and Wilhelms,1979; Stockdale _et al_.,1981). This occurred with equal diets in mid lactation as well as with restricted grazing. Grainger _et al_. (1982) reported that improved feeding in week 1-5 of lactation conserved body tissues, but better body condition at calving was associated with greater body loss in this period. In weeks 6-20 on equal feeding, change in body condition score was inversely proportional to feeding level in weeks 1-5 and the cows in better body condition at calving continued to lose more condition score. Broster and Thomas (1981) reviewed 46 trials and concluded that the previous less generously fed cows gained 0.15 kg/day more weight in mid lactation than those well fed throughout.

2.3 FACTORS CONTROLLING HERBAGE INTAKE BY GRAZING DAIRY COWS.

2.3.1 Voluntary Food Intake.

Food intake and its variation is one of the major factors determining level and efficiency of animal production from pasture (Bines,1979; Hodgson,1982; Leaver,1985). The principles of food intake control which have been studied mainly under indoor feeding condition are assumed to be applied to grazing animals with certain limitations (Arnold,1970), although food intake by grazing animals will be affected by many other factors by which stall-fed animals are not affected.

Voluntary food intake of animals is influenced by two main factors, metabolic factors - factors which influence the animal requirements for nutrients and its ability to metabolise absorbed nutrients, and physical factors - factors which influence the animal's ability to consume the feed, to accommodate and digest it in the digestive tract (Baumgardt,1970; Bines,1971). For grazing animals the regulation of food intake is determined by the inter-relationship between these two factors and behavioural factors (Hodgson,1977).

2.3.1.1 Metabolic factors.

The control of food intake can be considered as a component of the homeostatic regulation of energy balance between the animal and its environment (Baumgardt,1970; Baile and Forbes,1974; Baile and McLaughlin,1987). In general the animal attempts to maintain a constant energy balance by changing food intake in proportion to its energy requirement and its altered physiological and environmental circumstances (Baile and Forbes,1974).

Physiological control involve the potential feedback of the end products of digestion and metabolism to neural receptors in the brain. The receptor sites for the feedback control system which inform the brain about the nutritional state of the body apparently originate in the gastrointestinal tract, hepatic-portal system, adipose tissue and/or peripheral and cerebrospinal fluid (Baumgardt,1970; Forbes,1980).

Volatile fatty acids rather than glucose are the main products of energy digestion in ruminants and are possible components of food intake regulation system (Baile and Mayer,1970; Bines,1971; Van Soest,1982). Propionate and acetate are recognised as possible feedback signals of satiety in ruminants (Baile and Mayer,1970) whereas butyrate is less important. The role of lactate is controversial, probably depressing the motility of the stomach (Forbes,1980).

It has been suggested that the fall in rumen pH is involved in the cessation of feeding (Kaufmann,1976), although, as for the free fatty acids (Baile and Forbes,1974) in the short term, there is little information to show if they are a cause rather than an effect of changes in feeding.

2.3.1.2 Physical factors.

Food intake of ruminants is restricted primarily by rumen capacity since it is evident that ruminants fed bulky and fibrous feeds may stop eating before they have consumed sufficient nutrients to obtain the dietary energy required by their genetic potential for production (Campling,1970; Bines,1971; Meijs,1981). The physical limitation is related to the distention of the reticulorumen and rate of disappearance of digesta from the reticulorumen.

Distention of the reticulorumen

Ruminants fed a large proportion of roughage consume to a constant rumen fill (Campling,1970). The size of the rumen is partly determined by the size of abdominal cavity, which appears to be limited in the extent to which it can stretch (Bines,1971). However, the rumen capacity can be affected by foetal enlargement and fat deposition within the abdominal cavity which suggested that reduced the extension of the reticulorumen and this is associated with a reduced intake by animals(Forbes,1980). There are stretch receptors in the rumen wall but the exact mechanism of transmission still remains unknown. The probable mechanism can be by discomfort, by stimulation of the humoral intake regulating factors or by mechanism of rumination (Van Soest,1982).

The physical limitation of space in the gastro-intestinal tract implies that volume rather than mass is of importance (Raymond,1969; Waldo,1986). Physical controls are primarily related to the capacity of the digestive tract (Freer,1981), to the fibre content of the feeds and to the rate of degradation and passage, therefore the indigestible fraction of the DM is the major physical factor limiting intake (Chase,1985).

In addition physical properties of feed will influence quantities eaten at meals and patterns of eating. Higher density grains, for example, are likely to be consumed in large amounts in meals with low frequency, while low density straw diets are likely to be eaten in more frequent meals of small amounts (Baile,1975).

However, the role of gut fill as control mechanism of food intake is still controversial, and it has been associated with the type of diet. Some authors (Bines and Davey,1970) reported a limitation to food intake by gut capacity in cows fed mixed diet, whereas others (Waldo,1986) considered that herbage intake is not limited by small or large intestines.

Rate of disappearance of digesta

The rate of digesta passing from the reticulorumen depends on the chemical composition of the feed, the rate at which the feed is broken down physically (mastication and rumination) and chemically (microbial and enzymatic digestion), the capacity of muscular contraction of the gut and the size of the reticulo-omasal orifice (Meijs,1981; Ulyatt *et al.*,1985). Retention of feed in the reticulorumen allows substantial microbial fermentation to take place, with over 60% of OM digestion occurring in the reticulorumen (Ulyatt *et al.*,1985). Retention time is influenced by a number of dietary factors such as the amount of feed consumed, forage physical form, forage:grain ratios, fibre content and physical nature of the fibre (Freer,1981; Shaver *et al.*,1986).

Factors which are involved in the movement of particles from reticulorumen include size of particles, density of particles, rate of particle reduction, cell wall content of the feed, hydration time, pH and osmotic pressure, strength and frequency of ruminal and abomasal contraction (Shaver *et al.*,1986).

Undigested material can merely pass through the reticulo-omasal orifice after being reduced to fine particles (<2.0 mm). The size of particle is relatively insensitive to changes in digestibility, physical form of the feed, intake, type of pasture or liveweight of the animal. The amount of material passed per contraction of the reticulum rather than the particle size has been suggested to be probably more important.

2.3.1.3 Behavioural factors.

Daily herbage intake (I) of a grazing animal can be influenced by behavioural factors. The amount of daily herbage intake by a grazing animal is determined by the time spent grazing per day (GT, minutes), the amount of herbage consumed per bite (IB, gDM or gOM/bite) and the rate of biting per minute of grazing time (RB, bite/minute) (Allden and Whittaker,1970). Thus:

$$I = GT \times RB \times IB.$$

The variation in IB is usually greater than variations in either RB or GT (Stobbs,1973; Hodgson,1981) and appears to be the most sensitive component to variations in sward conditions (bulk density, sward height, leaf/stem strength, sward structure). Since any compensating changes in RB or GT are usually limited, IB is likely to be a major determinant of daily herbage intake (Leaver,1985, Hodgson, 1985).

The GT for a cow rarely exceeds 10 - 12 hours/day (Leaver,1985; Poppi et al.,1987), otherwise grazing would interfere with rumination time and other behavioural requirements. In the short term, the rate of herbage intake per minute of grazing time (RB x IB) falls steadily with increasing proximity of the grazed horizon to the ground level (Hodgson,1977).

The effect of supplementation has been reported to reduce GT between 9-38 minutes/kgDM for grazing cows supplemented with concentrates (Sarker and Holmes,1974; Journet and Demarquilly,1979; Arriga-Jordan and Holmes,1986), silage (Phillips and Leaver,1985b), or hay (Phillips and Leaver,1985a).

2.3.2 Pasture Factors.

2.3.2.1 Herbage mass.

Herbage mass is important for continuously grazed stock because it effectively controls the quantity of herbage available for grazing each day whereas herbage allowance is more important for rotationally grazed cows.

Increases in herbage mass per unit area have been reported to cause increases in daily herbage intake (Hodgson,1975; Jamieson and Hodgson,1979; Stockdale and King,1983; Zoby and Holmes,1983; Forbes and Hodgson,1985, Stockdale,1985), while other studies have reported decreases or no change (Hodgson et *al*.,1977; Reardon,1977; Bartholomew *et al*.,1981; Hodgson,1977; Meijs,1982). However, many examples have shown the relationship between herbage mass and herbage intake to be asymptotic (Hodgson,1977; Combellas and Hodgson,1979; Hodgson and Jamieson,1981; Meijs,1982). Such relationship indicates a constant increase in intake, if the response is linear, or a declining incremental increase, if the response is curvilinear, to a point - the asymtote - beyond which there is no further increase in intake. This decline in herbage intake, or total lack of any further increase beyond the asymtote is generally related to the decrease in herbage quality (Meijs,1981; Stockdale,1985) associated with pasture aging.

However, at a given level of herbage allowance, herbage intake is unlikely to be affected by the variation of herbage mass offered to lactating cows (Holmes,1987) or dry cows (Holmes *et al*.,1979). Combellas and Hodgson (1979) with lactating cows, confirmed the early finding of Reardon (1977) with steers that herbage intake was not affected by herbage mass within the range of 2,000-4,000 kgDM/ha but above this range intake declined progressively.

2.3.2.2 Herbage allowance.

For rotationally grazed stock herbage allowance (HA) has been shown to be an important determinant of the herbage intake and consequently of the animal performance of lactating cows (Combellas and Hodgson,1979; Le Du et al.,1979; Bryant,1980; Glassey et al.,1980; King and Stockdale,1984; Mitchell,1985; Stockdale,1985), or non-lactating cows (Holmes and McLenaghan,1980; Ngarmsak,1982).

The relationship between HA and herbage intake, and between HA and animal performance have been suggested to be asymptotic (Combellas and Hodgson,1979; Bryant,1980). Herbage OM intake approaches maximum at an allowance 4 times greater than the amount actually consumed (Hodgson,1976), but only starts to decline markedly when HA is less than twice intake for lactating cows (Le Du et al.,1979). In contrast to the former, Combellas and Hodgson (1979) reported that herbage intake of grazing cows was near maximal when grazing efficiency, defined as herbage intake expressed as a proportion of the herbage allowance, was 50% or less.

Associated with increase in HA is an increase in residual herbage mass (RHM), and HA or RHM can be used to indicate herbage intake (Le Du et al.,1979; Holmes,1987). The effect of HA can be affected by pasture species (Stockdale,1985), herbage mass (Combellas and Hodgson,1979), season (Holmes,1987) and quality (Hoogendoorn,1987). To avoid part of that variability

Butler *et al.*(1987) suggested that HA should be expressed in terms of green leaf allowance.

2.3.2.3 Herbage digestibility.

As a general principle, digestibility is a satisfactory way of examining nutritive value and its influence on the amount of food intake by an animal (Hodgson,1977). It will be determined by the pasture species present, stage of growth and management imposed upon it (Baker,1976). Factors affecting the digestibility have been reviewed in detail by many authors (Raymond,1969; Reid *et al.*,1980; Minson,1982).

Digestibility is a major determinant of pasture quality. Consequently it can affect animal performance (Holmes,1987). Hodgson (1977) showed a linear and constant rate of increase in herbage intake over a range of digestibilities up to OM digestibilities of 80-83% for grazing animals. However, in most experiments quoted by Hodgson (1977), digestibility was confounded by changes in season and time of year, and also by the physiological state of the cow. The relationship is therefore imprecise and it is not a good predictor. The differences in animal response are related to the differences in the site of digestion of the protein and organic matter (Poppi,1983). It seems that the effect of digestibility on herbage intake is related to rate of passage of feed through the digestive tract.

2.3.3 Animal Factors.

2.3.3.1 Size, liveweight, body condition, age and genotype.

The size of the animal is critical in determining the volume of the abdominal cavity which is related to rumen capacity (Bines,1979; Meijs,1981). In addition, the size and liveweight of grazing animals are highly correlated. Voluntary intake is therefore positively related to liveweight. However, for adult animals liveweight could be an imprecise scaler with respect to body size because of gut fill or fat content although it is generally reported that the heavier animal eats more (Bines,1976,1979; Meijs,1981).

The relationship between feed intake and liveweight may be affected by the confounding effect of the frame size and body condition. For example, at any given size for animals the fatter they are the heavier they are, therefore, intake is often inversely correlated with body weight (Forbes,1986). It is also evident that, at a comparable liveweight, thin cow at calving ate more than fat cows.

The age of the cow influences its feed intake in addition to any consequent effect of age on body weight. Feed intake increases as animal grows, but not in direct proportion to liveweight (Forbes,1986).

The variation in feed intake associated with genotype can be explained by differences in body weight and in level of milk production (Owen,1988). For grazing cows, high breeding index (HBI) cows ate more feed (6-20%) during part of lactation than did low breeding index (LBI) cows (Holmes and McMillan,1982). Of interest is to note that Friesians HBI were lighter than LBI but ate more feed per cow or per $kg^{0.75}$ whereas Jerseys HBI were heavier than LBI but ate more feed per cow or per $kg^{0.75}$ (Holmes et al.,1985; Bryant,1985).

2.3.3.2 Effect of pregnancy.

During pregnancy the volume and nutrient demand of the conceptus progressively increase and the dam's endocrine status changes (Forbes,1970,1971). Increases in intake in early and mid pregnancy (Forbes,1971; Bines,1971,1976) might be caused by increases in metabolic rate, by the growth of the heifer, by a possible increase in the rate of passage of the feed, by the energy requirement of the developing foetus or by elevated progesterone levels in the blood.

It is generally accepted that the intake falls as parturition approaches regardless of the type of diet (Forbes,1971; Journet and Remond,1976; Meijs,1981). A decline of 0.2 kgDM/week during the last 6 weeks of pregnancy was found by Journet and Remond (1976). The decline in intake at this stage was probably due to a reduction in volume of the abdominal cavity caused by physical compression of the uterus on the rumen (Baile and Forbes,1974; Bines,1979), and/or abdominal fat and endrocrine changes (Forbes,1971).

2.3.3.3 Effect of lactation

Many reports have shown that lactating cows ate more than non-lactating cows (Hutton,1963; Leaver et al.,1968; Bines,1976; Hodgson,1977), regardless of type of diet. On average lactating cows consumed 42% more than non-lactating cows of the same liveweight (ARC,1980), although the effect of pregnancy was probably confounded in some reports. It has been suggested that the apparent greater intake was probably due to hypertrophy of the alimentary tract (Leaver,1985) or to hormonal differences (Freer,1981).

Most studies of the feed intake in lactating animals have shown that there was a positive relationship between the level of milk production and feed intake (Bines et al.,1977; ARC,1980; MAFF,1984). Feed intake and milk production show a different pattern of variation over the lactation. Milk production rises rapidly immediately after parturition and usually reaches a peak between days 35-50, and thereafter declines steadily whereas food intake increases to reach a peak at an average of 16 weeks after parturition (Bines,1976,1979), developing a lag of energy intake balance whose reasons are incompletely established (Meijs,1981). It has been suggested that the factors are of physical origin (Bines,1976), abdominal fat (Journet and Remond,1976), delay of hypertrophy of gut wall, liver (Bines,1979), alimentary tract or endocrinological factors (Meijs,1981).

Taking the whole lactation period, however, feed intake is likely to show a positive relationship to lactation milk yield, although other complicating effects may cloud this relationship (Owen,1988). Over a lactation, multiple regression studies indicate that when other factors are taken into account, for each increase of 1 kg in lactation yield the dry matter intake of the cow increased by 0.5 kg (ARC,1980).

2.3.4 Effect of Supplementary Feeding

In general, the feeding of supplements causes decreases in the quantity of herbage eaten, due to the so-called substitution of one feed to the other. These effects have been discussed in detail in 2.1.1.

2.4 OBJECTIVES OF THE STUDY

Supplementary feeds commonly fed on dairy farms in New Zealand are hay and silage. Animal response from such feeds is generally low because the supplements are of low quality. A wide variety of grains and balanced concentrates have been used in many experiments overseas to investigate the feasible economic response, particularly in the long terms. Although animal response in the short term has often been shown to be uneconomic, when carryover response is taken into account, concentrate supplement may be justified.

The present study was carried out to assess the effect of concentrate supplementation in early lactation for spring calving cows on herbage consumption, residual herbage mass, total intake of DM and ME, milk production and composition, and liveweight and body condition score change.

CHAPTER 3: MATERIALS AND METHODS

3 MATERIALS AND METHODS.

The experiment was conducted at Massey University's Dairy Research Unit, Palmerston North, New Zealand, for 14 weeks during September-December 1987.

The unit is a seasonal supply farm of 48 ha, divided into 60 paddocks each of approximately 0.8 ha. The soil type is a Tokomaru silt loam, consisting of a 15-30 cm layer of heavy silt overlying a mottled clay loam. All paddocks have been drained with tiles and moles and are topdressed annually with 350 kg potassic superphosphate and 50-100 kg urea per hectare. The surplus grass during the year is conserved as silage (early conservation) or hay (late conservation).

The common abbreviations used in this thesis are given in Table.3.1.

Table 3.1.Common Abbreviations

LW	Liveweight
CS	Body condition score
HA	Daily herbage allowance
HM	Herbage mass
RHM	Residual herbage mass
DMI	Dry matter intake
IB	Intake per bite
RB	Rate of biting
GT	Grazing time
DM	Dry matter
DMD	Dry matter digestibility
OMD	Organic matter digestibility
DOMD	Digestible organic matter in the dry matter
GE	Gross energy
DE	Digestible energy
ME	Metabolisable energy
MEI	Metabolisable energy intake
SEM	Standard error of means

3.1 PRE-EXPERIMENTAL CONDITIONS.

3.1.1 Climatological Data

Climatological data during the experiment are given in Table 3.2.

Table 3.2.Climatological data throughout the experiment

Month	Rainfall (mm/month)	Air temp.(°C) Max.	Air temp.(°C) Min.	R.H. (%)	Sunshine (hrs/24 hrs)
September	67.1	15.2	7.1	79	4.1
	(79.2)	(14.9)	(7.0)	(79)	(4.2)
October	93.1	17.4	8.6	72	5.1
	(80.2)	(16.5)	(8.4)	(76)	(5.0)
November	62.3	19.6	11.3	74	6.6
	(70.8)	(18.7)	(10.0)	(74)	(5.7)
December	95.8	21.0	12.6	76	4.8
	(100.5)	(20.8)	(11.9)	(73)	(6.2)

() average 30 years data up to the recent year.

Source - Grassland Division. DSIR. Palmerston North.

3.1.2 Animals and Treatments.

The experiment comprised two groups of dairy cows, one group being fed pasture only (PF) and the other group being supplemented with concentrates (CF). 15 pairs of monozygous (identical) twins were used and each twin allotted to the two treatments, PF and CF. Details of the cows used in the experiment are given in Table 3.3.

Table.3.3.Data for the cows at the start of the experiment.

Mean values for:-	PF	CF
Calving date	19/8/87	24/8/87
Days in lactation	27±2	22±3
Milk yield (kg/cow/day)	17.3±1.6	15.2±1.2
Fat yield (kg/cow/day)	0.82±0.05	0.75±0.04
Protein yield (kg/cow/day)	0.65±0.05	0.59±0.04
Lactose yield (kg/cow/day)	0.87±0.08	0.76±0.06
Fat concentration (%)	5.0±0.2	5.1±0.3
Protein concentration (%)	3.9±0.1	3.9±0.2
Lactose concentration (%)	5.1±0.05	5.0±0.05
Liveweight (kg)	359±15	347±16
Condition Score (units)	4.9±0.2	4.3±0.2

Data shown were means±SE.

3.1.3 Animal, Sward and Feed Managements.

The experimental description is summarised in Table.3.4.

Table.3.4.Summary of experimental description.

Before the start of the experiment	-All cows grazed together with main herd, at generous herbage allowance.
Day 0-29 (Day 0 = 14/9/87)	-All cows grazed as a group on pasture restricted to approximately 20 kgDM/cow/day HA. Concentrates were given to CF cows.
Day 30-43 (The Experimental Period I)	-Experimemtal cows grazed in two separate groups, at approximately 20 kgDM/cow/day HA. Concentrates were given to CF cows.
Day 44-68	-Experimental cows returned to graze with main herd at generous allowance. Concentrates were given to CF cows.
Day 69-78 (The Experimental Period II)	-Experimental cows grazed in two separate groups, at approx.25 kgDM herbage allowance. Concentrates were given to CF cows.
Day 79-92	-Experimental cows returned to graze with main herd at generous allowance. Concentrates were given to CF cows until day 92 then concentrate feeding was ceased.
Day 92 onwards	-Cow performance was recorded for further 6 weeks.

Before the start of the experiment, the cows were generously fed with the main herd by day and night paddocks. They were then fed as a group on pasture restricted to approximately 20 kgDM/cow HA. At the same time the CF cows were gradually introduced to concentrates, and allowed to adjust to the allotted rations for 29 days. For the next 14 days (Experimental Period I) the cows were separately fed as CF and PF groups at an imposed allowance (approximately 20 kgDM/cow/day) and data were collected to determine animal response due to treatments. Following the Experimental Period I, all cows were generously fed with the main herd for a further 25 days. The trial was then repeated for a further 10 days, but at an allowance of approximately 25 kgDM/cow/day (Experimental Period II). The data on animal performance was collected for further 6 weeks following the cessation of concentrate feeding to determine the residual effect.

During the two Experimental Periods, each group of cows was given a fresh strip of pasture once daily, after the morning milking. Each paddock used was longitudinally divided into two equal areas, one for each treatment group. These areas were further subdivided into 4 to 6 breaks depending on size of paddocks and estimated herbage mass. Each break was occupied by either the PF or CF groups daily, and back-grazing was prevented by means of an electric fence.

The concentrate supplement was offered daily in communal troughs, immediately after each milking. The cows were allowed access to concentrate for approximately 1 hr before they returned to pasture. The quantities offered and left uneaten were weighed at every feeding period, so that the quantities consumed could be calculated.

3.1.4 Pastures and Concentrates.

The pastures used during the experiment comprised mainly perennial ryegrass (Lolium perenne) and white clover (Trifolium repens) with a small proportion of cocksfoot (Dactylis glomerata), phalaris (Phalaris tuberosa) and prairie grass (Bromus catharticus).

The area used to conduct the experiment was 4.6 ha divided into 5 paddocks.

The initial concentrate fed to the CF cows comprised mainly maize, wheat and oats, but consumption was low. Therefore it was necessary to change the concentrate to a mixture of commercial meal (Harvey's farm dairy meal) and ground oats in a ratio of approximately 2:1, which resulted in satisfactory consumption. Ground oats was used in the mixture as part of another experiment which was studying the flavour of milk.

3.2 MEASUREMENTS.

3.2.1 Feed Measurements.

The pasture was cut before and after grazing on 10 occasions during the whole experiment. The technique adopted (Walters and Evans, 1979) on each occasion involved cutting 10 quadrats (0.1875 m^2 each) to ground level for each treatment. A sheep shearing hand piece powered by a mobile petrol motor was used to cut the herbage samples. This operation was always made by the same operator, to minimise the variability associated with the technique (Thomson, 1986).

After cutting, the samples were washed to remove soil contamination and dried at 70-80°C for 36 hrs for dry matter determination. A subsample bulked from each pre-grazing cutting at each period was collected for chemical analysis.

The concentrate samples were taken from two consecutive days weekly (two samples each day). The samples from each two weeks from the start of the experiment to the end of the experiment were bulked and were then subsampled for gross energy and chemical analyses.

Samples of concentrates and dried herbage were ground through a 1-mm screen and were then subjected to analyses for:

a) Gross energy concentration - kJ/kg - (Adiabatic Calorimeter Bomb),

b) Total nitrogen concentration - g/kg - (Kjeldahl),

c) Ash concentration - g/kg - (500°C/24 hours),

d) In vitro digestibility (Roughan and Holland, 1977).

Calculation of crude protein was made by using the commonly-accepted equation that:

$$CP = 6.25N$$

where

CP = Crude protein (%)

N = N concentration in the dry matter (%).

Calculation of metabolisable energy was made by using the assumption of MAFF (1975) that:

$$M/D = 0.16DOMD$$

where

M/D = ME concentration in the dry matter.

DOMD = Digestible organic matter in the dry matter from in vitro analyses.

For the supplemented diets, it was assumed that there was no interaction between the two feeds.

3.2.2 Animal Measurements.

Daily herbage allowance, pre-grazing herbage mass, residual herbage mass and degree of defoliation were used as defined by Hodgson (1979). The daily metabolisable energy allowance was defined as the total ME offered in the diet to the cows, expressed as MJME/cow/day.

3.2.2.1 Intake

The average amount of pasture consumed by each cow of each group was estimated as the difference between the pre-grazing herbage mass and the residual herbage mass, multiplied by the area allocated daily and divided by the number of cows grazing during that time. It was expressed as kgDM/cow/day for dry matter and MJME/cow/day for metabolisable energy. Substitution rate was defined as the change (units) in intake of pasture when the animal consumed one unit of concentrate. It was expressed in dry matter (kgDM) or metabolisable energy (MJME).

3.2.2.2 Liveweight

Cows were weighed on two consecutive days immediately prior to the start of the experiment. Subsequently, they were weighed fortnightly after morning milking throughout the experiment. The liveweight change was defined as the difference in liveweight between the start and the end of the experiment.

3.2.2.3 Body condition

Body condition score for each cow was assessed at the same time as the liveweight. The score system used was that reported by Scott *et al*. (1980), with a range of 1-10. The scores of the two consecutive days were averaged at the start of the experiment.

3.2.2.4 Milk production and composition

Throughout the experiment, of 14 weeks, individual morning and evening milk yields were recorded on two consecutive days each week. However, during Periods I and II, of 14 and 10 days respectively, individual morning and evening milk yields were recorded on 9 and 8 days respectively. Aliquot milk samples were taken at this time for analysis of milk compositions using Milkoscan 140 A/B (Foss electric, Denmark).

3.3 STATISTICAL ANALYSIS.

All data were analysed using the Statistic Analysis System (SAS) computing package (SAS Institute, 1985).

Sward (HM, RHM, HA), intake (DMI, MEI, substitution rate of the DM and ME) and liveweight and body condition change data were analysed using analysis of variance (Steel and Torrie, 1986).

The model used to define the above data were:

$$y_{ij} = \mu + a_i + \varepsilon_{ij}$$

where

y_{ij} = the observation on the j^{th} individual exposed to the i^{th} treatment. $i=1,2$; $j=1,2,...,15$.

μ = the unknown population mean.

a_i = the effect of the i^{th} treatment.

ε_{ij} = the random error associated with the j^{th} individual exposed to the i^{th} treatment. It is assumed that ε_{ij} is normally distributed with mean 0 and variance σ^2.

Yields of milk, milk fat, protein and lactose, and milk compositions were analysed using the repeated measurement analysis of covariance (Finn,1974) as the following model.

$$y_{pij} = \mu_p + \alpha_{ip} + \beta_p x_{ij} + \varepsilon_{pij}$$

where

y_{pij} = the observation on the j^{th} individual measured in the p^{th} week and belonging to the i^{th} treatment. i=1,2. j=1,2,...,15. p=1,2.

μ_p = the overall mean together with the effect of the p^{th} week.

α_{ip} = the effect of i^{th} treatment in the p^{th} week.

β_p = regression coefficient of y_{ij} on x_{ij} in the p^{th} week.

x_{ij} = the initial observation on the j^{th} individual in the i^{th} treatment.

ε_{pij} = random residual effects, which are assumed to be identically and independently distributed within the p^{th} week, but there being covariance across weeks.

Liveweight and body condition score were analysed using the analysis of covariance (Steel and Torrie, 1986) as the following model.

$$y_{ij} = \mu + a_i + \beta x_{ij} + \varepsilon_{ij}$$

where

y_{ij} = the observation on the j^{th} individual exposed to the i^{th} treatment. i=1,2. j=1,2,...,15.

μ = the unknown population mean.

a_i = the effect of the i^{th} treatment.

β = regression coefficient associated with x_{ij}

x_{ij} = pre-experimental performance of the j^{th} cow exposed to the i^{th} treament.

ε_{ij} = the random error associated with the j^{th} individual exposed to the i^{th} treatment. It is assumed that ε_{ij} is normally distributed with mean 0 and variance σ^2.

The following symbols will be used throughout this thesis to determine the level of significance of differences between means.

*** Significant difference at the probability < 0.001

** Significant difference at the probability < 0.01

* Significant difference at the probability < 0.05

NS Not significant difference.

CHAPTER 4: RESULTS

4 RESULTS

4.1 CHEMICAL ANALYSIS AND GROSS ENERGY DETERMINATION OF THE FEEDS.

The Gross energy and chemical analysis of the feeds (±SEM) used in the experiment are given in Table 4.1. and shows the digestibility and energy level of the concentrate to be noticeably higher than the herbage. Digestibility of the herbage in Period I also appeared to be higher than in Period II.

Table 4.1.Data for the analyses of feeds used in the experiment (SEM)*.

Type of feeds	%DM	in vitro %DMD	in vitro %OMD	in vitro %DOMD	%CP	%ASH	GE (MJME/ kgDM)	ME (MJME/ kgDM)
Concentrates	86.6	82.6	84.5	77.1	11.4	5.85	18.3	12.3
	(0.1)	(0.4)	(0.3)	(0.4)	(0.3)	(0.5)	(0.1)	(0.1)
Herbage								
Period I	-	73.1	77.3	67.1	15.7	11.4	18.0	10.7
Period II	-	68.2	73.8	63.5	14.0	11.4	18.2	10.2

* Standard error of the mean

4.2 SWARD CHARACTERISTICS

4.2.1 Pregrazing Conditions

There was little variation in pregrazing pasture mass between paddocks within each period, being 3180±16 and 4378±107 kgDM/ha for Period I and Period II respectively. The pregrazing herbage mass (HM) in each area allocated to the PF and CF cows in both periods was not significantly different (p>0.05). Mean values and results of ANOVA for the amounts of HM for the two treatments in two periods are given in Table 4.2.

Table 4.2. Mean values and results of ANOVA for the amounts of pregrazing pasture mass (kgDM/ha) for the two treatments in Periods I and II.

Period I					Period II				
Pd.Nº	PF	CF	SEM	Sig.	Pd.Nº	PF	CF	SEM	Sig.
1	2641	2681			4	4537	4558		
2	3537	3429			5	4434	3984		
3	3413	3383							
MEAN	3197	3164	370	NS		4486	4271	292	NS

As shown in Table 4.3., the amounts of daily herbage allowance were not significantly ($p>0.05$) different between PF and CF treatments in both periods. However, the total DM offered to CF cows was significantly ($p<0.001$ in Period I, $p<0.05$ in Period II) greater than that given to PF cows in both periods due to the additional concentrate in the CF treatment.

The calculated stocking density in Period I was 163 cows/ha/day whereas this value was 185 cows/ha/day in Period II.

Table 4.3. Mean values and results of ANOVA for the amounts of herbage, concentrate and total DM allowance for the two treatments in Periods I and II (kgDM/cow/day).

	Period I				Period II			
	PF	CF	SEM	Sig.	PF	CF	SEM	Sig.
DM allowance								
As pasture	19.6	19.4	1.0	NS	24.4	22.9	1.7	NS
As concentrate	-	6.9			-	6.9		
Total DM								
allowance	19.6	26.3	1.0	***	24.4	29.8	1.7	*

The daily amounts of herbage ME, concentrate ME and total ME offered to the PF and CF groups in Periods I and II are shown in Table 4.4. There were no significant ($p>0.05$) differences in herbage ME allowance between the two groups in both periods. In contrast, total ME allowance for the CF cows were significantly ($p<0.001$ and $p<0.01$ in Periods I and II respectively) higher than for the PF cows in both periods, due to the additional concentrate ME offered to the former cows.

Table 4.4. Mean values and results of ANOVA for the amounts of ME offered from herbage, concentrate and total ME allowance (MJME/cow/day) for the two treatments in Periods I and II.

	Period I				Period II			
	PF	CF	SEM	Sig.	PF	CF	SEM	Sig.
ME allowance								
As pasture	210	208	11	NS	249	233	18	NS
As concentrate	-	85			-	85		
Total ME								
allowance	210	293	11	***	249	318	18	**

4.2.2 Herbage Intake.

The mean values for the amounts of herbage, concentrate and total DM consumed by the different groups in each period are presented in Table 4.5. Herbage consumption was significantly ($p<0.05$ and $p<0.01$ in Periods I and II respectively) depressed by the supplementation with concentrate in both periods. It was decreased by 1.8 and 3.2 kgDM/cow/day in Periods I and II respectively. The intake of concentrate supplement was similar in both periods.

Calculated substitution rates in Periods I and II were 0.27 and 0.48 kgDM decrease in herbage intake per kgDM increase in concentrate consumed respectively.

Total DM intakes were significantly ($p<0.001$ in both periods) higher in CF group than in PF group in both periods, because of concentrate DM eaten, and despite the reduced pasture intake. In Period I, total DM intake of the CF group was 4.9 kg/day higher than the PF group and 3.5 kg/day higher in Period II. The consumption of 1 kgDM concentrate increased total DM intakes by 0.73 and 0.52 kg/day in Periods I and II respectively (Table 4.7).

Table 4.5. Mean values and results of ANOVA for the amounts of DM consumed from the pasture, concentrate and total apparent DM intake (kgDM/cow/day) for the two treatments in Periods I and II.

	Period I				Period II			
	PF	CF	SEM	Sig.	PF	CF	SEM	Sig.
Apparent DM intake:								
As pasture	11.8	10.0	0.7	*	12.2	9.0	0.8	**
As concentrate	-	6.7			-	6.7		
Substitution rate	0.27				0.48			
Total DM intake	11.8	16.7	0.7	***	12.2	15.7	0.8	***

The calculated mean values for the daily amounts of ME consumed from the herbage, concentrate and total ME consumed (MJ/cow) by the two groups in Periods I and II are shown in Table 4.6.

Due to the decreases in herbage DM intakes, the ME consumption as pasture was significantly ($p<0.05$ and $p<0.01$ in Periods I and II respectively) decreased by the supplementation of concentrate in both periods. The reduction in herbage ME intake of the CF cows were 19 MJ/cow in Period I and 32 MJ/cow in Period II.

The ME intakes as concentrate were similar in both periods. The total apparent ME consumed was significantly ($p<0.001$ in both periods) greater in the CF group than in the PF group in both periods. The increment in total ME consumed were 64 and 51 MJ/day which corresponded to 77 and 61 % of the ME consumed as concentrate in Periods I and II respectively. In other words, the consumption of 1 MJME as concentrate resulted in increased total ME consumed by 0.77 and 0.61 MJ/day in Periods I and II respectively (Table 4.7).

Table 4.6. Mean values and results of ANOVA for the amounts of the ME consumed from the herbage, concentrate and total ME consumed (MJ/cow/day) for the two treatments in Periods I and II.

	Period I				Period II			
	PF	CF	SEM	Sig.	PF	CF	SEM	Sig.
ME intake:								
As pasture	126	107	8	*	124	92	8	**
As concentrate	-	83			-	83		
Total ME intake	126	190	8	***	124	175	8	***

Table 4.7. Increase in total DM and ME intakes caused by the consumption of 1 kgDM or 1 MJME as concentrates in Periods I and II.

	kgDM/kgDM as concentrate		MJME/MJME as concentrate	
	Period I	Period II	Period I	Period II
	0.73	0.52	0.77	0.61
MEAN	0.65		0.69	

4.2.3 Residual Herbage Mass.

Values for individual paddocks and mean values for residual herbage mass (RHM) are given in Table 4.8. There was no significant differences in the RHM between the two treatments in both periods (1305 vs 1569 kgDM/ha in Period I, 2255 vs 2654 kgDM/ha in Period II).

The mean values for the degree of defoliation are also given in Table 4.8. The degree of defoliation was depressed by the supplementation with concentrate. It was decreased by 12% and 13% units in Periods I and II respectively, but these differences were not significant.

Table 4.8. Mean values and results of ANOVA for the amounts of residual herbage mass (RHM, kgDM/ha) for the two treatments in Periods I and II.

	Period I				Period II			
Pd.Nº	PF	CF	SEM	Sig.	Pd.Nº	PF	CF	SEM	Sig.
1	1087	1432			4	2152	2847		
2	1768	2031			5	2358	2461		
3	1059	1569							
MEAN	1305	1569	332	NS		2255	2654	219	NS
Degree of defoliation (%)									
	59	47	7	NS		50	37	3	NS

4.3 ANIMAL PERFORMANCES.

4.3.1 General.

The data for the cows at the start of the experiment are given in the previous chapter (See Table 3.1). The results reported in the following tables were adjusted using the initial statistics as covariates. Initial milk, milk fat, milk protein and milk lactose yields were used as covariates in the statistical analysis of subsequent yields of milk, milk fat, milk protein and milk lactose respectively. Subsequent concentrations of fat, protein and lactose were also analysed using their initial concentrations as covariates.

4.3.2 Yields of Milk, Milk Fat, Milk Protein and Milk Lactose.

Table 4.9 shows the yields of milk, milk fat, milk protein and milk lactose for the treatment groups for the two periods.

Concentrate feeding significantly increased milk ($p<0.01$), milk protein ($p<0.001$) and milk lactose ($p<0.01$) yields during the two experimental periods. The daily response was 0.33 and 0.48 kg milk, 0.02 and 0.03 kg of milk protein, and 0.02 and 0.03 kg of milk lactose per kgDM of concentrate consumed in Periods I and II respectively. Concentrate feeding had no effect on the yield of milk fat during Period I. However, it increased the yield of milk fat ($p<0.05$) during the Experimental Period II.

There was a significant effect of time on all yields in Period I whereas this significance only appeared on milk and lactose yields in Period II. There was an interaction between time and group effect (Table 4.9).

The significance of the time effect and its interaction with group suggests that the significant difference between treatments was not constant with time.

Residual effect No residual effect on yields of milk, fat, protein and lactose was observed in week 1 following the cessation of concentrate feeding (Table 4.9, Figures 4.1, 4.2, 4.3 and 4.4).

Table 4.9. Yields of milk, milk fat, milk protein and milk lactose (kg/cow/day) for the two treatment groups in Periods I and II.

				Level of significance		
	PF[§]	CF[§]	SEM	Group	Time	Time*Group
Milk						
Period I	12.8	15.0	0.4	**	***	***
Period II	11.7	14.9	0.7	**	**	**
Week[Φ] 1	13.1	14.1	0.7	NS		
Milk fat						
Period I	0.623	0.685	0.033	NS	**	**
Period II	0.576	0.711	0.047	*	NS	NS
Week[Φ] 1	0.666	0.706	0.036	NS		
Milk protein						
Period I	0.446	0.580	0.020	***	**	**
Period II	0.421	0.595	0.033	***	NS	NS
Week[Φ] 1	0.491	0.540	0.026	NS		
Milk lactose						
Period I	0.639	0.765	0.033	**	***	***
Period II	0.570	0.761	0.046	**	*	*
Week[Φ] 1	0.652	0.717	0.039	NS		

§ adjusted values using initial corresponding yields as covariates

Φ Weekth after the cessation of concentrate feeding.

4.3.3 Milk Composition.

The concentration of milk fat, milk protein and milk lactose for the two treatments for the two periods are given in Table 4.10.

Concentrate feeding had no effect on milk fat and milk lactose concentrations in both periods. However, concentration of milk protein was significantly ($p<0.001$) increased by concentrate supplements in both periods. There was no interaction between time and group effects.

<u>Residual effect</u> No residual effect on milk fat and milk lactose concentration was observed a week after the cessation of concentrate feeding. However, residual effect on milk protein concentration was observed in week 1, but not in week 2 after concentrate feeding ceased (Table 4.10 and Figure 4.5, 4.6 and 4.7).

Table 4.10. Concentrations of fat, protein and lactose (%) for the two treatment groups in Periods I and II.

				Level of significance		
	PF[§]	CF[§]	SEM	Group	Time	Time*Group
Milk fat (%)						
Period I	4.89	4.79	0.15	NS	*	NS
Period II	5.04	4.94	0.20	NS	*	NS
Week[Φ] 1	5.21	5.22	0.18	NS		
Milk protein (%)						
Period I	3.53	3.99	0.09	***	*	NS
Period II	3.70	4.07	0.08	***	NS	NS
Week[Φ] 1	3.74	3.92	0.06	*		
Week[Φ] 2	3.71	3.71	0.10	NS		
Milk lactose (%)						
Period I	5.04	5.09	0.04	NS	NS	NS
Period II	5.00	5.04	0.04	NS	NS	NS
Week[Φ] 1	5.02	5.09	0.03	NS		

§ adjusted values using initial corresponding composition as covariates.

Φ Weekth after the cessation of concentrate feeding.

4.3.4 Liveweight and Body Condition Score.

The mean values for the initial liveweight, the final liveweight adjusted for initial weight, liveweight change, the initial score, the final condition score adjusted for initial score and change in condition score are given in Table 4.11.

The final liveweight was significantly ($p<0.01$) increased by the supplementation with concentrate. Both PF and CF cows gained weight but the gain in liveweight of the CF cows was significantly ($p<0.01$) higher than the PF cows. There was also a significant ($p<0.01$) difference in the final CS between the two groups. Cows with no supplement lost body condition score whereas cows with supplement gained body condition score. There was a significant ($p<0.001$) difference in changes in body condition score between the two groups (Table 4.11).

The relationship between changes in liveweight and body condition score is shown in Figure 4.8. Trends in liveweight change and body condition score change are also shown in Figures 4.9 and 4.10 respectively.

Table 4.11. Mean values and results of ANOVA for the initial and final liveweight (kg/cow), the initial and final body condition score (units), liveweight change (g/day) and condition score change (units/month) for the two treatment groups in Periods I and II.

	PF	CF	SEM	Level of sig.
Initial LW (kg)	359	347	22	NS
Final LW[$] (kg)	365	379	5	**
LW change (g/day) between initial and final LW	+122	+282	14	**
Initial CS	4.9	4.3	0.2	NS
Final CS[$]	4.4	5.2	0.2	**
CS change (CS/month)	-0.1	+0.2	0.02	***

[$]adjusted using initial weight or condition score as a covariate

Figure 4.1 Effect of concentrate supplementation on milk production throughout the experimental period

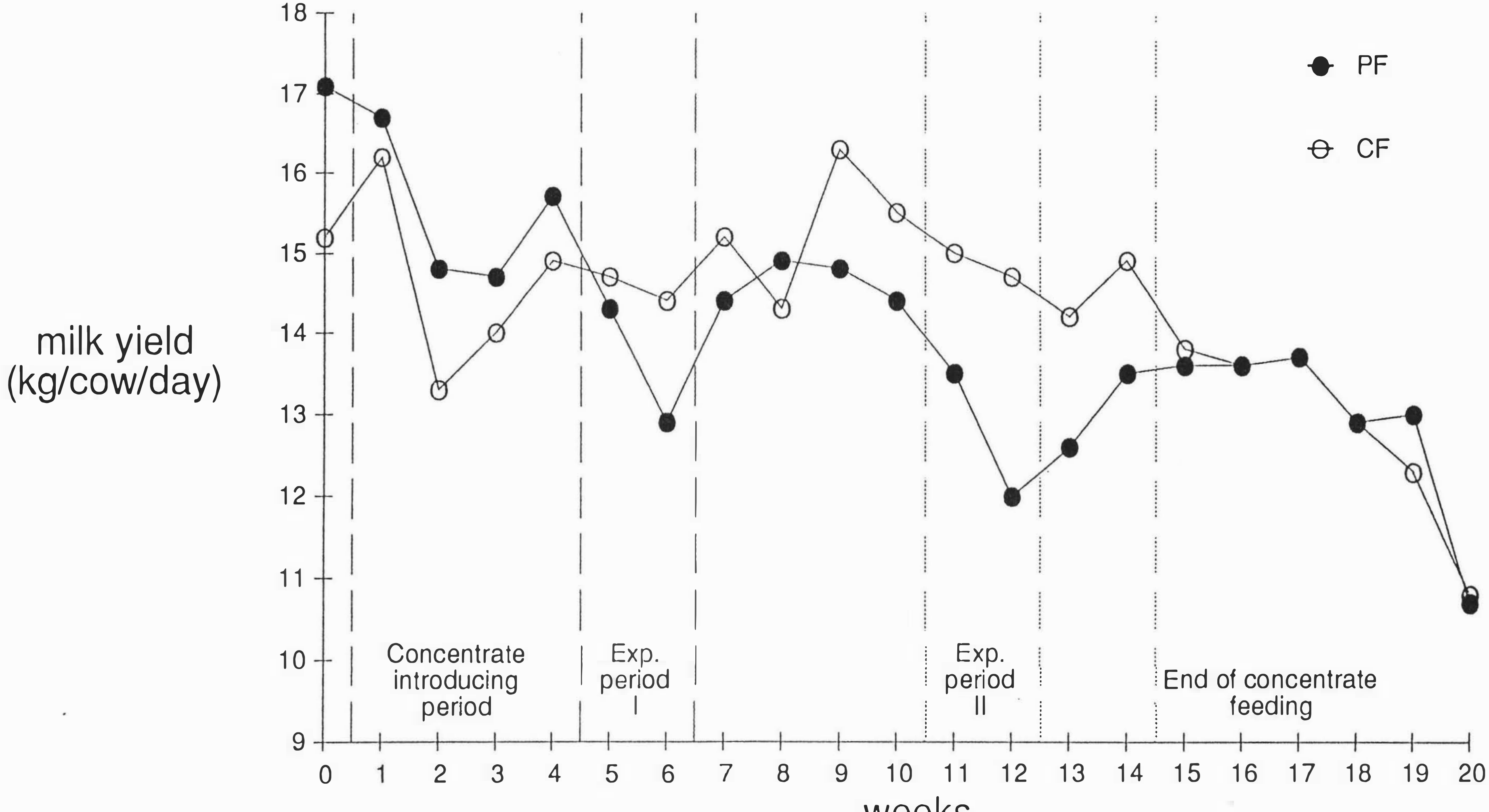


Figure 4.2 Effect of concentrate supplementation on milk fat yield

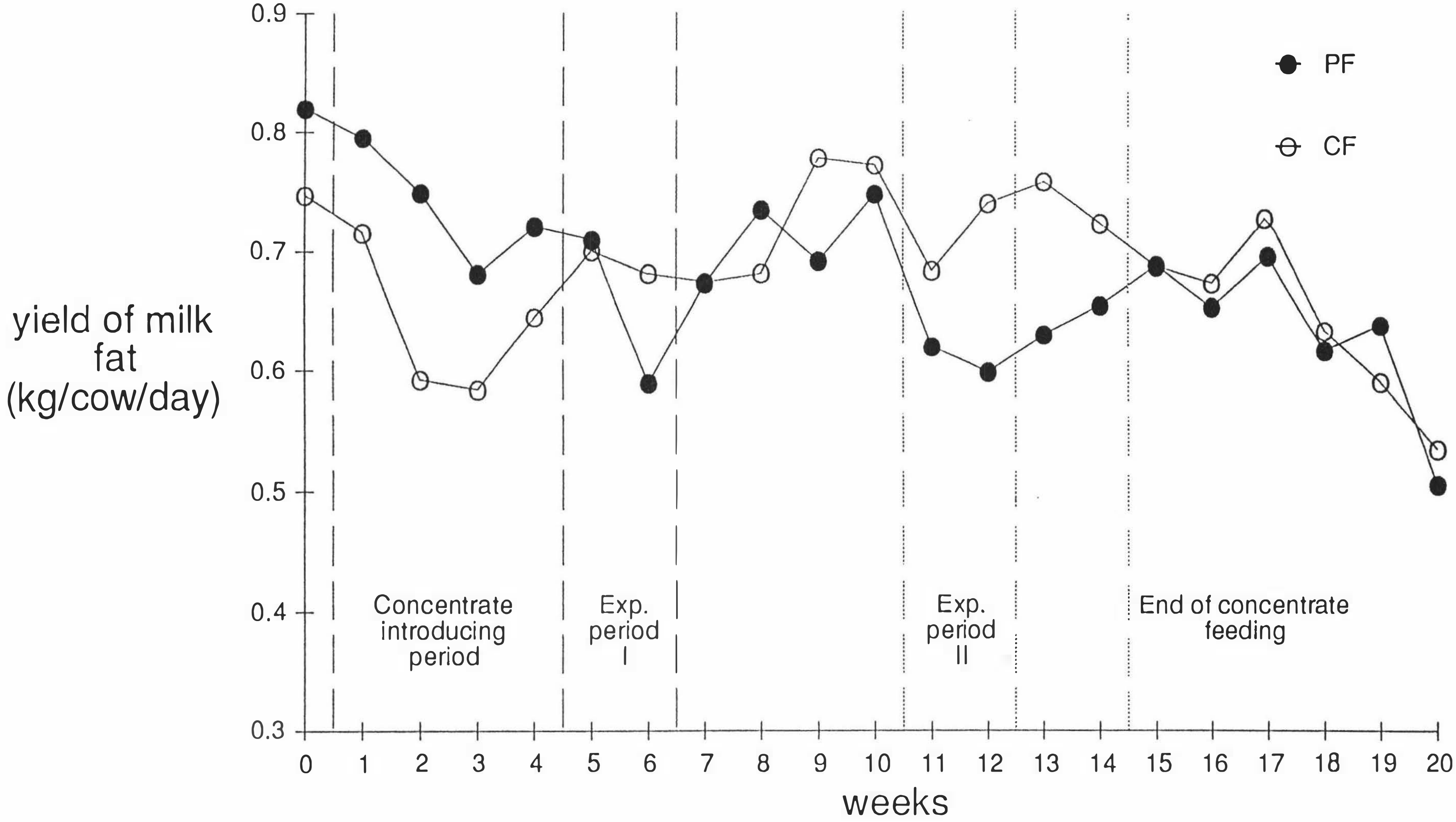


Figure 4.3 Effect of concentrate supplementation on milk protein yield

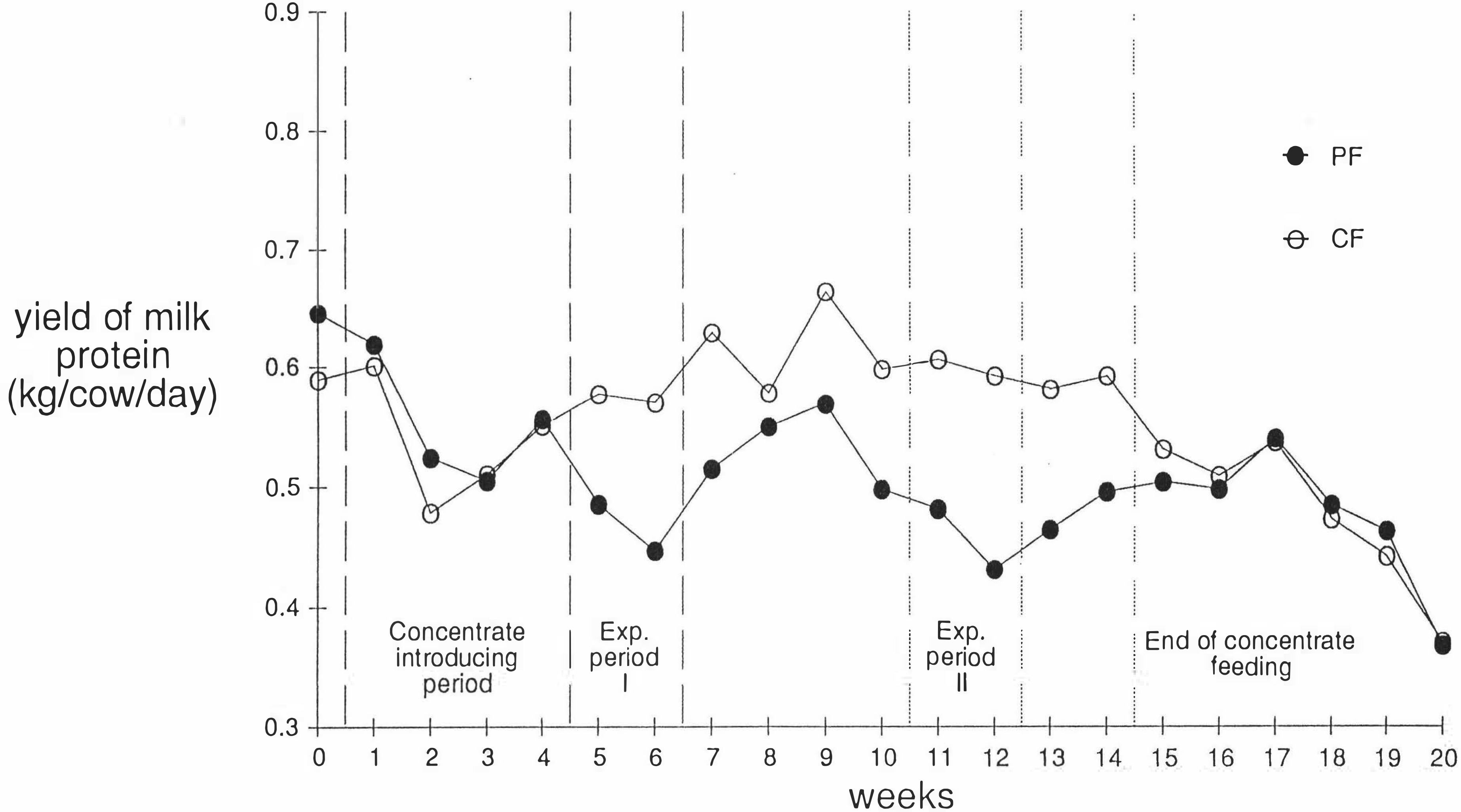


Figure 4.4 Effect of concentrate supplementation on milk lactose yield

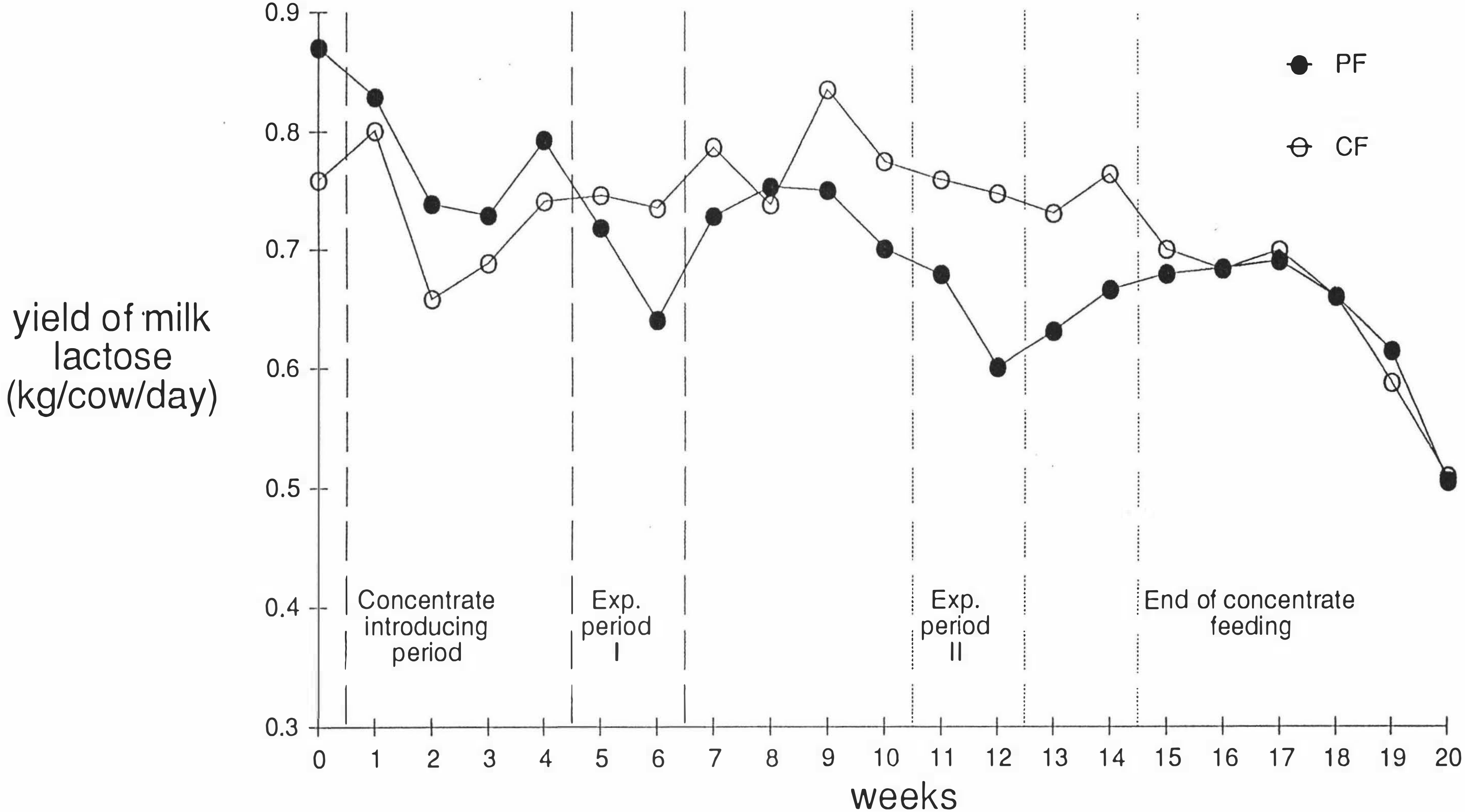


Figure 4.5 Effect of concentrate supplementation on concentration of milk fat

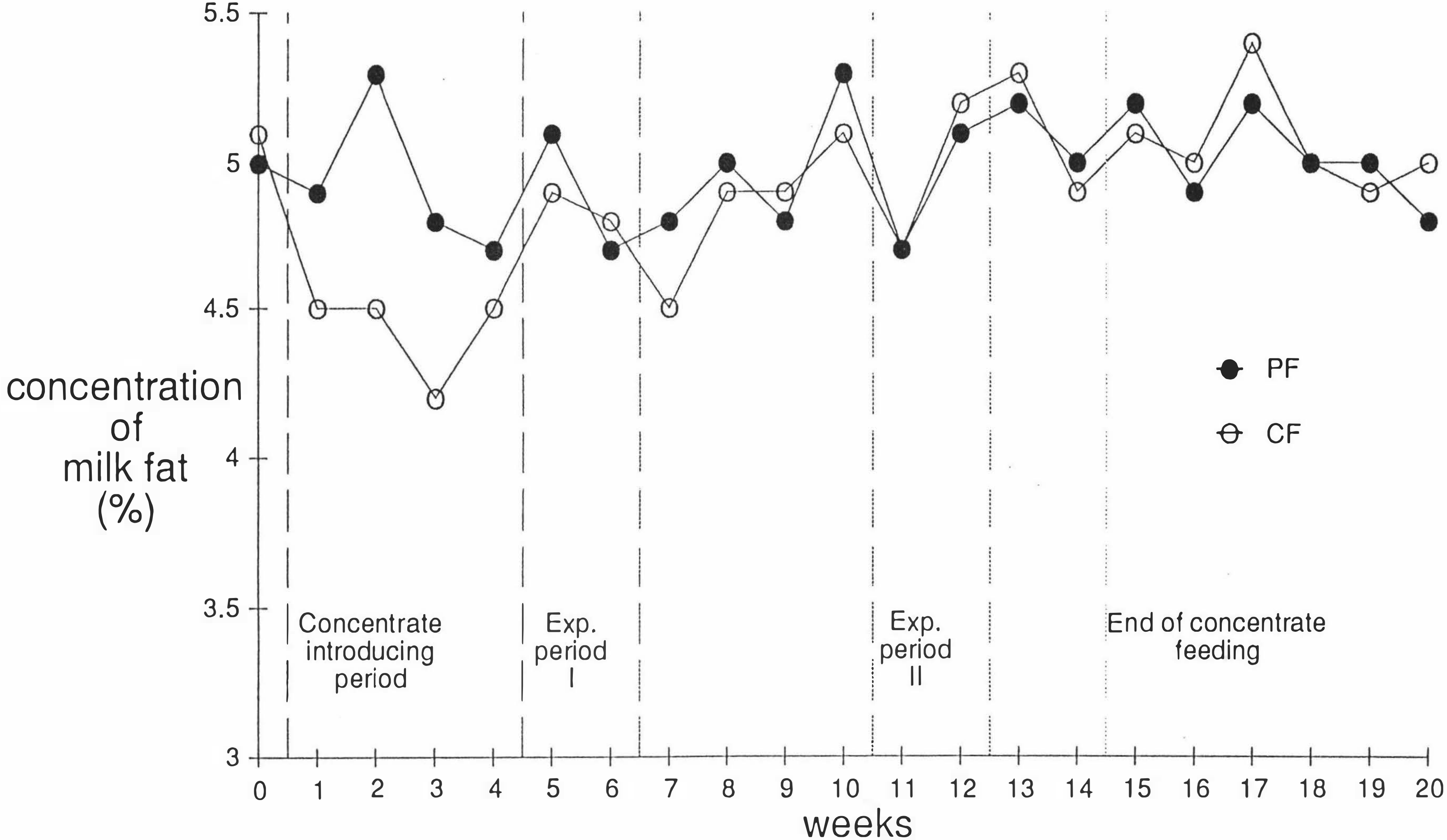


Figure 4.6 Effect of concentrate supplementation on concentration of milk protein

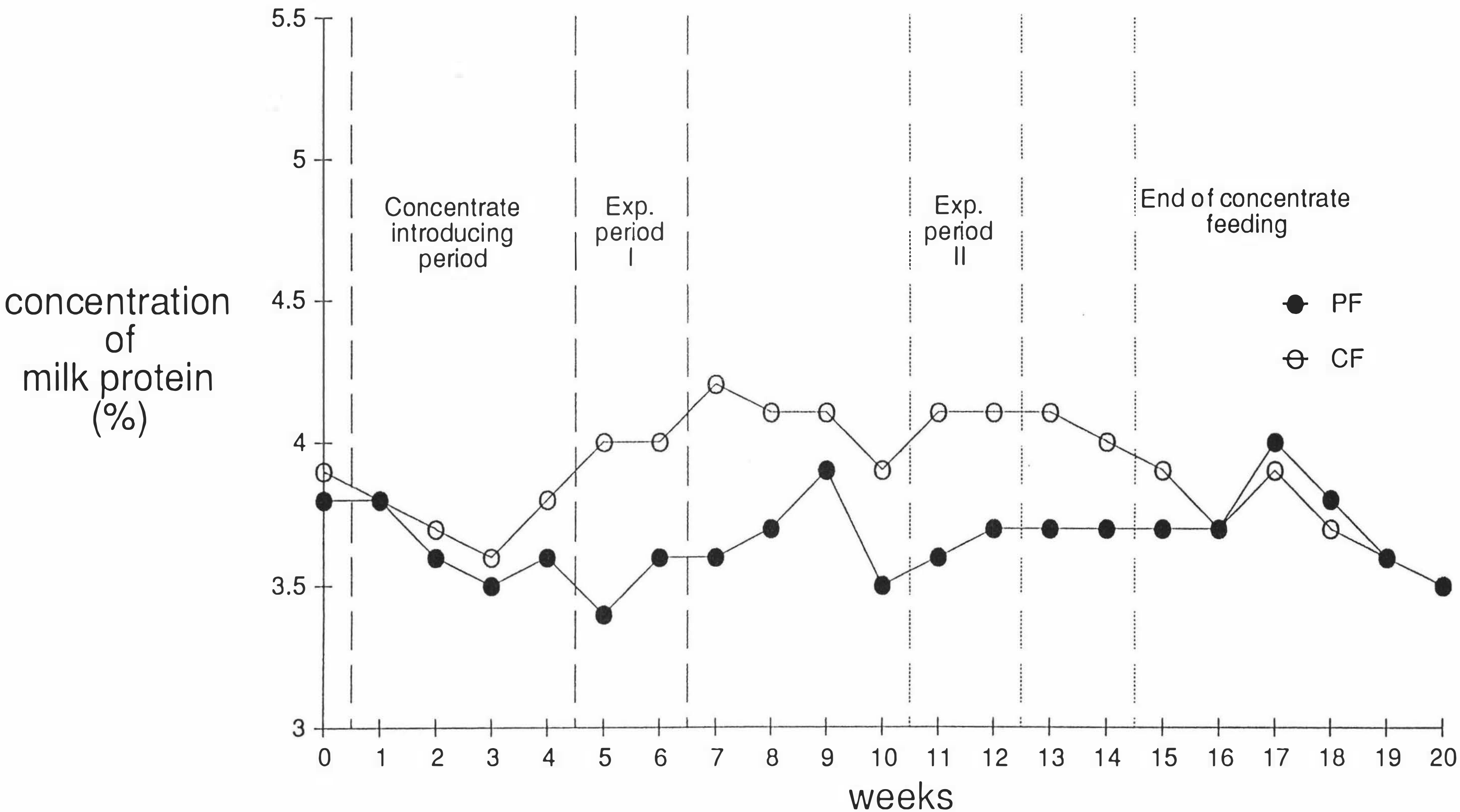


Figure 4.7 Effect of concentrate supplementation on concentration of milk lactose

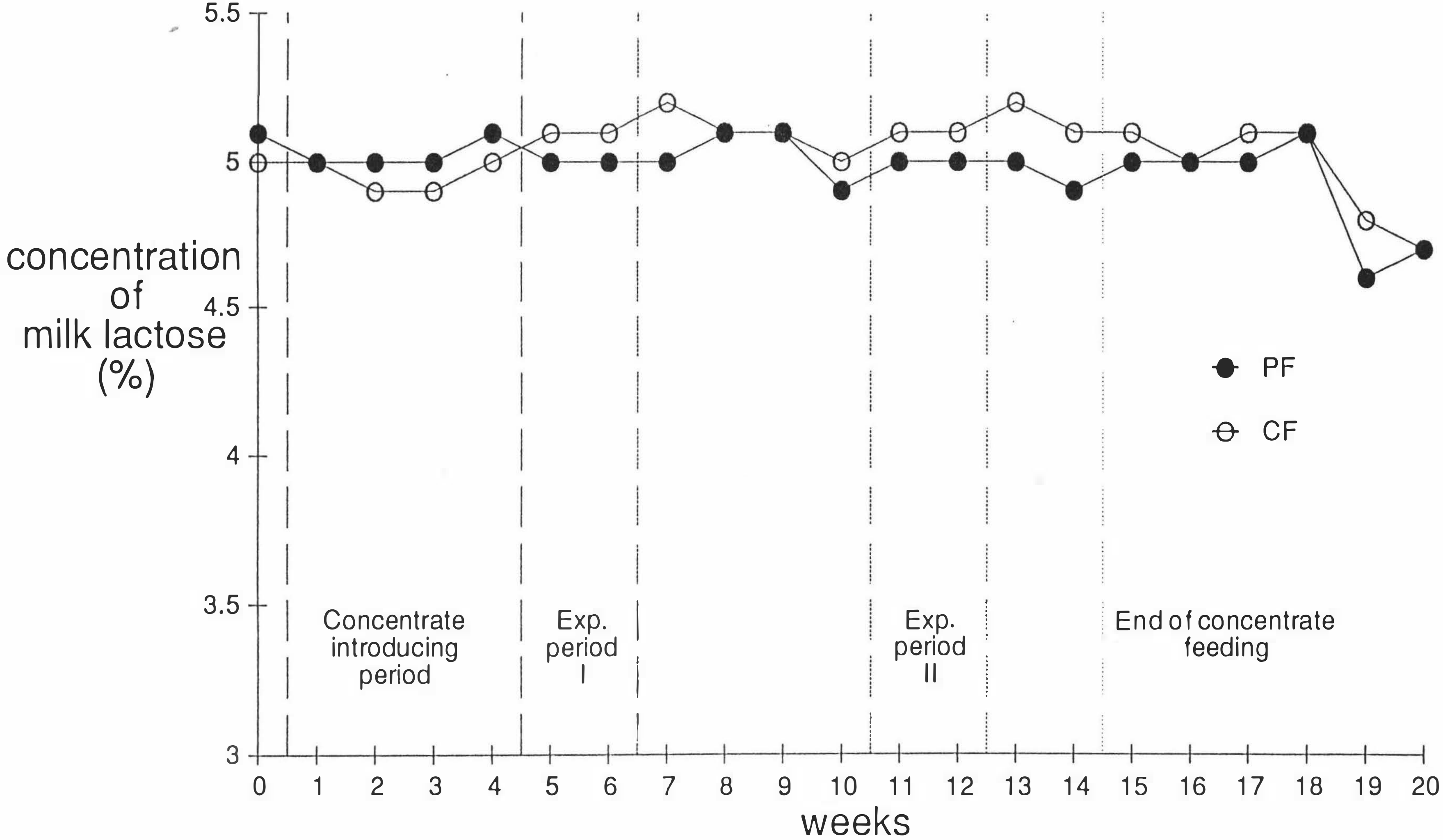


Figure 4.8 Relationship between changes in live weight and changes in body condition score over 14 weeks of experiment

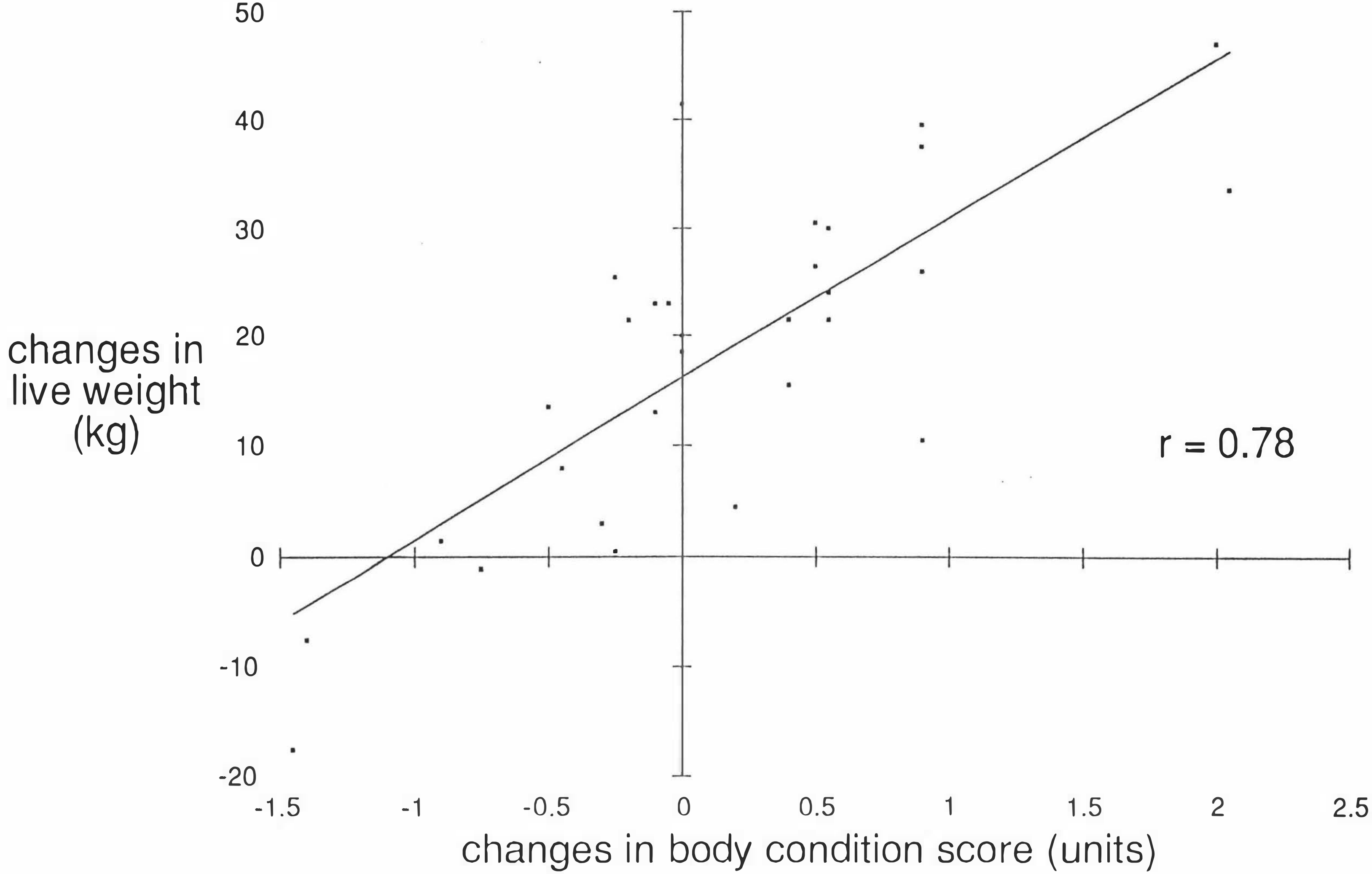


Figure 4.9 Trend in liveweight change over the experimental period

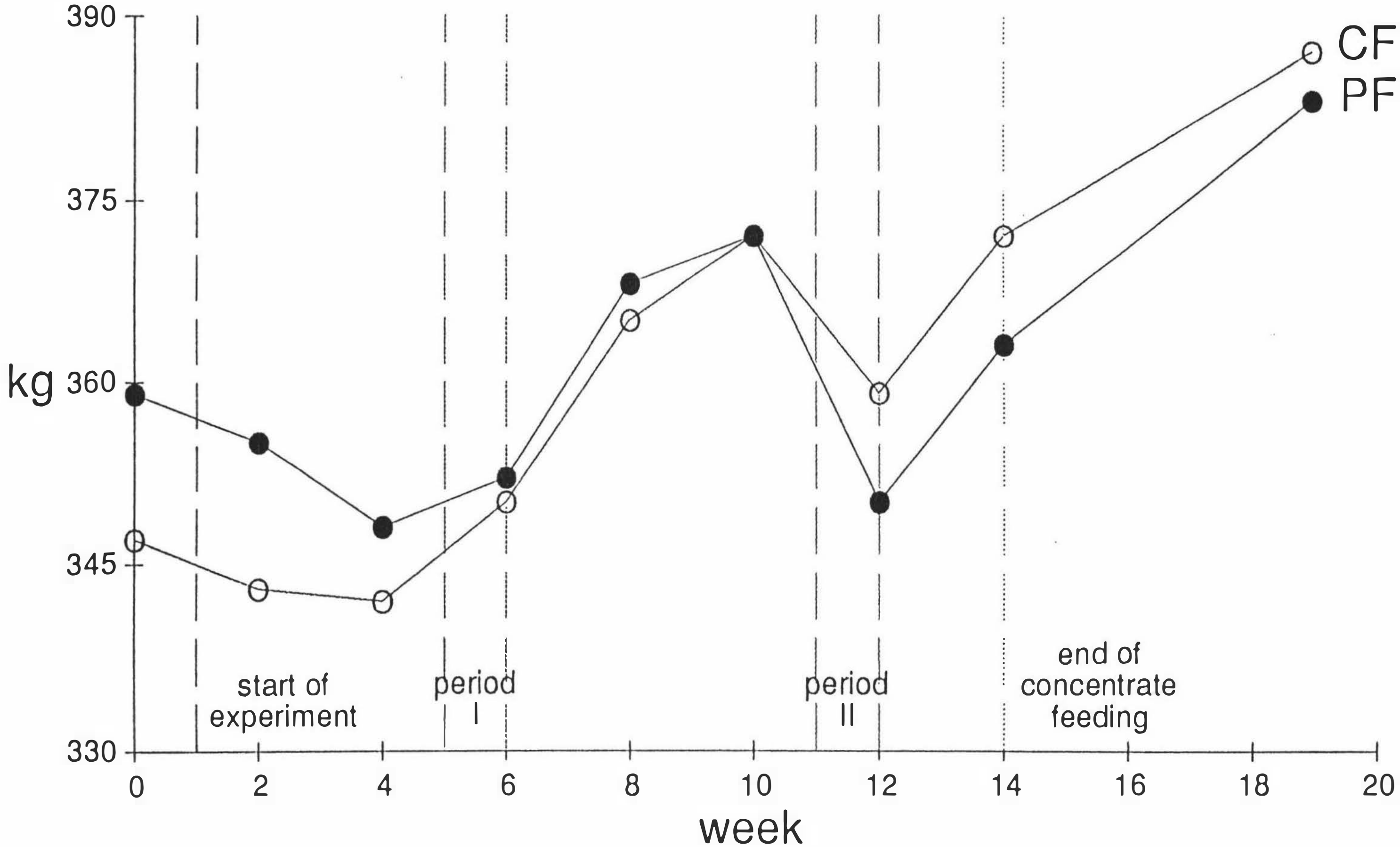
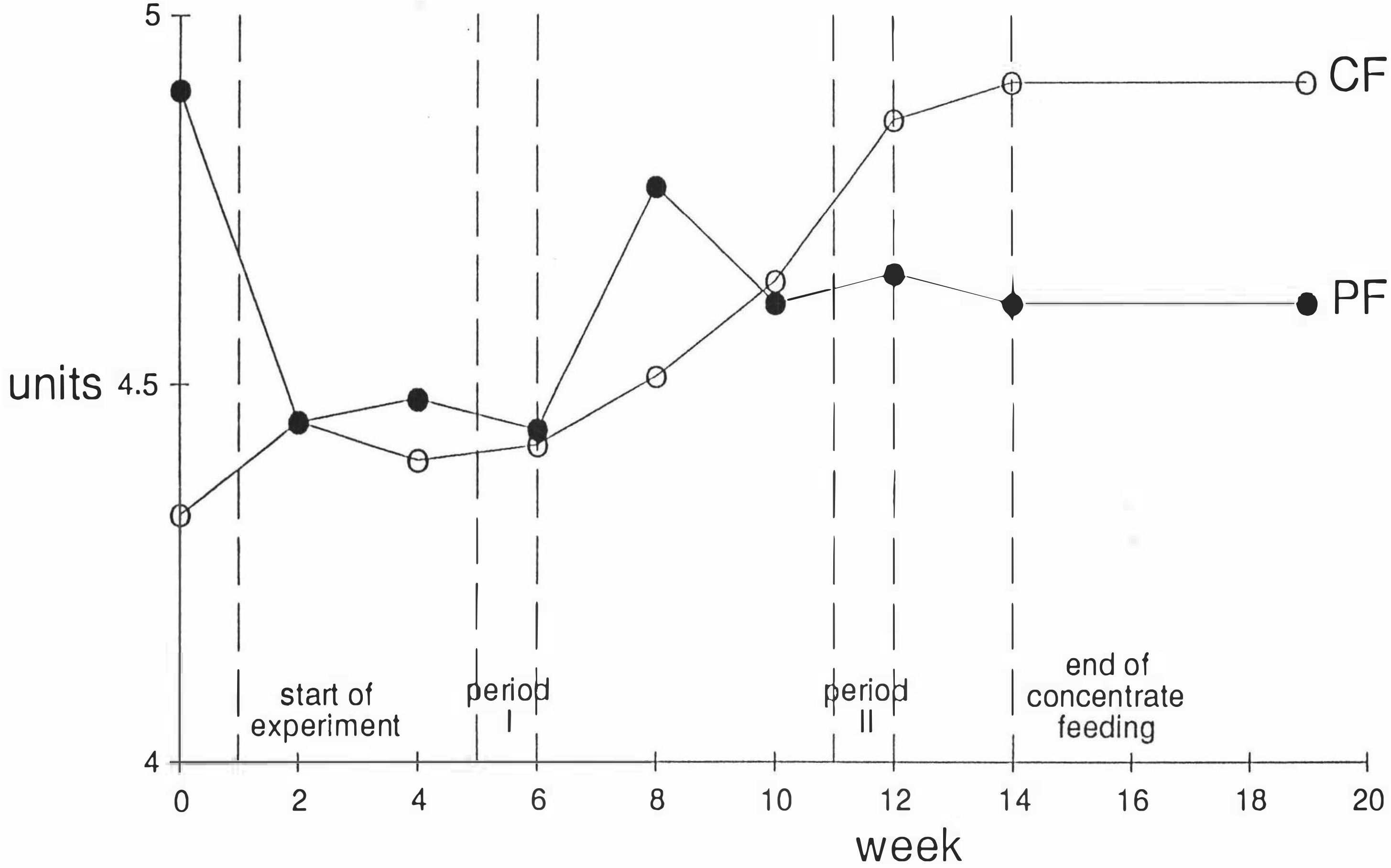


Figure 4.10 Trend in body condition score change over the experimental period



(a)

(b)

Plate 4.1 Effect of concentrate supplementation on residual herbage mass (a) unsupplemented group (b) supplemented group.

(a)

(b)

Plate 4.2 Effect of concentrate supplementation on residual herbage mass (a) unsupplemented group (b) supplemented group (closed up).

CHAPTER 5: DISCUSSION

5 DISCUSSION

5.1 EFFECT OF CONCENTRATE SUPPLEMENTATION ON HERBAGE INTAKE.

5.1.1 Measurement of Herbage Intake.

Herbage intake was measured by the sward cutting technique which also provides information on the herbage mass and allowance. The sward cutting technique had another advantage which was that the measurement technique was unaffected by concentrate supplementation, in contrast to methods based on indigestible marker technique (Milne et al.,1981). The major disadvantage of the technique was that it obtained only mean intake estimates for groups of cows, in case of group grazing as in the present study, and the labour input was high. Cutting to ground level had the advantage that no herbage could be grazed below the cutting level which resulted in an increase in accuracy of intake measurement (Meijs,1982), although sampling errors were the major determinant of accuracy.

Mean pregrazing herbage mass in Periods I and II, being 3180 and 4378 kgDM/ha (Table 4.2), could be considered to be in the range of values (2,000-4,000 kgDM/ha) within which it was suggested that DM intake was unaffected by herbage mass (Combellas and Hodgson,1979; Meijs,1981; Holmes,1987), although herbage mass in Period II was slightly higher than this range.

The higher mass (by 1,200 kgDM/ha) in Period II than in Period I can be attributed to the rapid growth rate rather than the maturity since there was no difference between the period of paddock closing (37±2 and 40±4 days in Periods I and II respectively). It is likely that higher mass in association with a reduction in digestibility (Table 4.1) reflected the maturity of pasture. However, such negative relationship may not always be caused by the period of regrowth.

A decrease in digestibility, which is regarded as one of the factors influencing intake (Hodgson et al.,1977), in Period II is probably due to a low proportion of legume to grass, a low proportion of leaf to stem or to a high proportion of dead materials. It may also be caused by the combination of these factors since all paddocks had been laxly grazed during the early period of growing season and such grazing pattern has been suggested to result in a reduction in the proportion of legume (L'Huiller,1987), in a low proportion of leaf to stem (Hall,1973; Baars et al.,1981), in a high proportion of dead materials (Hoogendoorn,1987) and, of importance, in a reduction of quality (Korte et al.,1984; Sheath and Boom,1985a,b; Hoogendoorn,1987). The apparent corresponding low values for crude protein percentage in both periods were probably reflected by these factors as well. Unfortunately, morphological and botanical composition of pasture were not determined in the present study, therefore the clear reason can not be further explained.

5.1.2 Herbage Intake and Substitution Rate.

Combellas and Hodgson (1979) reported that herbage intake of grazing cows was near maximum when grazing efficiency, defined as herbage intake expressed as a proportion of the herbage allowance, was 50% or less. Grazing efficiencies of 60% and 52% for the Periods I and II, respectively, in the present study would be likely to indicate intake restriction. In other words, herbage allowance of 20 and 25 kgDM/cow/day used in the present study are below the levels generally associated with maximum intake (Holmes,1987).

Grazing trials with lactating cows in early lactation have shown that concentrate feeding reduced herbage consumption (Jenning and Holmes,1984; Meijs and Hoekstra,1984; Arriga-Jordan and Holmes,1986; Meijs,1986; Stakelum,1986a,b,c). The substitution rates varied between 0.03 and 0.79 kgDM/kg concentrate DM eaten. The variation in substitution rates could be explained by differences in herbage digestibility, levels of concentrate feeding, restricted access to herbage causing low herbage intake. Leaver et al.(1969) reported substitution rate of 0.55 kg of herbage OM/kg concentrate OM consumed at restricted grazing with dairy cows. Meijs and Hoekstra (1984) suggested that the effect of concentrate feeding on herbage intake of grazing cows depends on the level of daily herbage allowance.

The average substitution rate found in the present study was 0.37 kgDM/kgDM concentrates (Table 4.5) and the average increase in intake was 0.69 MJME/MJME concentrate (Table 4.6). These are similar to the average values from a wide range of experiments (0.35 kgDM/kgDM concentrate and 0.79 MJME/MJME concentrate respectively, Table 5.1)

Increases in substitution rates with increasing the level of concentrate intake have been reviewed in zero grazing (Meijs,1981), although others did not found this relationship in indoor trials (Taparia and Davey,1970; Tayler and Wilkinson,1972) or in grazing trials (Meijs and Hoekstra,1984). The present study did not design to compare different levels of concentrate intake.

Meijs (1986) fed high or low quality concentrate to grazing cows in early lactation and estimated average herbage intake of unsupplemented cows of 12.05 kgDM/cow/day. Mean substitution rate when feeding 5.3 kgDM from concentrate was 0.33 which is similar to the present study. The early work of Leaver et al.(1969), in a trial comparing grazing systems in which unsupplemented cows were consuming 12.0 kg herbage OM, reported a mean substitution rate of 0.55 kg/kg concentrate with 3.64 kg concentrate fed. Intake estimates, however, were measured by animal-based techniques. Faecal output was predicted by chromic oxide feeding and digestibility of herbage intake was estimated by nitrogen regression. No allowance was made for the effect of the supplement on herbage digestibility.

Additionally, the supplemented cows were offered more herbage than the unsupplemented cows and, therefore, herbage allowance was confounded with the concentrate effect.

Meijs and Hoekstra (1984) suggested that daily herbage allowance rather than the level of concentrate consumed was the major factor determining the effect of concentrate on herbage intake of the grazing cows. They predicted increases in substitution rate from 0.11 to 0.69 when herbage allowance increased from 15 to 30 kgOM/cow/day. Similar results were obtained with concentrate feeding to grazing cows (Stakelum,1986b,c; Grainger,1987). The only supplementation trial known with strip-grazed dairy cows at a low allowance has been reported by Leaver et al.(1969) which has been mentioned earlier. The possible reasons for describing the lower subtitution rate at a low allowance have previously been given. In the present study, although the two measurement periods differed in herbage allowance, they also differed in other factors. In addition, the present experiment was not designed to determine effects of herbage allowance, therefore the effect of different allowance on substitution rate could not be compared.

5.1.3 Explanation of Reduced Herbage Intake.

The reasons for reduction in herbage intake when concentrates were fed are not fully understood. It is probable that metabolic control, physical limitation or the combination of two mechanisms may cause such reduction. However, this can probably be considered to be due to the physical control dealing with rumen capacity and rate of disappearance of digesta, and to metabolic limitation. Forbes (1983) has suggested several models for describing the effect of concentrate input upon voluntary intake of cows dealing with metabolic control and physical limitation. In the former case, he expected that concentrates would displace roughage in proportion to their ME concentration. This leads however to calculated substitution rates of greater than 1 for most typical forages, which are never seen, even with low yielding cows. Reduction in herbage intake in the present study is unlikely to be caused by metabolic control since the apparent ME intake by the CF cows was greater than their calculated ME requirements, (with requirements for maintenance, milk production and liveweight gain included, Table 5.5).

When physical limitation is considered, which is nearly always the case of grazing cows, Forbes (1983) suggested that concentrates would displace forage in the proportion to the space occupied by the two feeds and also suggested that the best readily available is cell wall contents, neutral detergent fibre. Using the typical value of 250 and 650 g/kgDM for concentrates and forage respectively (Forbes,1983), this gives a substitution rate of 0.38, which is similar to the values recorded in the present study. The reduction in herbage intake in the present study is more likely to be caused by physical limitation.

Table 5.1. Changes in intake of pasture and residual herbage mass per unit of additional Hay, Silage and Concentrate expressed as kgDM / kg supplement DM, MJME / MJME supplement or kgDM/ha by grazing cows.

Details	HA^*	I_s^*	I_h^*	S_r^*	$\Delta TDMI^*$	$\Delta TMEI^*$	ΔRHM^*
Hay							
Eldridge and	Low	2.1	5.7	0.10	+0.90	+0.76	-
Kat (1980)	High	2.4	4.3	0.50	+0.50	+0.38	-
Dry cows							
Stockdale *et al*.	22.4	5.7	7.9	0.32	+0.67	-	+310
(1981)	34.1	4.3	10.3	0.27	+0.73	-	+470
Early lact.							
Phillips and E	Low	1.5	13.4	0.40	+0.60	+0.47	-
Leaver (1985a)	High	1.3	14.0	0.15	+0.85	+0.80	-
Two stocking M	Low	1.7	12.2	0.76	+0.24	+0.07	-
rates.	High	1.5	12.2	0.47	+0.53	+0.43	-
Set stocking. L	Low	1.8	9.1	0.22	+0.78	+0.75	-
	High	1.6	10.0	0.00	+1.00	+0.93	-
Wills and Holmes	9.1	5.0	8.1	0.28	+0.72	+0.54	+387
(1988) Dry cows	13.4	5.0	10.5	0.40	+0.60	+0.35	+387
MEAN (Hay)	19.7	2.8	9.8	0.32	+0.68	+0.55	+388

Silage							
Bryant (1978)	20.0	8.8	7.5	0.36	+0.64	+0.70	+560
Wilted, Mid	20.0	7.8	7.5	0.36	+0.64	+0.70	+490
lactation.							
Bryant and Trigg	15.0	2.1	8.8	0.33	+0.67	+0.67	+170
(1982), Wilted,	15.0	4.0	8.8	0.42	+0.58	+0.58	+390
Early lact.							
Phillips and E	-	1.7	12.5	1.30	-0.30	-0.50	-
Leaver (1985b)	-	4.0	12.5	0.85	+0.15	0.00	-
Set stocking,	-	5.8	12.5	0.91	+0.09	-0.06	-
Same HA at L	-	4.1	10.2	0.68	+0.32	+0.32	-
same period.	-	10.4	10.2	0.73	+0.27	+0.27	-
MEAN (Silage)	17.5	5.4	10.0	0.66	+0.34	+0.30	+402
Concentrate							
Sarker and Holmes	-	4.0	9.9	0.57	+0.43	-	-
(1974) Dry cows.	-	6.0	9.9	0.47	+0.53	-	-
	-	8.0	9.9	0.43	+0.57	-	-
Jenning and	Low	4.0	12.6	0.03	+0.97	+0.97	-
Holmes (1984),	Low	4.0	12.6	0.13	+0.87	+0.88	-
Two concentrate	High	5.0	12.0	0.15	+0.85	+0.85	-
energy.	High	5.0	12.0	0.32	+0.68	+0.70	-

Meijs and	16.2	2.4	11.1	0.06	+0.94	-	-
Hoekstra (1984)	24.6	2.4	14.6	0.37	+0.63	-	-
Two Exps.Two HA.	16.4	3.2	11.6	0.08	+0.92	-	-
Early lact.	24.3	3.2	15.1	0.79	+0.21	-	-
	17.3	3.9	11.1	0.10	+0.90	-	-
	24.7	3.8	14.6	0.70	+0.30	-	-
	16.2	5.6	11.6	0.21	+0.79	-	-
	24.0	5.6	15.1	0.65	+0.35	-	-
Stockdale and	16.0	1.8	8.0	0.00	+1.00	-	+50
Trigg (1985)	25.8	1.8	10.6	0.94	+0.06	-	+320
	14.9	3.6	8.0	0.00	+1.00	-	-110
	26.6	3.5	10.6	0.43	+0.57	-	+320
	15.2	6.3	8.0	0.23	+0.77	-	+460
	26.3	6.2	10.6	0.30	+0.70	-	+330
Arriga-Jordan	CG	6.0	18.1	0.36	+0.64	+0.64	-
and Holmes	SG	6.0	15.3	0.13	+0.87	+0.86	-
(1986) Two							
grazing systems.							
Meijs (1986),	28.0	5.4	11.5	0.45	+0.55	+0.60	-
High or Low	28.0	5.3	12.6	0.21	+0.79	+0.81	-
Stakelum (1986a)	14.3	3.2	12.8	0.59	+0.41	-	+291
Late lact.	21.3	3.2	16.9	0.28	+0.72	-	+338

Stakelum (1986b)	13.6	3.5	12.2	0.37	+0.63	-	-
Early lact.	20.5	3.7	15.4	0.43	+0.57	-	-
Stakelum (1986c)	14.6	3.8	11.9	0.33	+0.67	-	-
Mid lact.	21.9	3.8	15.1	0.68	+0.32	-	-
Grianger (1987)	8.0	3.2	6.1	0.00	+1.00	-	+9
	17.0	3.2	11.8	0.27	+0.73	-	+124
	33.0	3.2	15.9	0.69	+0.31	-	+111
MEAN (Concs)	20.3	4.2	12.2	0.35	+0.65	+0.79	+245
Present study	19.5	6.7	11.8	0.27	+0.76	+0.77	+264
	23.6	6.7	12.2	0.48	+0.56	+0.61	+399
MEAN	21.5	6.7	12.0	0.37	+0.65	+0.69	+331

*HA Daily herbage allowance (kgDM/cow/day).

I_s Supplement intake (kgDM/cow/day).

I_h Herbage intake (kgDM/cow/day) by unsupplemented cows.

S_r Substitution rate (kgDM/kgDM supplement consumed).

ΔTDMI Change in total DM intake (kgDM/kgDM supplement consumed)

ΔTMEI Change in total ME intake (MJME/MJME supplement consumed)

ΔRHM Change in residual herbage mass (kgDM/ha).

5.1.4 Effect on Residual Herbage Mass.

RHM was increased by concentrate feeding although the increases (264 and 399 kgDM/ha in Periods I and II respectively) were not statistically significant. Since RHM is the consequence of the difference between pregrazing herbage mass and herbage intake, increases in RHM in both periods were presumably caused by reductions in herbage intake due to concentrate supplementation. This effect of supplementation on RHM had been observed by several workers as shown in Table 5.1, for different type of supplements and for different physiological stage of the animals.

Stakelum (1986a), at allowances of 14.3 and 21.3 kgDM/cow/day, reported substitution rates of 0.55 and 0.28 kgDM/kg concentrate DM and consequently supplemented cows left 291 and 338 kgDM/ha higher than unsupplemented cows respectively. A comparable finding was reported by Stockdale and Trigg (1985) for the high allowance (26 kgDM/cow/day), with 1.8, 3.6 and 6.3 kgDM concentrate supplementation. The results of the present study corresponded very well with the above trials.

It can be considered that the change in RHM depends on the change in herbage intake (kgDM/cow) and the stocking rate (cows/ha). For example, in Period I, change in herbage intake was 1.8 kgDM/cow and the number of cows/ha was 163. Using these values, it can be calculated the change in RHM of 293 kgDM/ha which closes to the value obtained from sward cutting technique (264 kgDM/ha, Table 4.5). Similar calculation can also be done for Period II.

Supplementation with concentrate caused pasture sparing effect, which might be utilised at a later grazing. Supplemented cows in the present study left 264 and 399 kgDM RHM/ha in Periods I and II respectively greater than unsupplemented cows, when the amount of concentrate consumed was 1092 and 1240 kgDM/ha in Periods I and II respectively. From the above figures, substitution rate can be calculated as 264/1092 = 0.24 and 399/1240 = 0.32 kgDM/kg concentrate DM consumed for Periods I and II respectively. The amount of RHM left due to supplementation represents an average 3450 MJ ME/ha. If all RHM left would subsequently be utilised, approximately 690 kg of milk or approximately 100 kg of gain would be produced from that amount of RHM/ha. However such RHM is not always utilised and the pasture may become aged and be of low quality.

In addition to an increase in RHM due to concentrate supplementation, there was also an evidence that feeding of concentrates might allow a farm to have a higher stocking rate (Hutton,1966). In Hutton's trial supplementation with 1250 kgDM concentrate per hectare during early lactation allowed stocking rate to increase from 3.75 cows/ha to 5 cows/ha without any effect on per cow production but milk fat per hectare was increased from 470 kg to 616 kg over the whole lactation period of 37 weeks.

The increase in RHM due to concentrate supplementation could increase the amount of pasture growth in the subsequent period (Brougham,1970; Hoogendoorn,1987) due to a higher leaf area index (LAI). However a higher herbage mass would result in swards having a greater percentage of reproductive tillers during the experimental period (spring), and thus a greater percentage of stem and consequently a greater percentage of scenescent matter, all of which would reduce the quality of herbage (Hoogendoorn,1987). The recommended level of RHM which not only give a reasonable net herbage accumulation rate but give a high leafy, quality pasture in spring and subsequent period, notably early summer, was approximately 1600 kgDM/ha (Hoogendoorn,1987) while the 2200 kgDM/ha suggested by Thomson (1985) seems rather high. In the present study the RHM of the CF treatment in Period I was close to Hoogendoorn recommended level (1569 kgDM/ha) but in Period II it was much greater (2650 kgDM/ha) which would result in swards having a low quality in the subsequent period.

Supplementation reduced the degree of defoliation by 12 and 13% in Periods I and II respectively, following the trend reported by Bryant and Trigg (1982) and Stockdale and Trigg (1985), although this effect was also influenced by the level of feeding, type of supplement and type of animal, reflecting the level of substitution of supplement for herbage.

5.2 EFFECT OF CONCENTRATE SUPPLEMENTATION ON MILK PRODUCTION AND COMPOSITION.

5.2.1 Milk Yield

The prime objective of the present study was to determine the effect of concentrate supplementation on animal performance. Although most experiments have always reported the response in terms of kg milk per kg concentrate DM eaten (Table 5.2), the response in terms of kg milk per kg extra DM eaten will also be included in the present study (Table 5.4) since it will give a measure of the response which can be interpretted in biological terms.

Concentrate supplementation increased yields of milk and its constituents in the present study, except for fat yield in Period I. Cows consumed similar amount of concentrates of 6.7 kgDM produced 17% and 27% more milk than unsupplemented cows, in Periods I and II respectively. The mean response to 1 kgDM concentrate consumption was 0.33 and 0.48 kg milk in Periods I and II respectively (average 0.40 kg of milk per kg concentrate DM, Table 4.9), which were in the range of responses reported by Leaver *et al.*(1968) and those summarised in Table 5.2 (0.32 and 0.68 kg milk/kgDM concentrate respectively). In the experiments reviewed by Leaver *et al.*(1968) the mean response in milk yield was 0.32 kg/kg increase in concentrate DM. Journet and Demarquilly (1979) reviewed ten experiments where cows were initially yielding over 25 kg/day milk, and showed the mean response in milk yield of 0.4 kg milk/kg of additional concentrate. The present results are generally similar to those reported in the literature.

Table 5.2 Change in yields of milk (kg/kgDM supplement) and its constituents (grm/kgDM supplement) per unit of additional Hay, Silage or Concentrate to grazing cows.

Reference and Exp. details	HA*	I_h*	I_s*	I_t*	S_r*	Responses			
						Milk	Fat	Prot.	Lact.
Hay								SNF	
Stockdale	30	9.4	1.2	9.1	1.25	-0.83	+29	-28	
et al.(1981)	29	9.4	2.8	9.5	0.96	-0.07	+4	-5	
Early lact.	25	8.3	5.3	12.3	0.24	0.00	+12	+7	
	22	7.9	7.0	13.0	0.27	+0.10	+4	+6	
	15	6.8	8.2	12.6	0.29	+0.56	+17	+49	
	14	6.9	9.2	13.4	0.28	+0.14	-3	+10	
Phillips E	HSR	13.4	1.5	14.3	0.40	+0.93	-	-	-
and Leaver	LSR	14.0	1.3	15.1	0.15	+0.92	-	-	-
(1985a) M	HSR	12.2	1.7	12.6	0.76	+1.12	-	-	-
	LSR	12.2	1.5	13.0	0.47	+0.40	-	-	-
L	HSR	9.1	1.8	10.5	0.22	+0.61	-	-	-
	LSR	10.0	1.6	11.7	0.00	+0.37	-	-	-
MEAN (Hay)	23	10.0	3.6	12.3	0.44	+0.35	+10	+6	
Silage									
Bryant (1978)	20	7.5	8.8	13.1	0.36	-	+19	-	-
Wilted	20	7.5	7.8	12.5	0.36	-	+20	-	-

Bryant and	E	15	8.8	2.1	10.2	0.33	+0.29	+29	+4	+15
Trigg (1982)		15	8.8	4.0	11.1	0.42	+0.45	+23	+17	+26
Phillips	E	-	12.5	1.7	12.0	1.30	-0.18	+8	-5	-8
and Leaver		-	12.5	4.0	13.1	0.85	-0.25	+7	-11	-11
(1985b)		-	12.5	5.8	13.0	0.91	-0.17	+6	-6	-8
	L	-	10.2	4.1	11.5	0.68	+0.15	+8	+6	+8
		-	10.2	10.4	13.0	0.73	+0.04	+6	+1	+3
MEAN (Silage)		-	10.0	5.4	12.2	0.66	+0.05	+14	+1	+4
Concentrate										SNF
Jenning and		HSR	12.6	4.0	16.5	0.03	+0.52	+13		+46
Holmes (1984)			12.6	4.0	16.2	0.13	+0.67	+14		+52
Early lact.		LSR	12.0	5.0	16.4	0.15	+0.42	+18		+36
Set stocking			12.0	5.0	15.7	0.32	+0.48	+4		+43
Arriga-Jordan		33	18.1	6.0	21.2	0.36	+0.52	+3		+43
and Holmes		22	15.3	6.0	19.4	0.13	+0.50	+5		+45
(1986)										
Stockdale and		15	8.0	1.8	9.9	0.00	+1.60	+72	+72	-
Trigg (1985)		26	10.6	1.8	10.7	0.94	+1.20	+56	+28	-
Late lact.		15	8.0	3.6	11.6	0.00	+0.78	+42	+33	-
		26	10.6	3.6	12.6	0.43	+0.83	+37	+31	-
		15	8.0	6.3	12.8	0.23	+0.70	+19	+22	-
		26	10.6	6.2	14.9	0.30	+0.55	+24	+24	-

Stakelum	M	14	12.8	3.2	15.1	0.59	+0.61	+17	+21	-
(1986a)		21	16.9	3.2	18.2	0.28	+0.22	+2	+11	-
Stakelum	E	14	12.2	3.5	14.4	0.37	+0.28	-	+19	-
(1986b)		21	15.4	3.7	17.5	0.43				
Stakelum	L	15	11.9	3.8	15.1	0.33	+0.50	-	+16	-
(1986c)		22	15.1	3.8	16.8	0.68				
Grainger		8	6.1	3.2	9.3	0.00	+0.97	-	-	-
(1987)		17	11.8	3.2	14.2	0.27	+0.69	-	-	-
Early lact.		33	15.9	3.2	16.9	0.69	+0.31	-	-	-
MEAN (Conc.)		20	12.2	4.0	15.0	0.32	+0.68	+23	+28	-
Present study		20	11.8	6.7	16.7	0.27	+0.33	+9	+20	+19
		24	12.2	6.7	15.7	0.48	+0.48	+20	+26	+28
MEAN		22	12.0	6.7	16.2	0.37	+0.40	+14	+23	+23

* As in Table 5.1 and

I_t = Total intake of supplemented cows (kgDM/cow/day).

However, when the response in the present study is expressed in terms of kg extra milk produced per kg extra DM eaten, this represents 0.45 and 0.92 kg of milk/kg extra feed DM eaten in Periods I and II respectively, being an average of 0.68 kg milk/kg extra DM, which is slightly lower than a mean response summarised in Table 5.4 (0.87 kg milk/kg extra DM eaten).

The relatively small response in milk yield to supplementary concentrates when expressed as kg milk/kg concentrate DM eaten, compared with response from extra feed DM eaten which was reported in the present study (Table 4.9) and in most experiments (Table 5.2 and 5.4) was probably due to the fact that when concentrates were eaten the intake of herbage decreased so that the animal's total intake of DM was increased by less than the quantity of concentrates eaten. This effect may be seen in the results of experiments summarised in Table 5.1. When the mean concentrate supplement DM of 4.2 kg was given to grazing cows and the mean substitution rate was 0.35 kgDM herbage/kgDM supplement, the total intake of DM by the cows increased only 2.7 kgDM, representing 0.61 kg increase in total DM intake/kgDM supplement. Compared with those experiments summarised in Table 5.1, the average total DM intake of supplemented cows increased by 4.2 kg, representing 0.65 kg increase in total DM intake/kgDM concentrate, when 6.7 kgDM of concentrates were consumed in the present study.

Table 5.3 Changes in concentrations of milk constituents (%), liveweight (grm/kgDM supplement) and body condition score (units/month) per unit of additional Hay, Silage or Concentrate to grazing dairy cows.

Reference and Exp. details	I_s*	I_t*	Responses: %fat	%pro.	%lac.	LW change	CS change
Hay				SNF			
Stockdale	1.2	9.1	+0.47	+0.37		-342	-
et al.(1981)	2.8	9.5	+0.08	+0.08		-117	-
Early lact.	5.3	12.3	+0.07	+0.05		-29	-
	7.0	13.0	0.00	-0.02		+51	-
	8.2	12.6	-0.04	-0.01		+12	-
	9.2	13.4	-0.05	-0.01		+66	-
Phillips	1.5	14.3	-	-	-	+40	-0.01
and Leaver	1.3	15.1	-	-	-	+46	+0.04
(1985a)	1.7	12.6	-	-	-	-159	+0.01
	1.5	13.0	-	-	-	+27	+0.04
	1.8	10.5	-	-	-	+33	+0.04
	1.6	11.7	-	-	-	+200	+0.11
MEAN (Hay)	3.6	12.3	+0.09	+0.08		-14	+0.04

Silage							
Bryant (1978)	8.8	13.1	-	-	-	+83	-
Wilted	7.8	12.5	-	-	-	+70	-
Bryant and	2.1	10.2	+0.02	-0.02	0.00	+167	-
Trigg (1982)	4.0	11.1	-0.01	+0.01	+0.01	+275	-
Phillips and	1.7	12.0	+0.08	+0.01	0.00	-135	-
Leaver	4.0	13.1	+0.08	-0.01	0.00	+37	-
(1985b)	5.8	13.0	+0.06	0.00	0.00	+3	-
	4.1	11.5	0.00	0.00	+0.02	+83	-
	10.4	13.0	+0.03	0.00	+0.01	+68	-
MEAN (Silage)	5.4	12.2	+0.04	0.00	0.00	+73	-
Concentrate				SNF			
Jennings and	4.0	16.5	-0.03	0.00		+100	-
Holmes(1984)	4.0	16.2	-0.04	-0.02		+132	-
Early lact.	5.0	16.4	0.00	0.00		+104	-
Set stocking	5.0	15.7	-0.08	0.00		+70	-
Arriga-Jordan	6.0	21.2	-0.05	0.00		+1	+0.01
and Holmes	6.0	19.4	-0.04	+0.01		+2	+0.03
(1986)							

Stockdale and	1.8	9.9	-0.12	+0.15	-	+51	-
Trigg 1985)	1.8	10.7	-0.04	-0.09	-	-56	-
Late lact.	3.6	11.6	+0.11	+0.07	-	+239	-
	3.5	12.6	-0.04	+0.03	-	+111	-
	6.3	12.8	-0.12	+0.08	-	+225	-
	6.2	14.9	-0.04	+0.06	-	+8	-
Stakelum	3.2	15.1	-0.10	-0.02	-	-	-
(1986a)	3.2	18.2	-0.07	+0.03	-	-	-
Stakelum	3.5	14.4	-	+0.05	-	+67	-
(1986b)	3.7	17.5					
Stakelum	3.8	15.1	-	0.00	-	-	-
(1986c)	3.8	16.8					
MEAN (Conc.)	4.0	15.0	-0.05	+0.04	-	+93	+0.02
Present study	6.7	16.7	-0.01	+0.07	+0.01	-	-
	6.7	15.7	-0.01	+0.05	+0.01	-	-
MEAN	6.7	16.2	-0.01	+0.06	+0.01	+24	+0.05

* As in Table 5.1

An animal's response to supplementary feeding has been shown to depend largely on the overall feeding level and on the initial herbage intake of unsupplemented cows (Leaver *et al*.,1968; Bryant,1978; Stockdale *et al*.,1981; Bryant and Trigg,1982; Stockdale and Trigg,1985; Phillips and Leaver,1985a,b; Stakelum,1986a; Grainger,1987). Jennings and Holmes (1984) reported the mean response in milk yield of 0.5 kg to 1 kgDM concentrate feeding where unsupplemented cows consumed average 12.3 kgDM of herbage and the mean total DM intake of supplemented cows was 16.2 kg. At comparable herbage DM intake of unsupplemented cows of 12 kg and total DM intake of supplemented cows of 16.2 kg, the mean response in milk yield to concentrate supplementation in the present study was 0.4 kg milk/kgDM concentrate.

However, when the responses are expressed in terms of kg milk/kg *extra* DM eaten, the response in the present study is similar to those of Jennings and Holmes (1984), representing 0.68 and 0.60 kg of milk per kg *extra* DM consumed for the former and the latter respectively.

At a comparable supplement consumption, response has been shown to be greater at low than at high allowance of herbage (Stakelum,1986,a; Grainger,1987). Grainger (1987) observed the response of 0.97 kg milk/kg concentrate DM at very low herbage allowance of 8 kgDM/cow/day, compared with a response of 0.31 kg milk/kgDM concentrate observed at an allowance of 33 kgDM/cow/day. Greater responses, of more than 1 kg milk/kg concentrate DM, have observed by Gordon (1979), and Le Du and New Berry (1982), at very low allowances. Increases in milk yield to concentrates may be larger at low allowances than at higher allowances when expressed as kg milk/kg concentrate eaten (Grainger,1987; see Table 5.2). However when expressed as kg milk/kg extra feed DM eaten, the difference in responses between different herbage allowances may be small. This is due to differences in substitution rate at different levels of herbage allowance. The differences in level of herbage allowance in the present study were imposed at different periods, therefore, milk response between periods could not be compared.

Although a high concentrate supplement was consumed in the present study, it is unlikely that the milk response was affected by the relatively high level of concentrates fed. At an average allowance of 20 kgDM/cow/day and an average herbage intake of unsupplemented cows of 12.2 kgDM/day from seven experiments reviewed where cows were fed an average 4.0 kgDM concentrates, the mean response in milk yield was 0.68 kg/kgDM concentrate (Table 5.2), representing 0.87 kg/kgDM extra eaten (Table 5.4). In the present study, the mean response of 0.40 kg milk/kgDM concentrate (Table 5.2), representing 0.68 kg/kg extra DM eaten (Table 5.4), was observed where supplemented cows consumed 6.7 kgDM concentrate, despite at comparable HA, herbage intake of unsupplemented cows and substitution rate to those summarised in Table 5.1.

Table 5.4 Changes in animal performances per kg <u>extra</u> feed DM eaten by grazing dairy cows.

References and Exp. details	HA*	I_h*	I_s*	I_t*	S_r*	Responses Milk*	Fat*	Pro*	Lac*	LWC*
Jennings and	HSR	12.6	4.0	16.5	0.03	+0.53	+13	-	-	+103
Holmes(1984)		12.6	4.0	16.2	0.13	+0.74	+14	-	-	+147
Early lact.	LSR	12.0	5.0	16.4	0.15	+0.48	+18	-	-	+118
Set stocking		12.0	5.0	15.7	0.32	+0.65	+4	-	-	+95
Arriga-Jordan	33	18.1	6.0	21.2	0.36	+1.00	+6	-	-	+2
and Holmes	22	15.3	6.0	19.4	0.13	+0.73	+7	-	-	+3
(1986)										
Stockdale and	15	8.0	1.8	9.9	0.00	+1.51	+68	+68	-	+48
Trigg (1985)	26	10.6	1.8	10.7	0.94	-	-	-	-	-
Late lact.	15	8.0	3.6	11.6	0.00	+0.78	+42	+33	-	+239
	26	10.6	3.5	12.6	0.43	+1.45	+65	+54	-	+194
	15	8.0	6.3	12.8	0.23	+0.92	+25	+29	-	+295
	26	10.6	6.2	14.9	0.30	+0.82	+35	+35	-	+12
Stakelum M	14	12.8	3.2	15.1	0.59	+0.85	+24	+29	-	-
(1986a)	21	16.9	3.2	18.2	0.28	+0.54	+5	+27	-	-
Stakelum E	14	12.2	3.5	14.4	0.37	+0.47	-	+32	-	+56
(1986b)	21	15.4	3.7	17.5	0.43					

Stakelum	L	15	11.9	3.8	15.1	0.33	+1.38	-	+25	-	-
(1986c)		22	15.1	3.8	16.8	0.68					
Grainger	E	8	6.1	3.2	9.3	0.00	+0.97	-	-	-	-
(1987)		17	11.8	3.2	14.2	0.27	+0.92	-	-	-	-
		33	15.9	3.2	16.9	0.69	+0.99	-	-	-	-
MEAN		20	12.2	4.0	15.0	0.32	+0.87	+25	+26	-	+109
Present study		20	11.8	6.7	16.7	0.27	+0.45	+12	+27	+26	-
		24	12.2	6.7	15.7	0.48	+0.92	+38	+50	+54	-
MEAN		22	12.0	6.7	16.2	0.37	+0.68	+25	+39	+40	+38

* As in Table 5.1 and

Milk = kg of milk/kg extra feed DM eaten.

Fat, Protein, Lactose and Liveweight Change = grm/kg extra DM feed DM eaten.

The trial of Stockdale and Trigg (1985) even found decreases in yield response with increasing level of concentrate intake. It seemed probable in the present study that level of concentrate did not affect the yield response.

Most concentrate-feeding experiments in Table 5.2 and 5.4 used cows which, at the start of the experiments, yielded more milk than cows in the present experiment, except in the trials of Stockdale and Trigg (1985), and Stakelum (1986a,c). Since the high yielding cows were likely to show the greater response to supplementary feeding than the low yielding cows (Broster and Thomas,1981), the higher response could therefore be achieved in those experiments.

Mention has already been made of the relationships between herbage allowance, total DM intake, herbage intake of unsupplemented cows and the levels of concentrate consumed, and the milk response to kg concentrate DM eaten or kg <u>extra</u> feed DM consumed. Milk response varied according to such factors when it is expressed per kg DM concentrate eaten. In contrast, when it is expressed per kg <u>extra</u> DM eaten, it appears that the response is unlikely to vary according to the factors discussed. A reliable response can therefore be achieved by expressing in terms of kg extra milk per kg <u>extra</u> feed DM consumed.

Calculated energy balance

Despite the high additive effects of concentrate supplement on intake (0.65 kg increase in total DM intake/kgDM concentrate eaten) the increase in milk yield (0.68 kg milk/kg extra feed DM eaten) was similar to the report reviewed by Bryant and Trigg (1982) (0.5 kg milk/kg extra feed DM eaten) when the cows have been eaten extra pasture.

Considering that supplemented cows gained more liveweight than unsupplemented cows, when the gain in liveweight was taken into account simple calculation showed that some 64-72% of the increased intake of ME in Periods I and II was accounted for by the recorded increases in milk yield and liveweight (Table 5.5), although the data did not allow very precise accounting of energy utilisation.

By theoretical calculation and as shown in Table 5.5, the average efficiency with which ME is utilised above maintenance for milk synthesis (k_l) of PF cows and CF cows was 0.62 and 0.45 respectively. The apparently lower calculated efficiency of ME utilisation for milk of supplemented cows than unsupplemented cows may arise from many factors, including an overestimate of ME intake, an underestimate of liveweight gain and reduced efficiency of ME utilisation due to concentrate supplementation.

However, An overestimate of ME intake by supplemented cows from feed measurements was unlikely to occur since cutting technique provided the corresponding favourable results in both periods for calculating energy utilisation in unsupplemented group in both periods. Concentrates were weighed properly before and after feeding.

It is probable that gut fill may contribute little to an underestimate of liveweight gain obtained by supplemented cows and thus leading to an underestimate of ME concentration in the gain, since weighing took place in the morning after milking and before meal feeding, and ,by measurement, supplemented cows ate less pasture than unsupplemented cows.

It is also probable that ME intake of supplemented cows was less efficiently utilised compared with the unsupplemented cows as shown in Table 5.5. The less efficiency of utilisation of unsupplemented cows can be attributed that when high concentrates were consumed, the proportion of propionate increased and that of acetate decreased. Incorporation of energy into tissue fat increased with a resultant depression in efficiency of milk synthesis (Blaxter,1967).

The reason for the decrease in efficiency which is the diversion of nutrients to body tissue rather than to milk has been confirmed by Tyrrell,1980; Baldwin and Smith,1983). Sutton et al.(1980) also observed severe milk fat depression on the high concentrate diets concomitant with increased tissue energy balance, reduced milk energy output and a decrease in efficiency of utilisation of dietary energy for milk production. Many recent experiments also observed similar trend of less utilised ME in concentrate supplemented cows (Jennings and Holmes,1984; Arriga-Jordan and Holmes,1986).

Table 5.5 Calculated energy balance for the two treatments in Periods I and II.

	Period I		Period II	
	PF	CF	PF	CF
Total DM Intake (kg/day)	11.8	16.7	12.2	15.7
Estimated ME Intake (MJ/day)	126	190	124	175
Gain in Body Energy (MJ/day)[a]	4	10	4	10
ME for Maintenance (MJ/day)[b]	49	48	48	49
ME Available for Milk (MJ/day)	73	132	72	116
Expected Milk Energy (MJ)[c]	47	86	47	75
Actual Milk Energy (MJ)[d]	45	54	43	55
Apparent Efficiency of ME Utilisation above Maintenance (k_1)[e]	0.62	0.41	0.60	0.47

a Using 35 MJ/kg liveweight gain (Holmes et al.,1981).

b Using k_m 0.60 MJ/kg$^{0.75}$ (Holmes et al.,1981).

c Assuming k_1 = 0.65.

d Calculated from actual milk yield and equation 1 (Tyrrell and Reid,1965).

e Calculated as Milk Energy/ME Available for Milk.

5.2.2 Yields of Milk Constituents

In addition to the increases in milk yield, yields of milk protein and milk lactose were increased by concentrate supplementation. The mean response was 23 grm of milk protein or milk lactose yield per kgDM concentrate eaten (Table 5.2). Yield of milk fat was unaffected by supplementation in Period I but it was in Period II, with the mean response of 20 grm fat/kgDM concentrate. These responses were similar to those summarised in Table 5.2. The increases in yield of milk fat by concentrate supplementation were due to increases in milk yield since milk fat concentration tended to be decreased. An increase in milk protein yield was due to both increases in milk yield and concentration of milk protein whereas an increase in yield of milk lactose was mainly due to an increase in milk yield since concentrate supplementation had no effect on milk lactose concentration.

5.2.3 Residual Effect on Yields of Milk and Its Constituents.

In the present study the difference in milk yield between treatment groups virtually disappeared within 1 week of cessation of concentrate feeding (Table 4.9 and Figures 4.1, 4.2, 4.3 and 4.4). The early work in New Zealand, Wallace (1957) found the residual effect of 80% of the immediate effect of concentrate feeding. The residual effect was greater at unrestricted than restricted pasture intake during the experiments. In recent Europian trials, Wood and Newcomb (1976) reported the immediate effect of 0.68 kg milk/kg concentrate and a residual effect of 0.5 times the immediate effect. Comparing a fixed amounts of concentrates over weeks 1-20, Johnson (1977) found 1.56 kg additional milk/additional kg concentrates. This was associated with little residual beneficial effect. In an Australian experiment where a supplement of 3.5 kg maize was fed during days 1-50 of lactation, Cowan et al.(1975) observed a residual effect as well as an initial response in both milk and fat production for the less severe stocking rates, but only an initial response with no residual benefit at the most severe stocking rate possibly because of nutritional stress. The immediate response was 0.6 kg milk from 1 kg maize. In the residual period the response was 0.6 times the immediate effect. More recently, no residual effect on yields of milk and its constituents was observed in the trials of Stakelum (1986a,b).

The absence, or the reduced size, of residual effect in recent trials was probably attributed to better understanding in husbandry, compared with in the past. In recent husbandry, body condition at calving which was the consequence of generous feeding before calving is of important. In addition, cows were generally well fed following the supplementation in most experiments. In the present study, like other recent trials, cows were well fed both before and after the experiment therefore residual effect could not be observed. The recovery period was less than 6 days since production was sampled every 6 day interval. In conclusion, if the supply of herbage is abundant following the cessation of supplementation, concentrate feeding had less, short-lived or no carryover effect on yields of milk and its constituents, provided that cows calved in good condition.

5.2.4 Composition of Milk.

Concentrate supplementation had no significant effect on concentrations of milk fat and milk lactose in the present study, although milk fat concentration tended to be decreased and lactose concentration tended to be increased (Table 4.10). Concentration of milk protein was increased in both periods (Table 4.10). Although the early evidence have shown the effects on milk composition to be small (Leaver et al.,1968) or to be absent (Johnson,1977), many recent experiments observed depressions in fat concentration with concentrate supplementation (Jennings and Holmes,1984; Arriga-Jordan and Holmes,1986; Stakelum,1986a). The depression in milk fat concentration when concentrates were fed was suggested to be due to an increased supply of glucogenic precursors in the form of propionic acid and a decreased supply of lipogenic precursors, namely acetic acid and butyric acid (Sutton,1981). An increase in supply of propionic acid has been indicated to stimulate the synthesis of milk protein in the infusion studies, thereby causing an increase in protein concentration (Rook and Balch,1961). This usually took place in association with reduced efficiency of energy utilisation. The only trial in which ground maize was fed observed an increase in milk protein concentration with small increase in propionic acid (Sutton et al.,1980). In addition, Sutton (1981) suggested that maize was digested more slowly than wheat and barley, and it produced a higher ratio of acetate to propionate in the rumen and a higher milk fat concentration.

However, the absence of a significant effect of concentrates on milk fat concentration in the present study was probably due to the complexity of commercial meal although it apparently comprised mainly oats, maize, wheat and barley with varying proportion. The varying proportion of such products of grain may contribute to the variation in products of digestion, notably probably higher ratio of acetate to propionate caused by maize. Thus it prevented the depression in fat concentration.

Mention has also already been made that protein concentration would be increased by maize therefore increased protein concentration in the present study was probably caused by a high proportion of maize as well as high proportion of other cereals which produced a high proportion of glucogenic precursors. It is also probable that other ingredients in the concentrate mixture may be involved in the varying rate and end products of digestion. The absence of any effect on lactose concentration was consistent with many other findings but it is not always separately reported from SNF concentration.

In the present study only concentration of protein showed short-lived residual effect, in week 1 but not week 2, following supplementation whereas concentrations of fat and lactose did not. The short-lived residual effect on protein concentration was probably reflected the significant increase in its concentration during supplementation. Some experiments reported no residual effect on milk composition (Stakelum,1986a,b,c). Unfortunately, reports of a number of trials did not include information regarding milk composition.

5.3 EFFECT OF CONCENTRATE SUPPLEMENTATION ON LIVEWEIGHT AND BODY CONDITION SCORE.

The pattern of liveweight change over the lactation is well defined. Commonly there is a fall in liveweight in the first few weeks after calving followed by a period of gain. Supplementation has been shown to reduce liveweight loss or even increase liveweight gain in early lactation (Broster and Thomas,1981; Bryant and Trigg,1982).

Although supplemented cows in the present study gained on average 160 grm/day (Table 4.11) more than unsupplemented cows, both groups showed a similar trend of liveweight change over the experimental period (Figure 4.9). There was a gradual fall during week 1 and 4, thereafter both groups gained weight over the rest period. This was in agreement with the common accepted pattern.

The response in liveweight change due to concentrate supplementation in the present study was 24 grm/kgDM concentrate eaten or 38 grm/kg extra feed DM eaten, which was much lower than the responses summarised in Table 5.3 and 5.4, being 93 grm/kg concentrate DM eaten or 109 grm/kg eatra feed DM eaten. Bryant and Trigg (1982) reviewed the response in liveweight change to extra feed DM eaten of 150 grm/kg. The reason for the much lower response is probably due to the underestimate of liveweight change in the present study.

The difference in liveweight between supplemented cows and unsupplemented cows persisted from the cessation of concentrate feeding through week 5 after the cessation, the last week of measurement, thereafter. This represented the benefit which supplemented cows obtained over unsupplemented cows. The amount of 160 grm/day benefit during the experimental period would probably be utilised to produce milk in the subsequent period or in the next lactation. This was supported by the finding of Hancock (1954) which reported an increase of 15% in milk production from supplementary concentrate fed over 3 years under New Zealand grazing conditions. However Cowan et al.(1975), in Australia, examined by covariance analysis the effect of supplementary feeding in early lactation on performance in the subsequent lactation and reported no significant effects.

The data recorded in the present study did not allow the utilisation of body reserve in the subsequent period to be analysed. The benefit of liveweight and condition score would be carried to the next lactation as cows calving in better condition should produce more milk in lactation (Grainger et al.,1982).

CHAPTER 6: CONCLUSION

CONCLUSION

In Periods I and II respectively, Concentrate feeding increased milk yield by 0.33 and 0.48 kg/kg concentrate DM eaten or 0.45 and 0.92 kg/kg extra feed DM eaten, increased milk fat yield by 9 and 12 grm/kg concentrate DM eaten or 12 and 38 grm/kg extra feed DM eaten, increased milk protein yield by 20 and 26 grm/kg concentrate DM eaten or 27 and 50 grm/kg extra feed DM eaten, and increased milk lactose yield by 19 and 28 grm/kg concentrate DM eaten or 26 and 54 grm/kg extra feed DM eaten.

Milk protein concentration was increased by 0.07 and 0.05 % per kg concentrate DM eaten but concentrate supplement had no effect on milk fat and milk lactose concentrations.

Supplemented cows gained 24 grm/kg concentrate DM eaten or 38 grm/kg extra feed DM eaten more liveweight and gained 0.05 units/month more condition score than unsupplemented cows.

Concentrate feeding, in Periods I and II respectively, increased total DM intake by 0.73 and 0.52 kg/kgDM concentrate eaten, increased total ME intake by 0.77 and 0.61 MJ/MJME concentrate eaten, reduced herbage intake by 0.24 and 0.44 kgDM/kgDM concentrate eaten and increased residual herbage mass by 264 and 399 kgDM/ha.

The results in the present study suggest that although it is beneficial to feed concentrate in early lactation, the response in terms of milk energy and tissue energy is just about half that of the expected value from energy intake. The present study was conducted in early spring when the supply of pasture was ample. If the pasture was in short supply, much bigger responses would be expected. Apart from an increase in residual herbage mass, it is clear that concentrate supplementation will allow an increase in stocking rate and thus an increase in production per hectare due to an increase in pasture utilisation. In conclusion, concentrate supplementation would be more beneficial when the supply of pasture is short, particularly on those farms with an early calving date, or when a farmer wishes to increase pasture utilisation by increasing stocking rate without reducing per cow production. In the longer term concentrate feeding might also be worthwhile due to greater liveweight gain than in unsupplemented cows which could be mobilised in the later stages.

CHAPTER 7: BIBLIOGRAPHY

BIBLIOGRAPHY

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