EFFECT OF DIFFERENT LEVELS OF DIETARY CALCIUM ON THE PERFORMANCE AND MINERAL AVAILABILITY IN CROSSBRED DAIRY CATTLE

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Thesis submitted in partial fulfillment of the requirement for the degree of

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DECLARATION

I hereby declare that this thesis entitled **"EFFECT OF DIFFERENT LEVELS OF DIETARY CALCIUM ON THE PERFORMANCE AND MINERAL AVAILABILITY IN CROSSBRED DAIRY CATTLE "** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, or any other University or society.

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Smitha Wilson

Dedicated to my beloved parents

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Introduction

1. INTRODUCTION

The present era of rapidly changing livestock production practises demands more attention to those nutrients needed in minute amounts. The stresses of confinement feeding, use of unnatural feeds, and high rates of production may result in a deficiency or imbalance of vital nutrients. This could limit further improvement in production of livestock and other products. Increased growth rates and milk production will greatly increase mineral requirements. Calcium is the most abundant mineral in the body; it is also the one most likely to be inadequately supplied in the diet. Optimum productive efficiency of livestock could be exploited only when the animals receive a balanced diet containing mineral supplements. For lactating cows nutrient supplementation for minerals go beyond correcting deficiency, are aimed rather at minimizing stress and optimising production efficiency.

The profitability of the dairy industry depends on the balance between the cost of feed input to the cow and the maintenance of her health on one side, and the value of her output of milk and calves on the other. The dairy cow produces more milk than she requires to feed her calves, and modern intensive methods of husbandry try to obtain still higher yields from the minimum quantity of feed. 'Production disease' is likely to become an increasingly serious problem when such intensive methods are used. The most critical time in the life of a dairy cow is the first few days post partum. The cow's metabolism is under severe stress as she transitions to lactation. The parturient dairy cow has a very responsive calcium homeostatic mechanism in order to minimize the development of a negative calcium balance due to the larger drain of calcium into the milk at the peak of lactation. Milk fever is a complex metabolic disorder that occurs at this prime time of lactation. The hallmark of the disease is severe hypocalcaemia, which probably accounts for most of the clinical signs associated with a milk fever episode. Of the various methods used in attempts to control the disease, the most progress has been made in dietary management.

In Kerala with the decline of grasslands and reduced availability of good quality forage, paddy straw forms the sole source of roughage. Antinutritional factors like oxalate are comparatively higher in paddy straw than in other fodder species. Oxalates, phytates and silica negatively affect calcium bioavailability. Anon (1994) based on mineral balance studies in dry non pregnant cows reported marginally lower negative balance with regard to calcium and attributed it to low calcium content and high oxalate content in paddy straw. Gowda and Prasad (2005) suggested additional calcium supplementation to meet the calcium requirement when rice straw is fed. They also pointed that higher level of silica in rice straw is the most likely factor for reduced digestibility responsible for reduced calcium release from the cell content. Sharma *et al.* (2004) reported that supplementation of minerals at 10-20 percent level higher than the normal requirement has improved the nutrient utilization and mineral retention. Syam Mohan (2003) in his assessment of dietary level of minerals for lactation in the cross bred lactating cattle of Kerala under grass based and paddy straw based systems of feeding indicated that requirement of P, Mg, Cu and Zn can be met solely from their content in the feed ingredients and calcium is the only element that needs to be supplemented under both systems of feeding.

Numerous researches involving the study of this macro mineral point out the need to increase the calcium level particularly after calving. Westerhuis (1975) recommended that after calving calcium in the rations should be greater than 1.0 per cent. Estimations of dietary calcium availability by Horst (1986) during lactation lends support to increase the recommended calcium concentration in the diet of high producing dairy cows from 0.6 to 0.75 particularly in early lactation. Tucker *et al.* (1992) based on his studies on the levels of dietary calcium concluded that occurrence of milk fever may be absent when the diets contain more than 1.6 per cent calcium.

Varghese (1998) in his assessment of mineral status of cattle in Kerala observed that most farmers were not following any definite pattern or schedule of feeding with regard to the quantities of concentrate or roughage provided to heifers as well as lactating cows. Indiscriminate addition of mineral supplements, most of them being of substandard quality without ascertaining the mineral content of the feeds and fodders and the mineral status of the animals have complicated the mineral nutrition of the animal especially calcium. The calcium content of compounded cattle feed collected from the different districts of Kerala also showed a wide variation from 0.32-0.98 percent on DM basis.

Underwood and Suttle (1999) reported that considerable confusion has arisen from the use of different criteria and assumptions while calculating mineral requirements as some have estimated minimum requirements, others average requirements and some safe allowances which cater for the most adverse individual circumstances and leave no animal at risk from deficiency. IS (1992) recommends the minimum calcium content in compounded cattle feed as 0.50 per cent, while the NRC (1989) specification for calcium in dairy cattle ration is 0.43-0.77 per cent

In such circumstances the levels of dietary calcium in paddy straw based rations will fall below the recommended levels, and can lead to incidences of metabolic disorders. Hence the present study is undertaken with the following objectives.

1. To study the effect of different levels of dietary calcium on the performance of dairy cattle during late gestation and subsequent lactation.

2. To study the effect of dietary calcium on the mineral balance in early lactating cows.

Review of Literature

2. REVIEW OF LITERATURE

Dwindling green grasses and increased practise of feeding paddy straw to dairy cattle necessitates adding extra Ca to diets. So an experiment with different levels of dietary Ca on the performance and mineral availability in crossbred dairy cattle is to be ascertained. Literature allied with this topic of interest is reviewed here.

2.1 DIETARY LEVELS OF CALCIUM

Boda and Cole (1956) reported that the Ca content of the diet determine the amount of Ca absorbed from the gastrointestinal tract and in most species the blood Ca level tend to rise or fall with the dietary Ca level.

Manston (1967) concluded that the percent of dietary Ca absorbed remained fairly constant in cows resulting in an increase in Ca absorption as the dietary intake increased. Long term experiments with pregnant heifers fed dietary Ca: P ratio of 2:1 and 1:1 showed better absorption of both elements from the 2:1 diet.

Gardner and Park (1973) disclosed two nutritional approaches to prevent parturient paresis. One was to severely restrict Ca intake during the dry period. The second approach was to enhance Ca absorption on higher Ca diets by adjusting Ca: P ratio to near 2.3:1 or other acceptable ratios after calving.

Westerhuis (1975) recommended that during dry period cows should be fed rations with 0.50 percent Ca in the dry matter of the total ration and after calving Ca in the rations should be greater than 1.0 percent. Belyea *et al.* (1976) indicated that low Ca diet for short times increases resistance to Ca stresses such as hypocalcaemia and parturient paresis.

Yarrington *et al.* (1977) suggested that the mobilization of skeletal reserves contribute significantly to Ca homeostasis near parturition in cows fed a low Ca diet.

Horst (1986) stated that estimations of dietary Ca availability during lactation supports to increase the recommended Ca concentration in the diet of high producing dairy cows from 0.6 to 0.75 per cent particularly in early lactation. Animals fed Ca according to NRC recommendation may be consuming less than that required to maintain Ca balance in early lactation. The data suggested that cows must be supplemented with 3.0 to 3.4 g Ca /Kg milk; this represented a 10 to 20 per cent increase in current supplement recommendations by NRC.

Shappel *et al.* (1987) opined that feeding low dietary Ca to cows in the pre partum period was effective in the prevention of severe hypocalcaemia at parturition. In contrast dietary treatment of pregnant heifers had no effect on serum Ca concentration at parturition. Oetzal (1991) stated that extremes in dietary Ca both high and low apparently were beneficial in preventing milk fever. Intermediate dietary concentration of Ca (near 1.6 per cent) was associated with higher incidence rates of the disease. However the over all effect of dietary Ca on milk fever was minor.

Tucker *et al.* (1991) suggested that feeding one per cent $CaCl_2$ for 3-week prepartum should provide prophylaxis for parturient paresis without seriously affecting systemic acid base status. Tucker *et al.* (1992) concluded that the prophylactic effects on the occurrence of milk fever of feeding a low DCAD (Dietary cation anion difference) during the dry period may be absent when diets contain more than 1.6 per cent Ca and DCAD is greater than 3. Horst *et al.* (1997) reviewed that there was no significant effect of dietary Ca on the incidence of milk fever in cows fed 0.5 per cent and 1.5 per cent Ca diets that had a CAD of approximately -100, +200 or +400 meq/Kg of diet.

Varghese (1998) reported that the average Ca content in the concentrate mixtures collected from different districts of Kerala ranged from 0.32- 0.98 per cent. Ramana *et al.* (2000) assessed the Ca content of straw as 0.31 to 0.72 per cent in the southern transition zone of Karnataka and the compounded cattle feed as 1.2 per cent on DM basis.

The preliminary results of Wilson (2001) demonstrated that feeding a supplement designed to reduce dietary Ca availability for 2 to 4 weeks immediately prior to calving, reduced the incidence of clinical milk fever.

Panda and Sahu (2002) based on their work had found the Ca content of paddy straw as 0.22 per cent on dry basis. Mann *et al.* (2003) has found out the Ca per cent of feed pellets as 1.15 (0.71 –1.56 percent). Mondal *et al.* (2003) assessed the paddy straw and maize grain to contain 0.12 and 0.24 per cent Ca. Kalita *et al.* (2003) analysed the Ca content of paddy straw of Kamrup district of Assam as 0.34 and of rice polish, wheat bran and crushed maize as 0.16, 0.18 and 0.21 and respectively.

Knowlton *et al.* (2004) suggested that absorption of both dietary Ca and P is influenced by the concentration of dietary P and P absorption is reduced with increasing dietary levels of Ca.

Sarkar *et al.* (2004) suggested that in a part of U.P and Uttaranchal the highest levels of fodder Ca was found in Nainital (0.52 per cent) and the lowest was found in Barielly (0.44 per cent). Also suggested that fodder samples of the Tarai region showed about 12.22 per cent deficiency of Ca, P and Mg.

Gowda and Prasad (2005) stated that level of Ca in the dietary DM was significantly lower in the group fed rice straw (0.40 per cent DM) as compared to group fed finger millet as against the Ca requirement of 0.43 to 0.77 per cent for dairy cattle (NRC, 1989). This suggests additional Ca supplementation to meet the requirement when rice straw is fed. They also pointed that higher level of silica in rice straw is the most likely factor for reduced digestibility responsible for reduced calcium release from the cell content.

Syam Mohan (2003) pointed that NRC (1989) values of Ca, P, Mg, Cu and Zn is applicable to crossbred lactating cattle of Kerala under both grass and paddy straw based feeding systems. The study also indicated that requirement of P, Mg, Cu and Zn can be met solely from their content in the feed ingredients and Ca is the only element that needs to be supplemented under both systems of feeding.

2.2 SERUM MINERAL STATUS

2.2.1 Serum Calcium Status

Clay Pool (1976) assessed the factors affecting the Ca status of dairy cattle in the Oregon coast and found that difference in serum Ca levels during winter and summer seasons was due to the difference in feeding programmes and the environmental factors between the two populations of cows.

Belyea *et al.* (1976) reported that cows fed a low Ca diet (0.25 per cent of dry matter) demonstrated a greater resistance to Ca challenge than cows fed a higher Ca diet(0.75 per cent of DM), as indicated by less depression and slower decline of Ca in plasma during EDTA infusion.

Kiatoko *et al.* (1978) determined the mineral status of grazing cattle in the San Carlos region of Costa Rica. No difference was detected in Ca of plasma between two soil types and among the 4 districts. Average Ca of plasma for all animals was in the range of 9.2 to 10.6 mg/ 100ml.

Analysis by Murtuza *et al.* (1979) revealed that the mean concentration of Ca in late pregnant and early lactating cows as 11.22 and 9.85(mg/dl). The study showed that serum Ca differed significantly between late pregnant and early lactating cows.

Moate *et al.* (1987) showed that daily injection of 1, 25, (OH) $_2D_3$ to lactating dairy cows resulted in increased dietary Ca absorption and elevated concentration of plasma Ca significantly.

Ballantine and Herbein (1991) observed that jersey cows had lower total Ca (7.447 mg/dl) and ionised Ca (4.25 mg/dl) than Holstein (8.10 and 4.66 mg/dl) on day of calving. Romo *et al.* (1991) stated that different treatment levels of low and high Ca (51 and 115g/day) did not affect the serum Ca in cows fed variable cation: anion balance.

Comparison by Oetzal (1996) revealed that prophylactic treatment of dairy cattle with $CaCl_2$ Gel 12 hours before expected calving, at calving and after calving significantly increased mean serum Ca concentration than those in control group. Poulin and Trembley (1998) stated that serum Ca were lower on the first day post partum than a week later. On the first day post partum serum Ca was associated in a curvilinear fashion with age, P and albumin.

Varghese (1998) after analysing the serum mineral status of lactating cattle in Kerala stated that animals in all the districts maintained normal mineral status except for Ca for which lower levels of 7.06, 7.56 and 7.74 were observed in Kottayam, Wayanad and Kasargod districts respectively. Kalita *et al.* (1999) reported that the mean concentration of Ca in normal cycling cows as 11.23 +/- 0.36mg per cent.

Ramana *et al.* (2000) opined that animals showing deficiency was 34 per cent in case of Ca in the blood plasma (7.67 mg %) in the southern transition zone of Karnataka. Singh *et al.* (2001) suggested that Ca in the blood is maintained within rather narrow limits at 9-11 mg/100ml in cattle (approximately 5meq/L).

Hansen (2002) studied the effect of zeolite supplementation and found that it significantly increased the plasma Ca level on the day of calving.

Melendez *et al.* (2002) recorded that 34.6 per cent of the total cows studied had a Ca concentration less than 7.3 mg/dl before receiving any treatment at calving.

Mondal *et al.* (2003) found out that the serum Ca of milch animals in coastal saline zone of West Bengal as 9.59.

Chan *et al.* (2006) reported that cows fed diets containing moderate Ca (0.99 per cent) or high Ca (1.50) per cent concentration for 21 day prepartum did not show significant variation on serum Ca concentration.

2.2.2 Serum Phosphorus Status

Steevans *et al.* (1971) observed that blood serum inorganic P was lower in the group of cows fed 0.4 per cent P compared to the 0.6 percent P. Claypool (1976) pointed that the variation in serum inorganic P in the dairy cattle of Oregon coast was due to the change in forage during the winter from alfalfa to silage.

Murtuza *et al.* (1979) showed that mean concentration of P in the serum of Hariyana cattle in late pregnant and early lactating cows was 5.24±0.43 and 3.44±0.13.

Chester-Jones *et al.* (1989) reported that serum in organic P was elevated consistently in lambs fed 2.4 per cent Mg.

Betteridge (1989) stated that mean serum P concentration was higher in cows on sandy soil than on peat loam. Kegley *et al.* (1991) reported serum P status of 5.1 and 4.8 (mg/dl) in growing steers fed 0.35 and 0.71 per cent Ca in diets.

Romo *et al.* (1991) stated that different treatment levels of high and low Ca (51 and 115 g/d) did not affect the serum P levels and the serum values of P decreased around parturition

Studies by Kume *et al.* (1998) showed that plasma P was unaffected by parity. Studies by Knowlton and Herbein (2002) showed that serum inorganic P content was proportional to dietary P content through out the 10 weeks of study.

2.2.3 Serum Magnesium Status

Dunham and Ward (1971) reported that serum Mg was not influenced by ration or by vitamin D supplementation or stage of lactation. Clay Pool (1976) pointed that greatest source of variation in serum Mg levels was due to difference between herds and other sources of variations are due to factors associated with season and stage of lactation or production.

Kiatoko *et al.* (1978) determined the mineral status of grazing cattle in the San Carlos region of Costa Rica and founded that serum Mg levels of plasma were below the normal values of 1.8 mg/100ml.

Field and Suttle (1979) have found out that reduction in plasma concentration of Mg was greatest at the lowest intake.

Murtuza (1979) analysed the mean concentration of Mg in the serum sample of Hariyana cattle in late pregnant and early lactating cows as 2.17±0.09 and 2.28±0.12 respectively

Studies by Moate et al. (1987) showed that daily injections of 1,25 $(OH)_2D_3$ depressed plasma Mg concentration. Chester-Jones *et al.* (1989) reported that increased dietary Mg resulted in linear increase in serum Mg.

Romo *et al.* (1991) stated that different treatment levels of low and high Ca levels (51 and 115g/d) and cationic: anionic balance of (23 and –8 meq) elevated the concentration of serum Mg. Kalita *et al.* (1999) reported that the mean concentration of serum Mg as 3.57 ± 0.15 mg per cent in normal cycling cattle.

Hansen *et al.* (2002) studied the effect of Zeolite supplementation and found that it significantly lowered the plasma Mg levels. Studies by Knowlton and Herbein (2002) showed that serum Mg content decreased linearly with increasing dietary P content in lactating cows.

Kalita *et al.* (2003) analysed the serum of cross-bred and non descript cattle of Kamrup District in Assam to contain 9.48 and 9.7 mg/dl of Mg. Studies by Bhattacharya *et al.* (2004) revealed that levels of serum minerals were highest in cows of organized farm followed by large, medium and small farms.

Chan *et al.* (2006) stated that cows fed diets containing moderate Ca (0.99 per cent) or high Ca (1.50 per cent) concentrations for 21 days prepartum, showed no significant difference in serum Mg concentrations.

2.2.4 Serum Zinc Status

Pryor (1976) observed a mean plasma Zn value of 0.82 micro g/ml with considerable variation in plasma Zn levels between cows. Kalita *et al.* (1999)

reported the mean concentration of serum Zn in normal cycling cows as 3.09 $\pm$ 0.2 ppm.

Radostitis *et al.* (2000) reported serum Zn levels as 80 –120 microgram/dl in sheep and cattle. Calves and lambs on deficient diets may have levels as low as 18 micro gram /dl. Ramana *et al.* (2000) stated that levels of Zn (0.66 ppm) were low in the blood plasma of animals in the southern transition zone of Karnataka.

Syam Mohan (2003) studied the average values of serum Zn (ppm) for the first, third and sixth month of lactation in the lactating cross bred cows of Kerala as 1.78,1.82 and 1.84 under grass based and 1.85,1.46 and 1.32 under the paddy straw based systems of feeding respectively.

2.3 MINERAL COMPOSITION OF MILK

Rook and Balch (1958) conducted the Mg metabolism in the dairy cows and found out the Mg in milk within a range of 8.45 to 13.85(g/day) in the cows fed freshly cut herbage of early stage of growth and 9.67 to 13.03 in the cows fed freshly cut herbage of a mature stage of growth.

Nickerson (1960) assessed the chemical composition of milk and observed the total P as 98.5, 95.1, 94.8 and 96.7, total Ca as 133.8, 134.1, 136.8 and 137.1 and total Mg as 9.8, 8.1, 7.1, and 8.5 mg/100g in 4 different seasons.

Cerubulis and Farell, Jr (1976) stated that average Ca of milks varied from 1.11g/l to 1.46g/l. Average Mg of the milks of the breeds varied from 0.099g/L to 0.12g/L.The average P of milks of breed tested varied from 1.01g/L for Holstein to 1.33g/L for jersey.

Fransson and Lonnerdal (1983) opined that cows milk contain about 4-5 times more Ca (854-1430 microg/ml) and Mg (87-131micro g/ml) respectively than in human milk.

Moate *et al.* (1987) showed that administration of 1,25$(OH)_2$ D_3 had no effect on the concentration of Ca and Mg in milk and no effect of Ca and Mg output in milk since milk yield was unaffected. Milk Ca (g/L) was 1.27 in control and treatment group and milk Mg (g/L) was 0.102 and 0.097 in control and treatment groups, respectively.

Salih *et al.* (1987) analysed colostrums and found that colostrum was higher in Mg, P and Zn than milk.

Mineral content of market samples of fluid whole milk assessed for Ca, P and Mg contained 106,83 and 9.8 mg/100gm respectively. (Pennington *et al.*., 1987)

Kume and Tanabe (1993) assessed the colostral Ca, P, Mg and Zn and found to contain 265-191mg/dl, 218 to 160 mg/dl, 28.1 to 38.6mg/dl and 17.1-25.8 ppm respectively.

Kume *et al.* (1998) have found out that colostral Ca, P, Mg and Zn were highest in the first lactation cows, although colostrums yield was lower.

Rodriquez *et al.* (2001) reported the Ca and Mg of raw cow milk as 1653mg/Land 113.9mg/L respectively.

Syam Mohan (2003) recorded average milk Ca as 1.20 and 1.36, P as 0.89 and 0.96, and Mg as 0.10 and 0.11g/L in the cross-bred dairy cattle of Kerala under the grass based and paddy straw based systems of feeding respectively.

2.4 MINERAL BIOAVAILABILITY

The mineral content of a feed or a supplement is of little value for ration formulation unless the availability or digestibility of the mineral is known. Biological availability tells how well mineral is digested and used by the animal to promote healthy production. As the Biological availability of mineral decreases the amount of that mineral needed to meet the cows requirement obviously will increase.

2.4.1. Calcium Bioavailability

Luick *et al.* (1957) reported that on low Ca: P diets the cows were in a negative Ca balance. When the dietary Ca: P was increased to greater than unity, more Ca was absorbed than was excreted, and positive Ca balance was achieved. There was an increased rate of absorption and decreased rate of metabolic faecal secretion. Dietary Ca: P levels influenced absorption more than faecal secretion.

Long term studies by Manston (1967) on pregnant heifers fed dietary Ca : P ratios of 2:1 and !:1 showed better absorption of both elements from the 2:1diet. The studies showed that absorption of Ca increased as the dietary concentration increased, however this trend was only for a few days and no improvement in plasma Ca was apparent.

Agarwal and Talapatra (1970) summarized that when average intake of Ca was 2.9 g in 7-12 month old male calves there was positive balance of 0.18g.

Agarwal and Talapatra (1971) found out that the availability of Ca from dicalcium phosphate was 56.2 per cent and from bone meal was 63.4 per cent.

Negi (1971) observed that the ingestion of soluble oxalates in amounts ordinarily present in paddy straw diets does not affect the Ca retention adversely.

The decreased absorption represented by the difference in intake minus faecal output may be only apparent as most of the excreted Ca is normally found in the faeces.

Ca can be absorbed from the lumen of the intestine by passive diffusion between the intestinal epithelial cells (Para cellular transport) and by active transport across the intestinal epithelial cells. Experimental studies suggest that if animals are fed a high Ca diet more than 50 per cent of the Ca absorbed will be by the Para cellular route. (Horst *et al.*, 1994)

Suttle (2000) recorded that the gut absorption of Ca in periparturient or lactating animals is much lower (34-44per cent) due to bone resorption at the time of greatest need.

Anon (2001) stated that marginally lower negative balance was seen with regard to Ca in dry non-pregnant cows. Also states that poor availability of Ca due to higher oxalate content in paddy straw may be the reason for the slightly negative balance for Ca.

Knowlton and Herbein (2002) stated that Ca intake, excretion in faeces and urine and apparent absorption were unaffected by dietary P concentration in early lactation cows.

Panda and Sahu (2002) reported that total oxalate intake at 0.58 per cent of dry matter intake of the animals seems to be harmless. When the levels of oxalate increased to 1.19 per cent, balance of Ca was negative. They recorded the Ca balance as 1.21, 0.37, -1.79, and -2.03 in cross bred bulls fed different oxalate levels.

Syam Mohan (2003) observed an average retention per cent of 24.13 and 18.54 in the third month of lactation and 25.32 and 21.12 in the sixth month of lactation in the cross bred cattle of Kerala under grass based and paddy straw based systems of feeding respectively.

Gowda and Prasad (2005) showed that gut absorption (25.9 and 15.4 per cent) and net retention (9.6 and 3.0g) and retention as per cent of total intake (15.6 and 8.3 per cent) were superior in cows fed finger millet straw compared to the group fed paddy straw.

2.4.2 Phosphorus Bioavailability

Young *et al.* (1966) observed that among the three test diets fed to sheep with varying Ca: P ratios of 10.4:1, 1.9:1 and 9.9:1 urinary P excretion was low on all treatment groups. There was no significant difference among the different treatment groups.

Manston (1967) suggested that an increase in dietary P results in at least a temporary increase in absorption of the element in dry Ayrshire cows.

Braithwaite (1983) suggested from the mineral balance and radioisotope studies conducted to test the adequacy of ARC (1980) recommendations that P requirement ought to be calculated according to net demands for P rather than immediate demands.

Horst (1986) reported that the large inflow of saliva (25 to 190 L/d) in cattle contributes 30-40g (70 to 80 per cent) of the total endogenous P. The salivary P mixes with dietary P before a portion of the total is absorbed during its passage through the small intestine. Thus factors that influence the absorption of dietary P also affect the net loss of endogenous P secreted from the salivary gland. So decreasing salivary P excretion during P deficiency or vice versa is a method for regulation of P homeostasis.

Kegley *et al.* (1991) showed that trials with 0.6 per cent Ca decreased faecal P excretion in beef steers. The effect of Ca on faecal P excretion may be due to increased P absorption, decreased endogenous secretion of P or a combination of these 2 factors.

Knowlton and Herbein (2002) after studying the P partitioning during early lactation in dairy cows fed diets varying in P content reported that P balance was highly variable and cows fed 0.34 per cent P diet were in negative balance for a longer period than were cows fed diets containing 0.51 or 0.61 per cent P. With increasing dietary P, serum concentration of inorganic P linearly increased but serum Ca and Mg decreased.

Panda and Sahu (2002) reported that varying levels of dietary oxalate did not exert significant effect on P assimilation. They recorded the P balance as 2.49, 2.46, 2.44 and 2.42 in different treatment of cross bred bulls which showed that oxalate did not exert significant effect on p assimilation.

Kalita *et al.* (2003) reported the P retention per cent of crossbred Jersey and Holstein lactating cows as 24.28 and 14.39 respectively.

Knowlton *et al.* (2004) recommended the need to improve P availability of dairy ration by 5 per cent and reducing P intake accordingly to keep the absorbed P constant. This would reduce P excretion by 15 percent thus reducing the potential pollution of surface water significantly.

2.4.3 Magnesium Bioavailability

Chicco *et al.* (1973a) opined that Urinary Mg concentrations are considered to provide more accurate information than serum Mg concentration regarding the element status in animals.

Feeding high dietary Ca decreased serum and bone Mg concentrations in sheep (Chicco *et al.*, 1973). Chester- Jones *et al.* (1989) observed that increasing dietary Mg linearly increased excretion of Mg in faeces and urine through out the study.

Kegley *et al.* (1991) showed that Lysocellin decreased Mg excretion and increased apparent Mg absorption. Mg retention was not affected. Also stated that 0.6 per cent level of Ca tended to decrease faecal excretion of Mg in the lysocellin fed and control group.

The gut absorption of Mg (34.75 & 26.16) was significantly higher in cows supplemented mineral mixtures than in cows without inorganic mineral micronutrient supplementation. (Gowda *et al.*, 2002).

Kalita *et al.* (2003) observed significant difference between retention per cent of Mg in lactating cross bred Jersey and crossbred Holstein. The values reported were 25.76 and 10.82 respectively.

Syam Mohan (2003) observed an average retention per cent of 16.70 and 11.84 in the third month and 32.47 and 24.03 in the sixth month of lactation in the cross bred lactating cattle of Kerala under grass based and paddy straw based systems of feeding respectively.

2.5 MILK QUALITY

Steevens *et al.* (1971) observed no significant difference in milk composition attributable to varying amounts of Ca and P in dairy ration.

The reverse evaluation of the effect of minerals in milk on the milk fat content among the Slovak spotted and black pied cattle showed that milk with a higher content of fat showed a significant difference in the content of milk Ca (Gabris and Bajan, 1983)

Naresh Kumar and Krishna Murthi (1989) reported the SNF content of cow milk as 8.78 to 9.22 in the gravimetric method and 8.64 to 9.21 in the density formula method.

Dogra *et al.* (1998) studied the performance of lactating cows on different silvi -herbage systems and recorded the fat per cent as 4.79-5.18, SNF per cent as 8.74-9.03 and total solids as 13.64-14.02 per cent.

Wilson (2001) assessed the efficacy of a feed supplement designed to reduce the dietary availability of Ca when fed during the last 2-3 weeks of pregnancy on milk solids production and found that milk solids production was higher in supplemental groups than in non-supplemented cows.

Syam Mohan (2003) recorded the fat content of milk from cows maintained on two dietary treatments as 3.87 and 3.58 per cent in the lactating cross bred cattle of Kerala under grass based and paddy straw based systems of feeding.

Materials and Methods

3. MATERIALS AND METHODS

3.1 ANIMALS

Twelve healthy crossbred cows at the last month of pregnancy, which had an average peak yield of minimum eight liters in their previous lactation, selected from the herd maintained at the University Livestock Farm and Fodder Research and Development Scheme (ULF&FRDS), College of Veterinary and Animal Sciences, Mannuthy, formed the experimental subjects for the study. The selected cows were divided into two groups (Group I and Group II) of six each as uniformly as possible with regard to age, parity and milk yield of previous lactation.

3.2 HOUSING AND MANAGEMENT

All the experimental cows were housed in the same shed with facilities for individual feeding and watering. Stall-feeding was practiced through out the experimental period. The animals were washed every day in the morning before 9 A.M. Stalls were cleaned twice daily before the morning and afternoon milking with frequent removal of dung.

3.3 FEEDING

Rations were computed for individual animals as per the ICAR (1999) standards except for dietary calcium. Paddy straw was the sole source of roughage for the two groups of animals. The experimental ration for each cow was revised fortnightly based on the individual body weight and milk yield. The daily allowance of concentrate was fed in two equal lots at 8.00 A.M and 3.00 P.M every day. Paddy straw was the sole source of roughage and was fed in 3 divided lots every day to ensure minimum wastage, regularity and uniformity of feeding. The balance of the concentrate and paddy straw left behind by each animal was collected and weighed separately every day to calculate the actual dry matter intake.

3.4 DIETS

The experimental animals of group I and II were allotted to two dietary treatments A and B as follows.

Paddy straw was fed to the two groups of animals. The cows of group I and group II were allotted randomly to two dietary treatment viz T1 (control ration) where in the compounded cattle feed containing 0.5 per cent calcium as per IS (1992) standards and T2 (experimental ration) where in compounded cattle feed contained 1.0 per cent calcium.

The ingredient, chemical and mineral composition of the concentrate mixture and paddy straw are presented in Tables 1, 2a and 2b.

3.5 MILKING AND MILK RECORDING

Animals were milked twice daily viz at 5.A.M. and 3. P.M. according to the farm routine, the timings being strictly adhered to during the entire period of the experiment.

3.6 PERIOD OF STUDY

All the experimental animals were fed as per the ICAR (1999) feeding standards except for dietary calcium and were maintained individually on their respective dietary regime from one month before calving to 3 months of lactation.

3.7 BLOOD PARAMETERS

Blood was collected from all the experimental animals from jugular vein on the commencement of the experiment, before calving, after calving, then followed by first, second and third month of lactation for estimating serum mineral concentrations. 25ml of whole blood was collected in labelled test tubes for serum separation. Clear serum was transferred in clean, dry labelled vials and stored at -20°C until the analysis of minerals were carried out. The serum profile of Ca, Mg and Zn were estimated using Atomic Absorption Spectrophotometer (Perkin Elmer 3110).

The serum inorganic P was analysed by phosphomolybdate method using the kits supplied by Agappe diagnostics.

3.8 MILK YIELD

Records of daily milk yield was maintained and the milk was analysed fortnightly for total solids, solids not fat (SNF) and fat content by Gerber's method

Milk was also analysed for the concentration of Ca, P and Mg immediately after calving and at first, second and third month of lactation.

3.9 METABOLISM TRIAL

A metabolism trial involving seven days collection period was conducted at the first month of lactation to study the balance of minerals. Before the commencement of the actual collection period in each balance trial, animals were subjected to a preliminary period of seven days when they were fed from the same consignment of concentrate and paddy straw as that of the collection period and the animals were trained for facilitating easy collection of urine quantitatively.

3.9.1 Sampling of Feeds

Representative samples of both concentrate and paddy straw were taken everyday during the trial for proximate analysis. Dry matter content of the feed was determined everyday and the other components was estimated on dry matter basis as per standard methods described in A.O.A.C. (1990) using composite samples taken after pooling the samples collected on all the seven days of the trial. The Ca, Mg and Zn content in feed and paddy straw were determined by Atomic Absorption Spectrophotometer (Perkin Elmer 3110). The P content in feed was determined by Vanado-Molybdate method (AOAC, 1990).

3.9.2 Collection and Sampling of Dung

Dung voided by each animal was collected manually in individual containers on a continuous twenty four hour basis during the balance trial. All possible precautions were taken to ensure the quantitative collection of dung uncontaminated by urine, feed residue or dirt. The entire quantity of dung voided by each animal during the previous 24 hours was weighed separately at 8 A.M. on every day and representative samples were taken after thorough mixing and were kept frozen till they were analysed. The process of collection, weighing, sampling and preservation of dung was continued till the end of the trial. Aliquots collected on all the seven days of the trial were pooled and composite samples were taken after thorough mixing for the determination of minerals as per the standard methods described in AOAC. (1990). Another one percent aliquots of the total dung voided by each animal on all the seven days of the trial were stored in airtight polythene (Polyvinyl) bags in a frozen state.

3.9.3 Collection and Sampling of Urine

Urine from each animal was collected manually in individual containers on a continuous twenty-four hour basis during the balance trial, taking all possible precautions to ensure quantitative collection without being contaminated with dung or dirt. The entire quantity of urine collected from each animal during the previous 24 hours was measured separately at 8.A.M. on everyday and one percent duplicate aliquots of the total urine were measured into separate labelled containers for each animal. The samples of urine collected were preserved with 100ml of 25% H_2SO_4. Composite samples taken from the pooled aliquots were used for the estimation of minerals at the end of the balance trial as per the standard methods described in A.O.A.C. (1990).

3.9.4 Collection and Sampling of Milk

Milk samples were taken from every animal at each milking on all seven days of the balance trial. Composite samples were prepared by mixing proportionate quantities (10%) of milk from each of the two milking of every cow. The samples were stored in chilled conditions for analysis of minerals at the end of the balance trial as per the standard methods described in A.O.A.C. (1990).

3.10 INCIDENCE OF METABOLIC DISORDERS

No incidence of any metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis were observed in any of the experimental animals during the period of study.

3.11 DATA ANALYSIS

Data gathered on various parameters were analysed statistically by student 't' test described by Snedecor and Cochran (1994).

Table1. Percentage Ingredient composition of the experimental diets.

Ingredient, kg	T1	T2
Yellow maize	44.00	44.0
Soya Bean Meal	25.00	25.00
Gingelly Oil cake	17.00	17.00
Wheat bran	12.90	11.30
Salt	1.00	1.00
Trace Mineral *	0.10	0.10
Calcite	0	1.60

To every 100 kg of each concentrate mixture, 30 grams of Nicomix AB_2D_3K (Nicholas Piramal India Ltd, Mumbai) was also added.

*Composition per Kilogram: $MnSo_4$ - 688.5g, ZnO - 268.0g, $COSo_4$ - 12.0g, CuSo4 - 20.7g and KI- 10.8g

Table 2a. Percentage chemical composition (dry matter basis) of concentrate mixtures and paddy straw

Nutrients	Concentrate mixture		Paddy straw
	Control ration	Treatment ration	
Dry Matter	92.53	93.70	88.82
Crude protein	20.80	20.66	4.58
Ether extract	3.09	3.28	0.69
Crude fibre	8.30	7.41	28.32
Total ash	9.17	9.10	14.90
Nitrogen free extract	58.64	59.55	51.51
NDF	38.20	37.99	70.11
ADF	10.80	10.99	44.42

Table2b. Percentage mineral composition (dry matter basis) of concentrate mixtures and paddy straw.

Minerals	Concentrate mixture		Paddy straw
	Control	Treatment	
Ca (g %)	0.42	0.86	0.27
P (g %)	0.53	0.48	0.22
Mg (g %)	0.25	0.20	0.13
Zn (mg %)	3.33	2.95	4.10

Results

4. RESULTS

The results of the present study are presented in the tables under various sub headings.

4.1 PREGNANCY

Data recorded during the last one month of pregnancy on average fortnightly body weight and daily dry matter intake of animals in Group I and Group II fed two dietary treatments viz., T1 (control ration) wherein the compounded cattle feed contained 0.5 per cent calcium and T2 (experimental ration) wherein compounded cattle feed contained 1.0 per cent calcium with paddy straw as the sole roughage in both rations respectively are depicted in tables 3 and 4. The serum mineral concentration of cows in Group I and Group II recorded at the start of the experiment are given in table 5. The initial body weight of the animals belonging to the Group I and II at the start of the experiment was 367.33 and 380.83 kg and that before calving was 389.00 and 402.33 Kg respectively. The average daily dry matter intake during pregnancy of the animals of Group I and II were 8.95 and 9.48 kg respectively.

4.2 LACTATION

4.2.1 Body Weight Changes During Lactation

Data on mean fortnightly body weight of cows in Group I and II maintained on rations A and B respectively are set out in table 6 and depicted graphically in Fig.1.

4.2.2 Dry Matter Intake

The average daily dry matter intake of the two groups of experimental cows during the first three months of lactation are presented in table 7 and graphically represented in figure 2. The mean cumulative dry matter intake recorded was 11.69 and 12.54 respectively. The dry matter intakes expressed as per cent of body weight and per kilogram metabolic body weight are also presented in table 7.

4.2.3 Milk Yield

Data on average daily milk yield of experimental cows of Group I and II recorded at fortnightly intervals are depicted in table 8 and illustrated graphically in figure 3. The mean cumulative milk yield recorded was 10.81 and 10.46 kg per day for Group I and II, respectively.

4.2.4 Milk Fat

Data on average daily milk fat per cent of experimental cows of Group I and II are depicted in table 9 and illustrated graphically in figure 4. The average milk fat per cent during the six fortnights of lactation studied was 3.86 and 3.78 respectively.

4.2.5 Total Solids and Solids Not Fat(SNF)

Data on average daily total solids and SNF per cent of experimental cows of Group I and II are depicted in table 10 and 11 and illustrated graphically in figure 5 and 6 respectively. The average total solids and SNF per cent during the six months of lactation studied was 12.46 and 12.64: 8.39 and 8.67 respectively for the Group I and II.

4.2.6 Serum Minerals

Data on serum mineral concentration of the experimental cows in Group I and II recorded before and after calving and at the first, second and third month of lactation are given in table 12 and 13 respectively and illustrated graphically in figure 7.

4.2.7 Mineral Composition of Milk

Data on mineral composition of milk in the experimental cows of Group I and II recorded immediately after calving and at the first, second and third month of lactation are presented in table 14 and illustrated in figure 8.

4.2.8 Metabolism Trial

Data on the metabolism trials conducted during the first month of lactation with respect to dry matter intake, dry matter outgo through dung, output of urine and milk are presented in table 15. The mineral content of the concentrate and paddy straw fed during the metabolism trials are given in table 16. The mineral content of dung, milk and urine collected from the experimental animals during the metabolism trial are given in table 17,18 and 19 respectively.

4.2.9 Mineral Balance

Data on retention of Ca, P, Mg and Zn in experimental animals during first months of lactation are depicted in tables20 to 23, consolidated in table 24 and graphically illustrated in figure 9. The average retention per cent for the animals of Group I and II are –14.34 and 17.80 for Ca, 6.39 and 6.80 for P, 16.23 and -10.09 for Mg and 56.61 and 58.48 for Zn respectively. Significant difference ($P<0.05$) was obtained for the Ca balance, Mg balance and per cent retention of Ca and Mg between two groups.

4.2.10 Incidence of Metabolic Disorders

No incidence of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis were observed in the experimental animals of the Group I and II during the course of the experiment.

Table 3. Fortnightly body weight* of experimental animals maintained on two dietary treatments during pregnancy, kg

Fortnight	Group I	Group II
1	367.33 ± 16.08	380.83 ± 13.10
2	389.00 ± 14.88	402.33 ± 12.61

*Average of six values

Table 4. Average daily dry matter intake* of experimental cows during pregnancy, kg

Fortnights	Group I			Group II		
	Conc.	Straw	Total DMI•	Conc.	Straw	Total DMI•
1	2.81±0.05	5.80±0.07	8.61±0.12	2.96±0.10	6.27±0.49	9.23±0.14
2	3.03±0.27	6.27±0.4	9.30±0.14	3.78±0.34	5.95±0.14	9.73±0.32
Mean ± SE	2.92±0.06	6.03±0.14	8.95±0.12	3.37±0.25	6.11±0.009	9.48±0.24

• DMI – Dry matter intake
* Average of six values

Table 5. Serum mineral content* of experimental animals at the start of experiment

Parameter	Group I	Group II
Ca (mg %)	8.59±0.76	8.55±0.73
P (mg %)	4.25±0.11	4.94±0.53
Mg (mg %)	3.02±0.05	2.80±0.10
Zn (ppm)	0.83±0.23	1.04±0.18

*Average of six values

Table 6. Fortnightly body weight* of experimental animals during lactation, kg

Fortnights	Group I	Group II
0	358.66±12.74	357.16±10.94
1	354.16±10.40	356.50±11.77
2	352.83±10.57	352.66±10.29
3	350.83±12.03	351.66±10.66
4	350.33±11.90	350.99±11.57
5	352.00±12.20	353.66±11.22
6	354.00±12.64	355.83±11.49

*Average of six values

Table 7. Average daily dry matter intake* (DMI) of experimental cows at fortnightly intervals for three months of lactation, kg

Fort-nights	Group I					Group II				
	Concentrate	Straw	Total DMI (Kg)	DMI as % b.wt	DMI/ Kg^0.75	Concentrate	Straw	Total DMI (Kg)	DMI as % b.wt	DMI/ Kg^0.75
1	5.86±0.83	5.88±0.11	11.74±0.57	3.25± 0.19	0.14± 0.005	6.15±0.33	6.05±0.08	12.20±0.30	3.45± 0.12	0.14± 0.004
2	6.29±0.09	5.73±0.16	12.02±0.21	3.41± 0.14	0.14± 0.005	6.56±0.01	6.08±0.05	12.64±0.05	3.56± 0.10	0.15± 0.003
3	6.35±0.11	5.69±0.21	12.04±0.28	3.41± 0.13	0.14± 0.005	6.55±0.00	6.14±0.06	12.69±0.06	3.57± 0.13	0.15± 0.004
4	6.26±0.12	5.43±0.36	11.69±0.47	3.25± 0.17	0.14± 0.007	6.48±0.08	6.11±0.09	12.59±0.05	3.47± 0.11	0.15± 0.002
5	6.12±0.20	5.29±0.39	11.41±0.57	3.25± 0.19	0.14± 0.007	6.52±0.03	6.11±0.09	12.63±0.12	3.45± 0.08	0.15± 0.002
6	6.17±0.24	5.14±0.38	11.31±0.58	3.21± 0.19	0.13± 0.007	6.54±0.01	6.00±0.09	12.54±0.10	3.44± .08	0.15± 0.002
Mean ± SE	6.17±0.07	5.52±0.12	11.69±0.14	3.30± 0.03	0.14± 0.002	6.46±0.07	6.08±0.02	12.54±0.07	3.49± 0.02	0.148± 0.001

*Average of six values

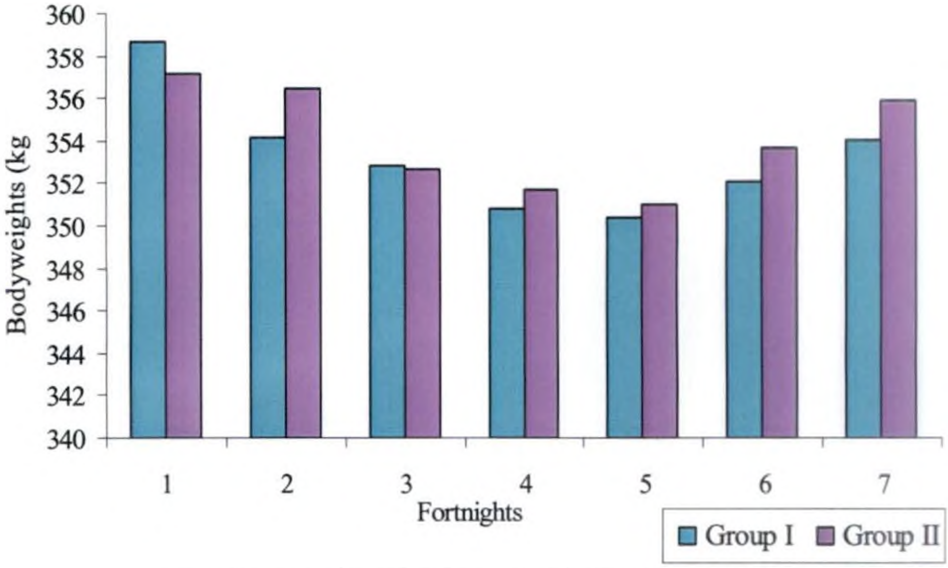

Fig. 1 Average fortnightly body weight of experimental cows maintained on two dietary treatments during lactation,Kg

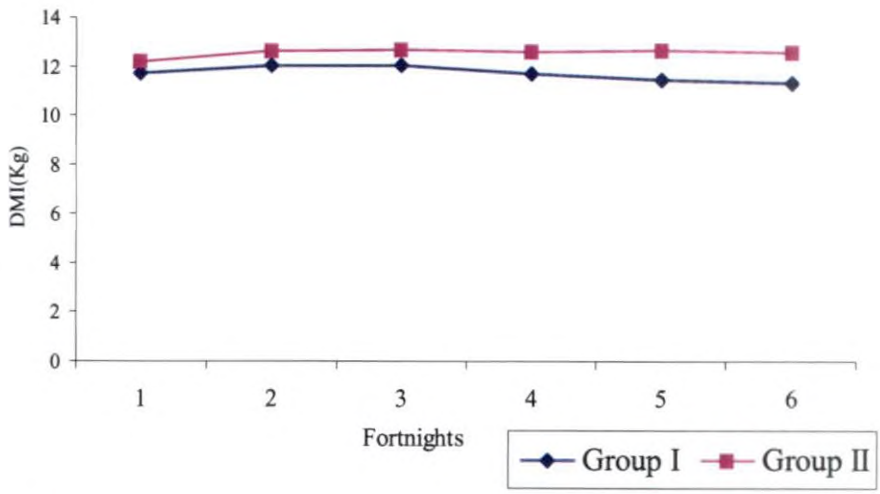

Fig. 2 Average daily dry matter intake of experimental cows maintained on two dietary treatments,Kg

Table 8. Average daily milk yield* of cows maintained on two dietary treatments at fortnightly intervals for three months of lactation, kg

Fortnights	Group I	Group II
1	9.87 ± 0.96	10.21 ± 0.55
2	11.66 ± 0.69	11.24 ± 0.71
3	11.61 ± 0.77	11.25 ± 0.85
4	10.99 ± 0.80	10.82 ± 0.80
5	10.74 ± 0.80	9.64 ± 0.76
6	9.99 ± 0.58	9.64 ± 0.76
Mean ± SE	10.81 ± 0.31	10.46 ± 0.33

*Average of six values

Table 9. Fat content of milk* from cows maintained on two dietary treatments, %

Fortnights	Group I	Group II
1	3.60 ± 0.10	3.45 ± 0.11
2	3.80 ± 0.15	3.64 ± 0.05
3	3.90 ± 0.13	3.80 ± 0.18
4	3.90 ± 0.13	3.95 ± 0.11
5	3.99 ± 0.11	3.87 ± 0.11
6	3.98 ± 0.09	3.99 ± 0.12
Mean ± SE	3.86 ± 0.09	3.78 ± 0.12

*Average of six values

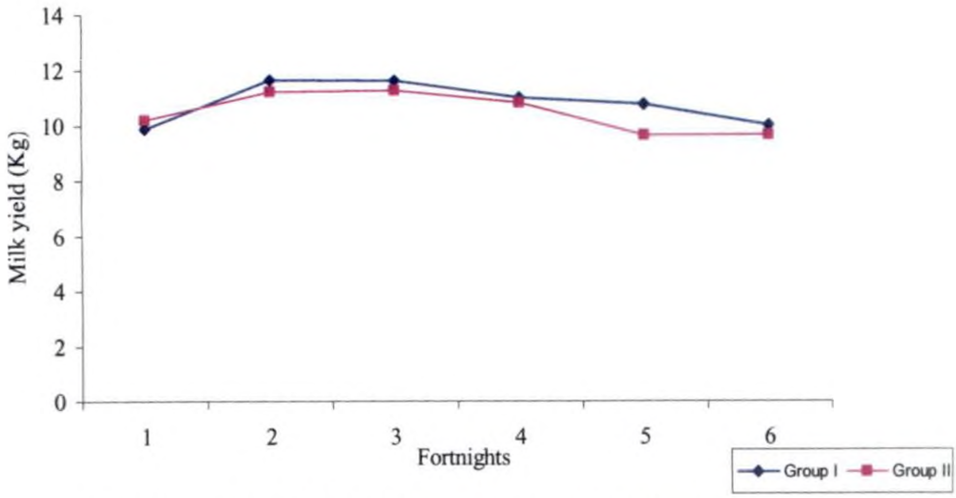

Fig.3. Average daily milk yield of experimental cows maintained on two dietary treatments,Kg

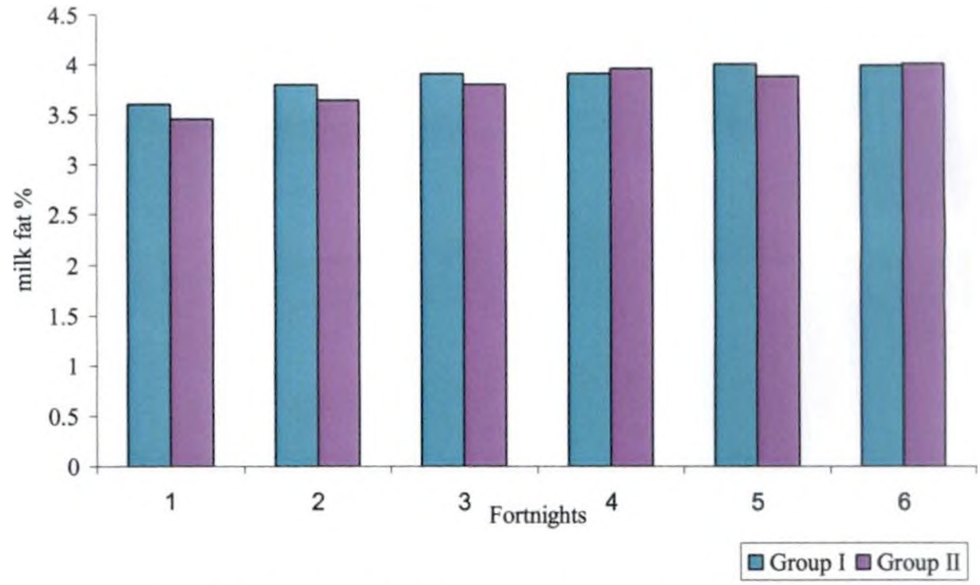

Fig. 4 Fat content of milk from cows maintained on two dietary treatments.%

Table 10. Total solids content of milk* from cows maintained on two dietary treatments, %

Fortnights	Group I	Group II
1	11.55 ± 0.17	12.18 ± 0.16
2	12.75 ± 0.21	12.27 ± 0.18
3	12.52 ± 0.11	12.65 ± 0.18
4	12.55 ± 0.10	12.85 ± 0.16
5	12.88 ± 0.15	12.78 ± 0.06
6	13.14 ± 0.15	13.10 ± 0.15
Mean ± SE	12.46 ± 0.25	12.64 ± 0.15

*Average of six values

Table 11. Solids not fat (SNF) content of milk* from cows maintained on two dietary treatments, %

Fortnights	Group I	Group II
1	7.98 ± 0.21	8.70 ± 0.19
2	8.33 ± 0.31	8.57 ± 0.17
3	8.60 ± 0.19	8.66 ± 0.31
4	8.18 ± 0.28	8.85 ± 0.23
5	8.61 ± 0.11	8.61 ± 0.12
6	8.64 ± 0.20	8.65 ± 0.19
Mean ± SE	8.39 ± 0.12	8.67 ± 0.04

*Average of six values

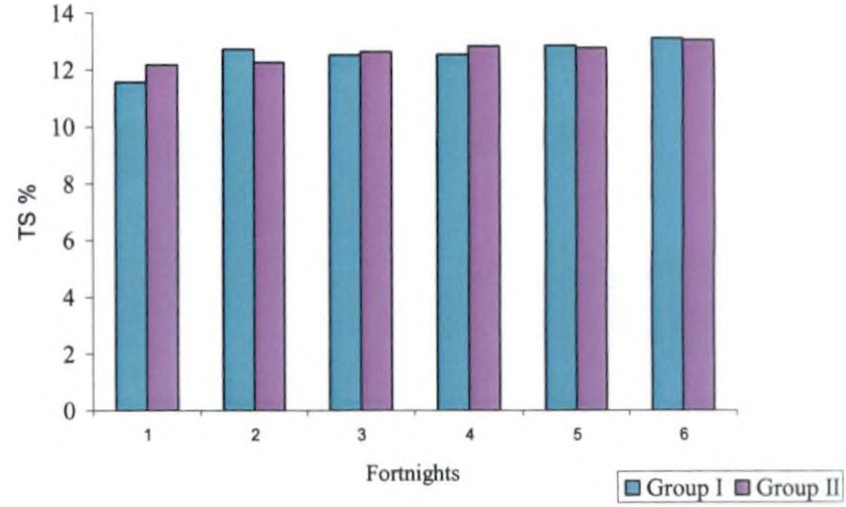

Fig.5 Total solids content of milk from cows maintained on two dietary treatments,%

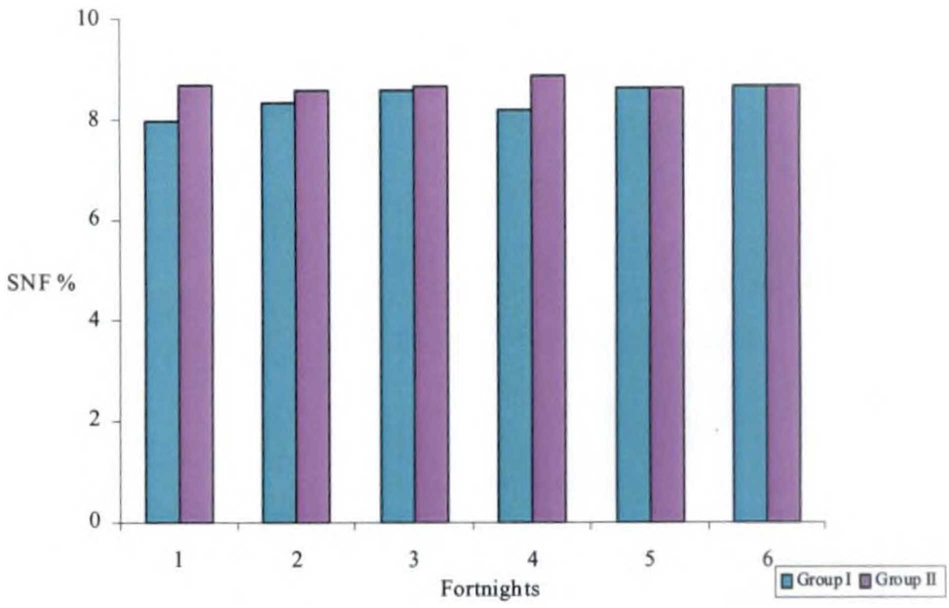

Fig.6 Solids Not Fat(SNF) % of milk from cows maintained on two dietary Treatments

Table 12. Serum mineral content* of cows maintained on two dietary treatments before and after calving

Parameter	Group I		Group II	
	BC	AC	BC	AC
Ca (mg%)	8.18 ± 0.53	8.00 ± 0.44	8.3 ± 0.52	7.87 ± 0.46
P (mg%)	3.51 ± 0.15	3.99 ± 0.70	4.27 ± 0.74	4.18 ± 0.68
Mg (mg%)	2.96 ± 0.22	2.83 ± 0.25	3.00 ± 0.15	2.86 ± 0.14
Zn (ppm)	1.22 ± 0.21	1.5 ± 0.44	1.5 ± 0.44	1.04 ± 0.18

*Average of six values, BC – Before calving, AC – After calving

Table 13. Serum mineral content* of cows maintained on two dietary treatments for three months of lactation

Parameter	First month of lactation		Second month of lactation		Third month of lactati	
	Group I	Group II	Group I	Group II	Group I	Group
Ca (mg%)	7.78 ± 0.59	7.75 ± 0.18	9.11 ± 0.33	7.07 ± 0.23	9.45 ± 0.39	9.63 ± 0
P (mg%)	4.06 ± 0.39	4.50 ± 0.33	4.51 ± 0.61	4.50 ± 0.82	4.81 ± 0.94	4.23 ± 0
Mg (mg%)	2.91 ± 0.12	2.85 ± 0.17	2.93 ± 0.13	2.89 ± 0.06	2.93 ± 0.04	3.05 ± 0
Zn (ppm)	1.66 ± 0.33	0.91 ± 0.09	1.41 ± 0.21	1.25 ± 0.30	1.58 ± 0.29	0.96 ± 0

*Average of six values

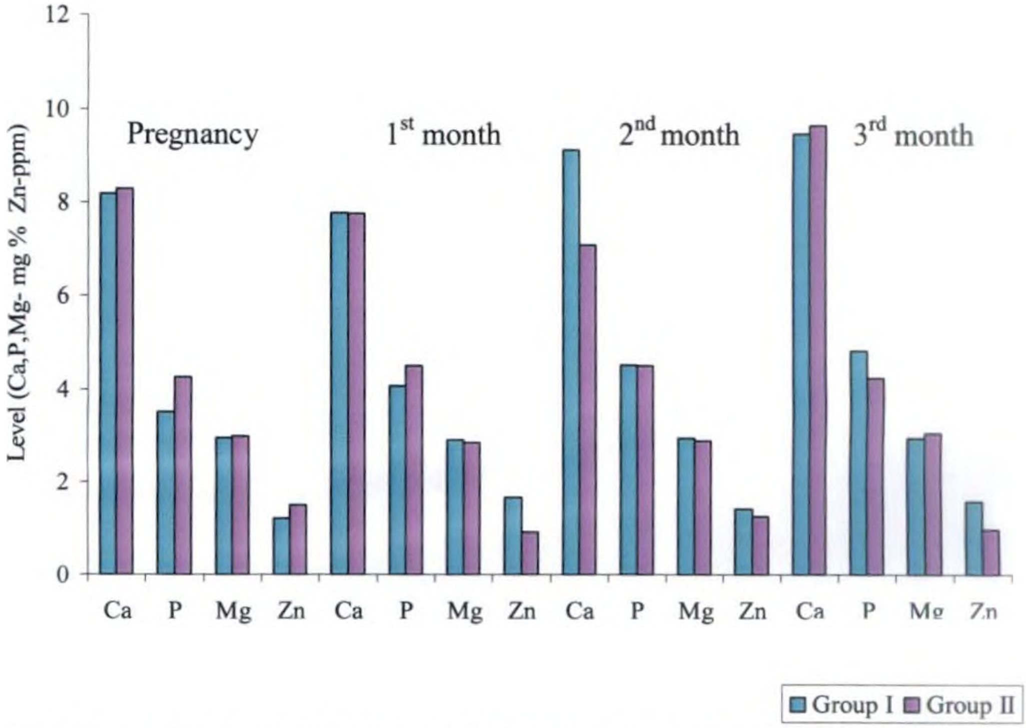

Fig .7. Serum mineral content of cows maintained on two dietary treatments

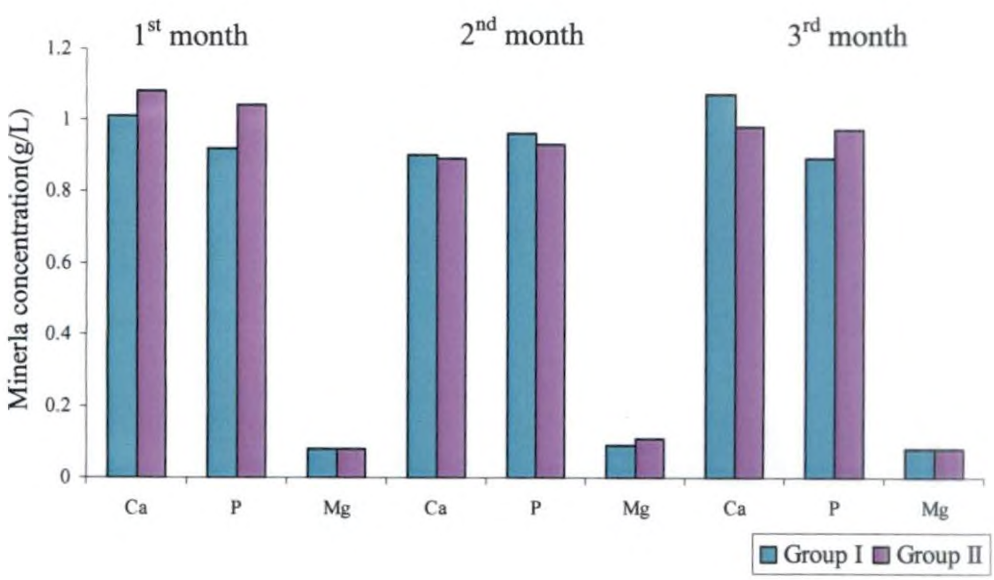

Fig.8. Mineral content of milk of cows maintained on two dietary treatments.

Table 14. Mineral content of milk* from cows maintained on two dietary treatments for three months of lactation, g/L

Parameter	AC**		First month		Second month		Third month		Average	
	Group I	Group I	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II
Ca (g/L)	1.89± 0.26	1.69 ± 0.17	1.01 ± 0.20	1.08 ± 0.27	0.9 ± 0.1	0.89 ± 0.04	1.07 ± 0.17	0.98 ± 0.11	0.98 ± 0.03	0.98 ± 0.04
P (g/L)	1.16± 0.06	1.14 ± 0.06	0.92 ± 0.13	1.04 ± 0.07	0.96 ± 0.10	0.93 ± 0.19	0.89 ± 0.07	0.97 ± 0.13	0.95 ± 0.02	0.98 ± 0.02
Mg (g/L)	0.53± 0.10	0.41 ± 0.05	0.08 ± 0.01	0.08 ± 0.01	0.09 ± 0.01	0.11 ± 0.04	0.08 ± 0.01	0.08 ± 0.19	0.08 ± 0.005	0.09 ± 0.007

*Average of six values **After calving.

Table 15. Average daily dry matter intake and outgo of dung, urine and milk during the metabolism trial, kg

Animal No.	Body weight	Dry matter intake			Dry matter outgo	Urine	Milk
		Conc	Straw	Total			
Group I							
1291	338	5.95	6.03	11.98	7.54	66.30	10.47
1262	366	6.47	6.09	12.56	4.85	11.82	13.15
1279	358	6.47	6.19	12.67	4.08	17.10	11.97
Co98	340	6.48	5.75	12.23	3.91	16.7	8.5
T736	330	6.47	5.75	12.22	4.34	9.76	11.57
1276	393	6.47	6.2	12.67	4.89	31.92	11.45
Mean ± SE	354.16 ± 10.4	6.38 ± 0.90	6.00 ± 0.09	12.38 ± 0.12	4.93 ± 1.2	25.6 ± 1.20	11.18 ± 0.70
Group II							
1281	320	6.55	5.94	12.49	5.07	15.19	10.47
1252	388	6.04	6.01	12.06	5.11	23.45	14.38
Co39	346	6.52	6.09	12.61	4.89	24.78	11.21
1223	338	6.51	6.15	12.66	4.06	11.39	9.2
Coo9	366	6.55	6.10	12.66	4.26	14.83	10.47
1233	381	6.55	5.75	12.31	4.24	15.79	10.1
Mean ± SE	356.5 ± 24.03	6.45 ± 0.90	6.00 ± 0.06	12.46 ± 0.10	4.60 ± 0.19	17.57 ± 8.31	10.97 ± 0.80

Table 16. Mineral composition of experimental diets fed to cows during the metabolism trial

Minerals	Control Ration	Treatment Ration	Paddy Straw
Ca (g/Kg)	5.3	9.5	2.6
P (g/Kg)	7.1	7.1	0.97
Mg (g/Kg)	2.51	2.59	1.02
Zn (ppm)	33.33	29.55	41.09

Table 17. Mineral composition of dung voided by experimental animals during the metabolism trial

Animal No.	Parameter			
	Group I			
	Ca (g/kg)	P (g/kg)	Mg (g/kg)	Zn (ppm)
1291	9.67	10.94	5.72	30.2
1262	8.90	7.80	4.16	31.5
1279	10.22	7.71	4.22	29.2
Co98	10.10	8.30	2.67	30
T736	7.60	7.50	2.74	28.2
1276	9.96	7.95	2.09	31.6
Mean ± SE	9.40 ± 0.44	8.36 ± 0.57	3.60 ± 0.29	29.25±1.2
	Group II			
1281	10.12	8.80	4.87	28.3
1252	9.90	7.70	3.42	26.5
Co39	9.49	7.00	4.53	27
1223	10.85	7.00	4.79	28.2
Coo9	10.40	6.81	3.42	33.2
1233	10.19	7.95	4.68	25.06
Mean ± SE	10.16 ± 0.21	7.54 ± 0.34	4.28± 0.30	28.77 ±0.17

Table 18. Mineral composition of milk voided by experimental animals during the metabolism trial

Animal No.	Parameter			
	Group I			
	Ca (g/kg)	P (g/kg)	Mg (g/kg))	Zn (ppm)
1291	1.40	1.04	0.08	4.60
1262	0.80	0.70	0.08	3.55
1279	0.95	0.90	0.06	4.00
Co98	0.945	1.07	0.08	4.60
T736	1.02	0.9	0.10	4.90
1276	0.95	0.93	0.10	5.00
Mean ± SE	1.01 ± .09	0.92 ± 0.05	0.08 ± 0.01	4.54 ± 0.31
	Group II			
1281	0.99	1.10	0.07	4.85
1252	0.80	0.95	0.06	3.00
Co39	0.98	0.99	0.10	5.60
1223	1.14	1.13	0.09	5.00
C009	0.84	1.02	0.08	5.90
1233	1.00	1.10	0.08	4.90
Mean ± SE	0.95 ± .05	1.04 ± 0.03	0.08 ±0.01	4.87 ± 0.45

Table 19. Mineral composition of urine voided by experimental animals during the metabolism trial

Animal No.	Parameter			
	Group I			
	Ca (g/kg)	P (g/kg)	Mg (g/kg)	Zn (ppm)
1291	0.12	0.02	0.16	0.04
1262	0.17	0.03	0.18	0.06
1279	0.11	0.02	0.17	0.06
Co98	0.17	0.02	0.185	0.03
T736	0.08	0.10	0.22	0.04
1276	0.34	0.06	0.17	0.04
Mean ± SE	0.16 ± -0.03	0.04 ± 0.01	0.18 ± 0.01	0.04 ± 0.04
	Group II			
1281	0.18	0.06	0.17	0.03
1252	0.14	0.02	0.18	0.02
Co39	0.19	0.08	0.10	0.03
1223	0.15	0.003	0.27	0.03
C009	0.14	0.08	0.18	0.02
1233	0.21	0.06	0.14	0.04
Mean ± SE	0.17 ± 0.01	0.05 ± 0.01	0.17 ± 0.01	0.02± 0.03

Table 20. Calcium balance of experimental cows maintained on two dietary treatments during the metabolism trial

Treatments	Group I	Group II
Number of cows	6	6
Ca intake (g/day)		
Concentrate	33.85 ± 0.74	61.35 ± 0.87
Straw	15.59 ± 0.23	15.61 ± 0.017
Total	49.44 ± 0.87	76.98 ± 0.87
Ca outgo (g/day)		
Dung	40.64 ± 2.68	40.26 ± 8.02
Urine	4.68 ± 1.53	4.62 ± 1.66
Milk	11.21 ± 0.89	11.70 ± 1.12
Total	56.54 ± 4.38	63.27 ± 2.70
Ca balance (g/day)	-7.09 ^{a} ± 4.05	13.71 ^{b}± 2.96
Per cent retention of Ca	-14.34 ^{a} ± 8.20	17.80 ^{b} ± 3.76

a, b – Values with different superscripts in the same row differ significantly between groups($P<0.05$)

Table 21. Phosphorus balance of experimental cows maintained on two dietary treatments during the metabolism trial

Treatments	Group I	Group II
Number of cows	6	6
P intake (g/day)		
Concentrate	45.35 ± 0.65	46.07 ± 0.70
Straw	5.81 ± 0.08	5.82 ± 0.06
Total	51.17 ± 0.68	51.90 ± 0.70
P outgo (g/day)		
Dung	37.12 ± 4.63	34.92 ± 2.27
Urine	0.86 ± 0.29	2.01 ± 1.03
Milk	9.89 ± 0.35	11.40 ± 0.52
Total	47.89 ± 4.74	48.36 ± 3.85
P balance (g/day)	3.27 ± 5.32	3.53 ± 4.16
Per cent retention of P	6.39 ± 3.50	6.80 ± 5.88

Table 22. Magnesium balance of experimental cows maintained on two dietary treatments during the metabolism trial

Treatments	Group I	Group II
Number of cows	6	6
Mg intake (g/day)		
Concentrate	16.61 ± 0.25	16.14 ± 0.22
Straw	6.11± 0.09	6.28 ± 0.19
Total	22.72 ± 0.25	22.43 ± 0.32
Mg outgo (g/day)		
Dung	13.78 ± 1.82	20.60 ± 1.12
Urine	4.26 ± 1.50	3.20 ± 0.43
Milk	0.99 ± 0.15	0.86 ± 0.06
Total	19.04 ± 2.27	24.66 ± 1.29
Mg balance (g/day)	$3.69^{a} \pm 2.42$	$-2.25^{b} \pm 2.91$
Per cent retention of Mg	$16.23^{a} \pm 10.78$	$-10.09^{b} \pm 5.77$

a, b – Values with different superscripts in the same row differ significantly between groups(P<0.05)

Table 23. Zinc balance of experimental cows maintained on two dietary treatments during the metabolism trial

Treatments	Group I	Group II
Number of cows	6	6
Zn intake (mg/day)		
Concentrate	212.62 ± 3.17	190.63 ± 2.68
Straw	246.60 ± 3.76	246.81 ± 2.68
Total	459.22 ± 4.73	437.44 ± 3.66
Zn outgo (mg/day)		
Dung	148.54 ±18.13	106.25 ± 6.75
Urine	1.10 ±0.37	0.47 ± 0.07
Milk	49.09 ± 2.17	52.32 ± 3.65
Total	198.74 ± 18.51	181.65 ± 8.76
Zn balance (mg/day)	260.48 ± 21.24	255.78 ±8.17
Per cent retention of Zn	56.61 ±4.35	58.48 ± 1.89

Table 24. Consolidated data on mineral balance during the metabolism trial

Parameter	Average retention (% of intake)	
	Group I	Group II
Ca	-14.34 ± 8.20	17.80 ± 3.76
P	6.39 ± 3.50	6.80 ± 2.63
Mg	16.23 ± 10.78	-10.09 ± 5.77
Zn	56.61 ± 4.35	58.48 ± 1.89

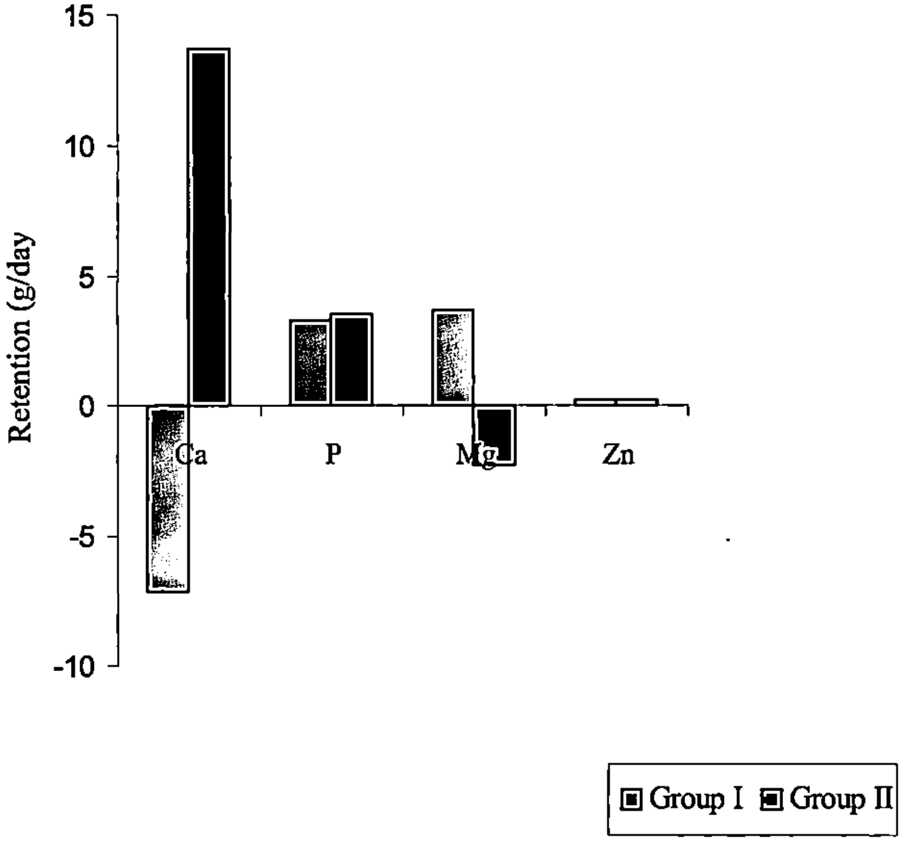

Fig.9 Mineral balance of experimental cows maintained on two dietary treatments

Discussion

5. DISCUSSION

The results obtained during the course of the experiment are discussed below under separate heads.

5.1 PREGNANCY

The experiment was conducted from the last month of pregnancy to three months of lactation. Daily dry matter intake and fortnightly body weight were recorded for the animals of Group I and II maintained on the two dietary treatments viz., T1 (control ration) where in the compounded cattle feed contained 0.5 per cent calcium and T2 (experimental ration) where in compounded cattle feed contained 1.0 per cent calcium respectively, and are presented in tables 3 and 4. All the experimental animals were in good body condition with increase in body weight as expected during pregnancy, the initial body weight being 367.33±16.08 and 380.83±13.10 kg, respectively and the final body weight recorded were 389±14.88and 402.33±12.61 kg respectively for the group I and II. No significant difference could be observed between the body weights of animals belonging to both the groups for the two fortnights. The dry matter intake of cows during pregnancy was sufficient to meet the requirements during pregnancy, the values being 8.95±0.12 and 9.48±0.24 kg for group I and II respectively and did not show any significant difference. The serum mineral concentration of cows in group I and II recorded at the start of the experiment are given in table 5, and graphically represented in figure 7. The average values for serum minerals at the start of the experiment for the animals in group I and II were 8.59±0.76 and 8.55±0.73 mg per cent for Ca, 4.25±0.11 and 4.94±0.53 mg per cent for P, 3.02±0.05 and 2.80±0.10 mg per cent for Mg and 0.83±0.23 and 1.04±0.18 ppm for Zn respectively. The data on serum mineral concentrations obtained at the start of the experiment were within the normal range reported for the species. Higher values than those obtained in the present study were reported by Syam Mohan (2003) except for serum Mg for which almost similar values was reported. The values for serum Ca, P, Mg and Zn reported were 10.50, 8.02, 3.17 and 1.96 mg per cent for the crossbred cattle of Kerala in the eighth month of pregnancy.

Based on the results obtained on the dry matter intake, body weight and serum mineral content it could be inferred that all the experimental animals were in normal physiological status. No symptoms of any metabolic disease were also observed during the pregnancy.

5.2 LACTATION

5.2.1 Body Weight Changes during Lactation

Mean fortnightly body weight of cows in group I and II maintained on the two dietary treatments viz., T1 (0.5 per cent Ca in compounded cattle feed) and T2 (one per cent Ca in compounded cattle feed) respectively are set out in table 6 and depicted graphically in figure 1. The average initial body weight of cows after calving were 358.66±12.74 and 357.16± 10.94 kg respectively for the group I and II. Thereafter bodyweight declined for animals in both the groups and the animals of group I and II started gaining the body weight from the fifth fortnight. Thereafter cows of both group recorded an increasing trend in body weight during the experimental period of three months of lactation. The final bodyweight on completion of three months of lactation were 354.00±12.64 and 355.83 ± 11.49 kg respectively for group I and II. Statistical analysis of the data on fortnightly bodyweights of animals in the two groups showed no significant difference during any of the fortnights studied.

This observation is in accordance with the findings of Touchberry and Batra (1976) who observed decline in body weight only during the first and second month of lactation and a steady increase thereafter in Holstein, Guernsey and their crosses. Where as Syam Mohan (2003) reported a decline in bodyweight for the cross bred lactating cattle of Kerala after calving and the animals regained their initial body weight only in the seventh fortnight.

5.2.2 Dry Matter Intake

The average daily dry matter intake of experimental cows during the first six fortnights of lactation are presented in table 7 and graphically represented in figure 2. The overall average daily dry matter intakes of the animals in group I and II were 11.69± 0.14 kg and 12.54 ± 0.07 kg. The average dry matter intake when expressed as per cent body weight was 3.30 ± 0.03 and 3.49±0.02 and the corresponding values for metabolic body size were 0.13±0.002 kg and 0.148±0.001 kg for group I and II respectively. Similar values for dry matter intake was reported by Syam Mohan (2003) in the lactating cross bred cattle of Kerala under green grass based system of feeding, where as lower values of dry matter intake than those obtained from the present study were obtained under paddy straw based system of feeding. The values reported were 11.53 and 10.01 for green grass based and paddy straw based systems of feeding respectively. The average dry matter intake expressed as per cent body weight and the corresponding values for metabolic body size under green grass based system of feeding are also comparable in these two studies.

Lower values of dry matter intake than those reported in the present study was obtained by Sheena (2005) in the cross bred cows of Kerala under early lactation the values was in the range of 10.53-10.65. Higher values than that obtained in the present study were reported by Raina *et al.* (1976) and Sharma *et al.* (1976) who obtained values of 13.55±0.272 and 13.33 kg respectively for cross-bred milch cows in India. The values obtained for the dry matter intake expressed as per cent of the body weight for the animals of group I and II were in par with the values of 3 to 3.6 per cent reported by Edwards *et al.*. (1980) and Annexstad *et al.* (1987).

5.2. 3 Milk Yield

Average daily milk yield during the six fortnights of experimental cows of group I and II maintained under the two different dietary treatments presented in table 8 and illustrated graphically in figure 3, reveal that cows of both groups attained peak yield in the second fortnight and maintained it to the third fortnight, the values being 11.66± 0.69 and 11.24 ± 0.71 kg for the second fortnight and those for the third fortnight were 11.61± 0.77 and 11.25± 0.85 kg respectively for the animals of group I and II. Milk yield was gradually reduced there after the values being 10.99± 0.80 kg and 10.82± 0.80 kg for the fourth fortnight and 10.74± 0.80 kg and 9.64± 0.76 kg for the fifth fortnight respectively for the animals of group I and II.

The average values for the milk yield for crossbred cattle in Kerala obtained by Devasia (1989) and Varghese (1998) were lower than the values obtained in the present study for all the fortnights. The trend in the decline also showed variation where in Devasia (1989) observed increase in the milk yield up to sixth fortnight with a further decline during the subsequent fortnights, whereas peak yield in the present study was obtained in both the groups in the second fortnight itself and it was maintained only up to the third fortnight in both the groups. The overall average milk yield per day obtained in the present study during the three months of lactation were 10.81±0.31 and 10.46±0.33 respectively for the group I and II, were in agreement to that obtained by Syam Mohan (2003) for the cross bred lactating cattle of Kerala. Lower values than those obtained from the present study were reported by Sheena (2005) the average value being 9.30 for the early lactating cross bred cows of Kerala.

5.2. 4 Milk Fat

The average daily milk fat percentage of experimental cows of group I and II maintained under the two dietary treatments during the six fortnights are presented in table 9 and illustrated graphically in figure 4. Average milk fat percent during the three months of lactation were 3.86±0.09 for group I and 3.78±0.12 for group II. No significant difference could be observed for the fat per cent between the two groups during the period of study. The values obtained in the present study are within the range of 3.46 to 4.23 for early lactation reported for crossbred cattle in Kerala (Radhika, 1997). Comparable values of milk fat were obtained by Sheena (2005) in the range of 3.95-4.06 for the cross bred cows of Kerala in early lactation. Devasia (1989) reported values in the range of 4.95 to 5.10 per cent for crossbred dairy cattle in Kerala. Pradhan *et al.* (1975) and Chawla and Mishra (1976) also reported higher values ranging from 5.1 to 5.7 and 4.42 to 5.15 per cent respectively than those reported in the present study where as Iype *et al.* (1994) reported average values of 3.28 for milk fat of crossbred cattle in Kerala.

5.2.5 Total Solids and Solids Not Fat Per cent

The average daily total solids and solids not fat (SNF) per cent of milk of cows during the six fortnights of experimental cows of group I and II maintained under the two different dietary treatments are presented in table 10 and 11 and illustrated graphically in figure 5 and 6. Average values of total solids and SNF during the three months of lactation were 12.46±0.25 and 12.64±0.15: 8.39±0.12 and 8.67±0.04 for group I and group II. No significant difference could be observed for the total solids and SNF per cent between the two groups during the period of study. Almost similar values of total solids and SNF percent in milk was obtained by Sheena (2005) who reported values for total solids and SNF per cent in the range of 12.1-12.8 and 8.30-8.88 respectively in the early lactating cross bred cows of Kerala. Comparable values of SNF per cent was obtained by Gowda and Prasad (2005) in Holstein Fresian cross bred medium yielding cows the values being 8.9 and 8.8.

5.2. 6 Serum Minerals

Serum concentration of Ca, P, Mg, and Zn of cows in group I and II recorded before and after calving are presented in tables 12 and illustrated in figure 7. The values recorded for Ca in group I and II were 8.18±0.53 and 8.3±0.52 before calving and 8.00±0.44 and 7.87±0.46 after calving (mg per cent), for P were 3.51± 0.15 and 4.27±0.74 before calving and 3.99±0.70 and 4.18±0.68 after calving (mg per cent), for Mg were 2.96±0.22 and 3.00±0.15 before calving, 2.83±0.25 and 2.86±0.14 after calving(mg per cent) and for Zn (ppm) were 1.22±0.21 and 1.5±0.44 before calving and 1.5±0.44 and 1.04±0.18 after calving respectively. Murtuza *et al.* (1979) reported higher values than those from the present study for serum minerals except for serum Mg. The values being 11.22 and 9.85 for serum Ca, 5.24 and 3.44 for serum P, 2.17 and 2.28 for serum magnesium in late pregnant and early lactating cows respectively.

Serum concentration of Ca, P, Mg, and Zn of the experimental cows in group I and II at the first, second and third month of lactation are presented in table 13 and illustrated in figure 7. No significant differences were observed between the values for serum minerals of animals in group I and II during the different periods of lactation studied. The average values for serum Ca at the first, second and third month of lactation were 7.78±0.59, 9.11±0.33 and 9.45±0.39 for group I and 7.75±0.18, 7.07±0.23 and 9.63±0.33 mg per cent for group II. Regarding inorganic P the average serum values recorded during the first, second and third month of lactation were 4.06±0.39, 4.51±0.61 and 4.81±0.94 for group I and 4.50±0.33, 4.50±0.82 and 4.23±0.69 mg per cent for group II respectively. Similar to Ca and P, normal levels were recorded for serum Mg during the first, second and third month of lactation the values being 2.91±0.12, 2.93±0.13 and 2.93±0.04 for group I and 2.85±0.17, 2.89±0.06 and 3.05±0.004 mg per cent for group II respectively. For serum Zn were 1.66±0.33, 1.41±0.21 and 1.58±0.29 for group I and 0.91±0.09, 1.25±0.30 and 0.96±0.29 respectively for three months of lactation in group II respectively. Syam Mohan (2003) reported higher values of serum Ca, P, Mg and Zn in the range of 10.17 -11.17, 5.02 -5.01, 3.25 -3.08(mg%), 1.78 - 1.84(ppm) respectively in the cross bred cattle of Kerala under grass based and paddy straw based systems of feeding during the first month of lactation. On perusal of the data obtained by Varghese (1998) who assessed the serum mineral status of lactating cattle in Kerala, the values obtained in the present study for both groups fall with in the range reported by him. According to him average values of serum Zn lies in the range of 0.93 -1.92(ppm) in the cross bred cattle of Kerala. The results obtained with respect to serum minerals fall in the normal range reported for the species by Underwood (1981). In accordance with the results obtained in the present study lack of effect of dietary levels of Ca on serum mineral concentrations were reported by Steevens *et al.* (1971) and by Chan *et al.* (2006) at 0.99 and 1.5 per cent levels in ration. Since there is no significant difference in the values of serum minerals between the two groups during lactation it could be inferred that the different levels of calcium in the compounded ration for group I and II did not affect the serum mineral status.

5.2.7 Mineral Composition of Milk

Concentration of Ca, P, and Mg in milk of the experimental cows in group I and II recorded at first, second, and third month of lactation are presented in table 13 and illustrated graphically in figure 8. The mineral content of milk collected immediately after calving were 1.89±0.26 and 1.69±0.17 for Ca, 1.16± 0.06 and 1.14±0.06 for P and 0.53±0.10 and 0.41±0.05 for Mg in g/L respectively for group I and II. The average mineral content with respect to first, second and third month of lactation for the animals of group I were1.01±0.20, 0.9±0.1 and 1.07±0.17 g/L for Ca, 0.92±0.03, 0.96±0.10 and 0.89±0.07g/L for P and 0.08±0.01, 0.09±0.01 and 0.08±0.01 g/L for Mg in group I. Those in group II were 1.08±0.27, 0.89±0.04 and

0.98±0.11 g/L for Ca, and 1.04±0.07, 0.93±0.19; and 0.97±0.13 g/L for P, and 0.08±0.01, 0.11±0.04 and 0.08±0.19 g / L for Mg, respectively. The overall average mineral composition of milk of the animals of group I and II for three months of lactation were 0.98±0.03 and 0.98±0.04 g / L for Ca, 0.92±0.015 and 0.98±0.02 g / L for P, 0.08±0.002 and 0.09±0.009 g / L for Mg. Statistical analysis of the data on mineral content in milk estimated at different periods of lactation did not reveal any significant difference between the groups and the values obtained in milk mineral concentration are within the normal range reported for the species.

Overall average obtained in the present study for Ca, P and Mg were found to be lower than the results obtained by Cerbullis and Farrel (1976) who obtained values for Ca, P and Mg as 1.25 g, 1.14 g and 0.11 g / L respectively and Penington *et al.* (1987) who obtained values as 1.06, 0.83 and 0.098 respectively. Syam Mohan (2003) in his assessment of dietary levels of minerals for lactation in the cross bred cattle of Kerala reported average mineral content of milk as 1.22, 0.99, 0.11 g/L, for Ca, P, Mg under paddy straw based system of feeding.

Results of the present study suggest that mineral composition of milk is not altered by the two different levels of dietary calcium followed in the present study.

5.2.8 Mineral Balance

The results on the mineral balance of experimental animals in group I and II maintained on the two dietary treatments viz., T1 (0.5 per cent Ca in compounded cattle feed) and T2 (one per cent Ca in compounded cattle feed) respectively are detailed in table 20 to 23 and consolidated in table 24 and illustrated in figure 9.

5.2.8.1 Calcium Balance

Results on Ca balance of the experimental animals belonging to group I and II maintained on two dietary treatments respectively are depicted in table 20 and consolidated in table 24. The average daily retention for the group I and II were –7.09±4.05 g and 13.71±2.96 g against an average daily intake of 49.44±0.87 and 76.98±0.87 g (dietary levels of 0.39 and 0.61 per cent in group I and II) and the corresponding per cent retention were –14.34±8.20 and 17.80±3.76 respectively during the first month of lactation. Statistical analysis of the data revealed significant difference for retention between the two groups ($P<0.05$). The present study agrees with the observations of Hansard *et al.* (1954, 1957) who reported an apparent absorption of –19 to +26 for Ca in adult cattle. Higher values of Ca balance was reported by Syam Mohan (2003), the average daily retention were in the range of 10.74-14.93g at dietary level of 0.55 percent in ration and the corresponding per cent retention were in the range of 18.54-24.13 during the third month of lactation. Lower values of dietary intake and difference in the stage of lactation may be the reason for the lower values of Ca balance obtained in the present study. Mc Donald *et al.* (1995) stated from the balance experiments that even very liberal allowances of Ca and P are frequently inadequate to meet the needs of the cow for these elements during the early part of lactation. Anon (1994) reported marginally lower negative balance –4.24 g/day for maintenance in cattle and attributed it to poor availability of Ca due to higher oxalate content in paddy straw.

Results of the current study indicate that calcium at one per cent level in compounded cattle feed is better than 0.5 per cent level, to avoid negative balance of calcium in early stages of lactation, when paddy straw formed the sole roughage source. As evidenced from the data on calcium balance in the animals of group I (0.5 per cent calcium in compounded cattle feed) the calcium intake per day was insufficient to meet the calcium demand and the animals were in negative balance.

The serum values for Ca were within the normal range reported for species and no metabolic disorders were observed in any of the experimental cows including those in negative balance possibly due to the homeostatic mechanisms. Hence it could be inferred that feeding one per cent Ca in compounded cattle feed along with paddy straw was better to meet the Ca requirement at first month of lactation.

5.2.8.2 Phosphorus Balance

Results on P balance of the experimental animals fed the two dietary treatments, are presented in table 21 and consolidated in table 24 reveal an average daily retention of 3.27±5.32 and 3.53±4.16 g with a corresponding per cent retention of 6.39±3.50 and 6.80±5.88 against a daily intake of 51.17±0.68 and 51.90±0.70 g (dietary levels of 0.41 per cent) respectively for the group I and II. The P requirement was met in the ration from the ingredients alone without any inorganic P supplementation. Statistical analysis of the data revealed no significant difference between the two groups. The retention values obtained in the present study are in agreement with that obtained by Ward *et al.* (1972) who reported retention values for P ranging from -3 to 6 g / day in lactating cows. Syam Mohan (2003) obtained an average daily retention of 0.06-0.46 g with a corresponding per cent retention of 0.02-1.82 against a daily intake of 35.60-36.07 g (dietary levels in the range of 0.32-0.36 per cent) during the third month of lactation.

The values obtained for P balances are in agreement with Kinal *et al.* (1999) who reported an average daily P balance of 3.4 to 11g per day in lactating cows. Compared to the present study higher values of 23.14 and 47.39 per cent retention of P during the fourth and fifth month of lactation was reported by Anon (2001) in which the higher values were obtained at a higher dietary intake achieved by inorganic P supplementation. Knowlton and Herbein (2002) after studying the P partitioning during early lactation in dairy cows fed diets varying in P content reported that P balance was highly variable and the cows fed 0.34 per cent P diet were in negative balance longer than were cows fed diets containing 0.51 and 0.61 per cent P.

The results of the present study suggest that different levels of dietary Ca followed in the present study did not alter the availability of P in the ration.

5.2.8.3 Magnesium Balance

Results on Mg balance of the experimental animals fed the two dietary treatments, presented in table 22 and consolidated in table 24 revealed an average daily retention of 3.69 ± 2.42 and -2.25 ± 2.91 g with a corresponding per cent retention of 16.23 ± 10.78 and –10.09 ± 5.77 against a daily intake of 22.72 ± 0.25 and 22.43 ± 0.32 respectively for the group I and II. The Mg requirement was met in the ration from the ingredients alone without any inorganic supplementation. Statistical analysis of the data revealed significant difference for retention and retention as percentage of intake ($P<0.05$). Syam Mohan (2003) recorded an average daily retention in the range of 3.51-6.80 g with corresponding per cent retention in the range of 11.84-16.70 against daily intakes in the range of 30.45-41.20 during the third month of lactation. Higher values than those obtained in the present study were reported possibly due to higher dietary levels of the element.

The results obtained in the present study are very much agreeing with the results obtained by other workers. Rook and Storry (1962) reported availability of Mg in diets to range from 5 to 30 per cent. Similar values for apparent absorption of Mg ranging from 9 to 54 per cent were also observed by many workers in ruminants consuming mixed concentrates and roughage diets, although most values were between 15 and 30 per cent (Monroe, 1924; Pfeffer *et al.*, 1970; Poe *et al.*, 1985; Teller and Godeau, 1987; Chester Jones *et al.*, 1989). Anon. (2001) stated that the average Mg retention percent during the fourth and fifth month of lactation in crossbred cows of Kerala were 39.25 and 53.78 against a dietary intake of 29.37 and

31.55 g respectively in which the higher values were obtained at a higher dietary intake achieved by inorganic supplementation. The results of the present study are suggestive of significant effect of dietary Ca on Mg retention, this may be explained on the basis of mineral interactions existing between Ca and Mg. Jacobson *et al.* (1972) reported that requirement of Mg increased as dietary levels of Ca increased. Chicco *et al.* (1973) recorded that increased concentration of dietary Ca (0.78 per cent) decreases Mg utilization in ruminants and enhanced the urinary loss of Mg. Hence, it may be inferred that even though high levels of Ca improve Ca balance there is a need for Mg supplementation to avoid negative balance of the element arising due to interaction of the two elements.

5.2.8.4 Zinc Balance

Results on Zn balance of the experimental animals fed the two dietary treatments are depicted in table 23 and consolidated in table 24. Data on Zn balance estimated from the metabolism trial revealed that the average daily intake of Zn were 459.22 $\pm$ 4.73 and 437.44$\pm$3.66 mg in group I and II respectively. The average retention were 260.48$\pm$ 21.24 and 255.78$\pm$8.17 mg for the group I and II respectively. The per cent retention recorded in group I and II were 56.61$\pm$4.35 and 58.48+1.89 respectively suggesting that the animals were in positive balance and there was no significant difference between the groups. Anon (2001) has reported values for per cent retention of Zn ranging from 29.45 to 36.54 per cent which are almost similar to those observed in the present study. Syam Mohan (2003) reported an average daily retention of 42.32 and 30.14 during the third month of lactation in the cross bred cattle of Kerala. Kirschgessner and Schwarz (1976) observed that under condition of Zn deficiency the cows exhibited a negative Zn balance where animals with the higher milk yields showed the most negative Zn balance and remained for the longest period in the negative phase.

The above discussion shows that retention values obtained in the present study agree with that in the literature, also the animals exhibited normal values of serum and milk of the element. Hence it can be inferred that the different dietary levels of calcium followed in the present study did not alter the availability of Zn in the ration.

5.2.9 Incidence of Metabolic Disorders

Manifestations of symptoms of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis were not observed during the course of study. The serum levels of Ca and Mg were also within the normal limits specified for healthy animals. Rothera's test for the presence of ketone bodies in urine used for testing the incidence of ketosis in animals, also proved to be negative. The results are suggestive that Ca at one per cent level in compounded cattle feed is better than 0.5 per cent level to avoid negative balance of calcium during early lactation when paddy straw is the sole roughage source.

Summary

6. SUMMARY

A study was conducted to assess the different levels of dietary Ca on the performance and mineral availability in cross bred dairy cattle. Twelve healthy crossbred cows at the last month of pregnancy, which had an average peak yield of minimum eight litres per day in their previous lactation were divided into two groups (Group I and Group II) of six each as uniformly as possible with regard to age and milk yield. The experimental animals of group I and II were allotted to two dietary treatments viz., T1 (control ration) where in the compounded cattle feed contained 0.5 per cent calcium as per IS (1992) standards and T2 (experimental ration) where in compounded cattle feed contained 1.0 per cent calcium. Paddy straw was the sole source of roughage for both the rations.

Rations were computed for individual animals as per the ICAR standards (1999) and the animals were fed and maintained individually on their respective dietary regimes from the last month of pregnancy to 3 months of lactation. Individual records of daily intakes of concentrate and paddy straw, daily milk production, fortnightly body weight, milk fat, total solids and solids not fat per cent were maintained throughout the experiment. Blood was collected for estimation of serum minerals at the commencement of the experiment, before and after calving, followed by first, second and third month of lactation. The contents of minerals in milk were also analysed, immediately after calving and during the first, second and third month of lactation. A metabolism trial was conducted at the first month of lactation to study the balance of minerals. Incidence of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis were also studied in all the experimental animals during the course of experiment. Data gathered on various parameters were analysed statistically.

The average initial body weight of cows of group I and II at the beginning of lactation was 367.33 and 380.83 kg. Thereafter, there was a decline in bodyweight

for animals in both the groups and the animals started gaining the body weight in the fifth fortnight for the group I and II respectively. From then onwards there was a gradual increase in bodyweight of cows in both the groups, the final bodyweight on completion of 90 days of lactation being 354.00 and 355.83 kg respectively for group I and II. The overall average dry matter intake for the animals of group I and II was 11.70 and 12.54 kg and the values did not differ significantly. Increase in the dry matter intake was observed in group I animals during the third fortnight. Peak dry matter intake was observed during the second and third fortnight for the cows in group II. The values for the milk yields in all the twelve fortnights between the animals of the two groups did not differ significantly, the average values being 10.81 and 10.46 litres per day respectively for the group I and II. No significant difference could be observed for milk fat, total solids and solids not fat per cent in milk, the values being 3.86 and 3.78, 12.46 and 12.64 and 8.39 and 8.67 per cent, respectively for the animals of group I and II.

The average values for serum minerals at the start of the experiment, before and after calving, and at first, second and third month of lactation were as follows. The values recorded before and after calving in group I and II for Ca were 8.18±0.53, 8.00±0.44; 8.3±0.52 and 7.87±0.46, for P were 3.51± 0.15, 3.99±0.70; 4.27±0.74 and 4.18±0.68, for Mg were 2.96±0.22, 2.83±0.25; 3.00±0.15 and 2.86±0.14, and for Zn (ppm) 1.22±0.21, 1.5±0.44; 1.5±0.44 and 0.66±0.18 respectively. The average values for serum Ca at the first, second and third month of lactation were 7.78±0.59, 9.11±0.33 and 9.45±0.39 for group I and 7.75±0.18, 7.07±0.23 and 9.63±0.33 mg percent for group II. For inorganic P the average serum values recorded during the first, second and third month of lactation were 4.06±0.39, 4.51±0.61 and 4.81±0.94 for group I and 4.50±0.33, 4.50±0.82 and 4.23±0.69 mg per cent for group II respectively, serum Mg during the first, second and third month of lactation were 2.91±0.12, 2.93±0.13 and 2.93±0.04 for group I and 2.85±0.15, 2.89±0.06 and 3.05±0.04 mg per cent for group II respectively. No significant differences were observed between the values for serum minerals of animals in group I and II during the different periods of lactation studied.

The overall average mineral composition of milk of the animals of group I and II and for three months of lactation were 0.98±0.03 and 0.98±0.04 g / L for Ca, 0.95±0.02 and 0.98±0.02 g / L for P, 0.08±0.005 and 0.09±0.007 g / L for Mg respectively. Statistical analysis of the data on concentration of different minerals in milk estimated at different periods of lactation did not reveal any significant difference between the groups.

Results on Ca balance of the experimental animals revealed an average daily retention of –7.09 and 13.71g with a corresponding percent retention of –14.34 and 17.80 respectively for the group I and II. Statistical analysis of the data revealed significant difference for retention of Ca and retention as per cent of intake between the two groups($P<0.05$) Results on P balance revealed an average daily retention of 3.27 and 3.53 g with a corresponding per cent retention of 6.39 and 6.80 respectively for the group I and II. Statistical analysis of the data revealed no significant difference between the two groups. Results on Mg balance revealed an average daily retention of 3.69 and –2.25 g with corresponding per cent retention of 16.23 and –10.09 respectively for the group I and II. Statistical analysis of the data revealed significant difference for retention and retention as percentage of intake ($P<0.05$) for Mg. Results on Zn balance of the experimental animals fed two dietary treatments revealed an average daily retention of 260.48 and 255.78 mg and corresponding per cent retention of 56.61 and 58.48 respectively for the group I and II. There was no significant difference between the two groups with regard to Zn balance.

No incidence of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis was observed in any of the animals in both groups under study. An overall critical evaluation of the results obtained in the present study helps to infer that Ca at one per cent level in compounded cattle feed is better than 0.5 per cent to avoid negative balance of calcium during early lactation when paddy straw is the sole source of roughage. The current study also indicate that, with high levels of dietary Ca there is a need for Mg supplementation to avoid negative balance arising due to interaction of the two elements.

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EFFECT OF DIFFERENT LEVELS OF DIETARY CALCIUM ON THE PERFORMANCE AND MINERAL AVAILABILITY IN CROSSBRED DAIRY CATTLE

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ABSTRACT

An investigation spread over a period of four months was undertaken in crossbred dairy cattle to assess the effect of different levels of dietary calcium on the performance and mineral availability in cross bred dairy cattle. Twelve healthy crossbred cows in the last month of pregnancy having an average peak yield of minimum eight litres per day in their previous lactation were selected. They were divided into two groups of six each as uniformly as possible with regard to age and milk yield and allotted to two dietary treatments viz., T1 (control ration) where in the compounded cattle feed contained 0.5 per cent calcium as per IS (1992) standards and T2 (experimental ration) where in compounded cattle feed contained 1.0 per cent calcium. Paddy straw was the sole roughage source in both the rations.

All the experimental animals were fed as per ICAR (1999) standards except for dietary Ca and maintained individually on their respective dietary regime from the last month of calving to three months of lactation. Average dry matter intake, fortnightly body weight, milk yield, milk fat percentage, total solids, solids not fat, serum minerals, mineral content of milk, balance of Ca, P, Mg and Zn and incidence of metabolic disorders were the criteria employed for evaluation.

Average body weights and dry matter intake of animals revealed no significant difference for both the groups during all the fortnights studied. Highest dry matter intake for the group I was recorded during the third fortnight and for group II in the second and third fortnight. Average daily milk yield, fat percent, total solids and solids not fat per cent in milk in all the six fortnights did not differ significantly between the groups. The average mineral concentration in milk collected after calving, and at the first, second and third month of lactation for the animals in group II and I did not differ significantly. The mineral content in serum and milk in both groups were within the normal range reported for the species. Results with respect to balance of P and Zn did not differ significantly whereas that for Ca, and Mg differed significantly ($P<0.05$) between the two groups. Higher retention values were recorded in group II for Ca and group I for Mg. The average retention percent of Ca and Mg differed significantly ($P<0.05$) the higher values recorded

in group I for Mg and in group II for Ca. There was no incidence of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis in both groups of animals.

An overall critical evaluation of the results obtained in the present study helps to infer that different levels of calcium followed in the present study has a major effect on improving the Ca balance of early lactating cows. The results suggest that levels of Ca in compounded cattle feed at one per cent is better than 0.5 per cent to avoid negative balance of calcium during early lactation when paddy straw is the sole roughage source. The study also indicates that with high levels of dietary Ca there is a need for Mg supplementation to avoid negative balance arising due to interaction of the two elements.