ENERGY SUPPLEMENTATION ON PRODUCTION PERFORMANCE OF COWS UNDER FIELD CONDITION

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requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **"ENERGY SUPPLEMENTATION ON PRODUCTION PERFORMANCE OF COWS UNDER FIELD CONDITION"** is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"ENERGY SUPPLEMENTATION ON PRODUCTION PERFORMANCE OF COWS UNDER FIELD CONDITION"** is a record of research work done independently by **Dr.Ruby Augustine** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Milk production is a process that implies the use of energy. During early lactation, the energy needs of the cows increase exponentially leading to a negative energy balance or energy deficiency. The reason for the negative energy balance is that following parturition, milk out put rises faster than feed intake. To meet their energy needs the cows metabolize their body reserves. The negative energy balance and rate of mobilization of body reserves appear directly related to the post partum interval to first ovulation and lower conception rate.

Thus, an energy deficient ration leads to a reduction in milk production. Besides the reduction in milk production, negative energy balance or energy deficiency in dairy rations can also lead to metabolic disorders such as ketosis, delayed maturity and reduced conception rate in cows. In Kerala the non availability of good quality fodder and high cost of concentrates and paddy straw have led to a quantitative and qualitative deficiency in the rations of dairy cows, of which energy deficiency is found to be common. This has led to reduced milk production, delayed maturity and poor conception rate in cows among small and marginal dairy farmers. Studies have shown that supplementation of energy in the form of ground cereal grains and fat especially as rumen inert fat resulted in early maturity in heifers and in promoting milk production and conception rate in early lactating cows. Fats in the rumen protected form (usually calcium salts of fatty acids) have little negative effect on digestibility of the basal feed ingredients. They also have the added advantage of being dry fats that can be easily mixed into the diet.

Hence, this study was conducted to assess the effect of supplementing energy in early lactating cows in the form of maize and rumen protected fat under field condition.

Review of Literature

2. REVIEW OF LITERATURE

2.1 ENERGY REQUIREMENTS FOR LACTATION

The energy requirements of lactating cows and buffaloes are given by Indian Council of Agricultural Research (I.C.A.R., 1998). The TDN requirement of lactating cattle is 33.7 $g/W_{kg}^{0.75}$ for maintenance and 315 g/kg of 4 per cent fat corrected milk (FCM). The corresponding values for lactating buffaloes are 32 to 35.3 $g/W_{kg}^{0.75}$ and 410 g/kg of 6 per cent FCM. The energy requirement of small breed cows in early lactation weighing 454 kg, producing 15 kg milk with a dry matter intake of 9.9 kg is 21.2 Mcals of NE (N.R.C., 2001).

Neville (1974) conducted feeding trials to determine the energy requirements for maintenance and milk production of non-lactating and lactating beef cows using the approach of maintaining body weight at equilibrium during the test period. The total digestible nutrient (TDN) requirements for lactating cows were 0.0104 kg TDN/kg /24 hour and 0.2915 kg/kg of 4 per cent FCM. The corresponding ME requirements based on body weight were 0.174 Mcal $/W_{kg}^{0.75}$ /24 hour and 1.122 Mcal /kg of 4 per cent FCM.

Paul *et al.* (2002) determined the energy requirement of lactating riverine buffaloes by multiple regression analysis. The TDN requirement for maintenance was 35.3 $g/W_{kg}^{0.75}$ and for producing 1 kg of 6 per cent FCM was 406g.

Sharma *et al.* (2007) determined the energy requirement of lactating Murrah buffaloes fed different levels of diammonium phosphate. The daily requirement of energy for lactating Murrah buffalo was 49.5 g TDN or 179.4 kcal $ME/W_{kg}^{0.75}$ for maintenance and 346 g TDN or 1252 kcal ME per kg of 4 per cent FCM. From the partitioning of energy, it appeared that about 64.5 per cent of TDN consumed was utilized for maintenance and 35.5 per cent diverted for milk production. Similarly 64.55 per cent of ME intake was utilized for maintenance and 35.45 per cent for milk production.

2.2 ENERGY SUPPLEMENTATION AND MILK YIELD

2.2.1 Fat as Energy Source

Palmquist and Conrad (1978) compared high fat diets (2.9 to 10.8 per cent ether extract (EE) in total dry matter) for cows in early lactation. Milk production of Jersey cows tended to increase with high fat diet.

DePeters *et al.* (1987) compared complete mixed diets containing 0, 3.5 or 7 per cent of fat and observed greater milk yield for cows fed diets containing 3.5 and 7 per cent fat. Andrew *et al.* (1991) also observed that the milk yield was higher with feeding 2.95 per cent calcium salts of long chain fatty acids (Ca-LCFA) in lactating cows, but there were no treatment effects on yields of 4 per cent FCM. However Sklan and Moallem (1991) observed that cows fed Ca soaps of fatty acids produced more milk and FCM for 90 days after calving. Similarly in another study Erickson *et al.* (1992) reported increased milk yield and FCM yield by feeding 3 per cent of Ca salts of fatty acids (CSFA) to cows in early lactation. Sklan *et al.* (1992) examined the effects of dietary fat as cottonseed, fatty acids or Ca soaps of fatty acids in the rations of high yielding lactating cows receiving low forage. Inclusion of up to 510 g / d of fatty acids, cotton seed and Ca soaps of fatty acids enhanced FCM yield in early lactation. Kim *et al.* (1993) reported that milk production was approximately 10 per cent higher for cows fed supplemental fat in the form of Ca-LCFA at 4 per cent level of diet dry matter (DM).

Garcia-Bojalil (1998) reported that supplemental fat increased milk production (2 kg/ d) starting at 3 weeks post partum when highly degradable protein diets of early lactating Holstein cows were supplemented with Ca-LCFA at 2.2 per cent of dietary DM. Schroeder *et al.* (2002) reported that feeding 1 kg/day of supplemental fat in the form of partially hydrogenated oil increased FCM yield from 23.4 to 26.3 kg per day in grazing dairy cows in early lactation.

Onetti and Grummer (2004) examined the response of dairy cows to different supplemental fat sources viz., tallow; CSFA and selected hydrolyzed tallow fatty acids (SHTFA). Feeding tallow with diets high in corn silage had no effect on milk production, while a moderate positive response was observed when tallow was fed with alfalfa based diets or diets with corn silage and alfalfa in similar proportions. Supplemental SHTFA resulted in moderate positive milk yield response regardless of the main forage in the basal diet. A significant positive milk yield response was observed when CSFA were fed with diets high in corn silage. An interaction between stage of lactation and amount of supplemental fat was observed, with supplemental fat increasing milk production of early lactation cows, but not that of mid lactation cows where milk fat depression occurred.

Sampelayo *et al.* (2004) observed that fat supplementation increased milk production when goats in their six months of lactation were fed with 9 per cent polyunsaturated fatty acids rich protected fat. Schroeder *et al.* (2002) stated that fat supplementation to the cows grazing high quality pastures generally increased milk production. Strusinska *et al.* (2006) observed a mean daily milk yield of 32.6 kg/day in Holstein cows during 120 days of lactation when fed with concentrate containing 19.5 per cent crude protein (CP), and 1 kg of fat protein supplement (Megapro plus) which was 10.3 per cent higher than in the control group. The FCM yield increased in the above treatment.

Mixed diets containing 0, 15 and 30 per cent of protected tallow supplement fed to Holstein cows during the first 15 weeks of lactation did not affect milk yield, but increased FCM yield. (Smith *et al.*, 1978). Kent and Arambel (1988) reported that feeding Ca-LCFA along with whole cottonseed had no effect on actual milk yield and FCM. Similarly Jerred *et al.* (1990) opined that prilled fat supplementation did not enhance lactation performance when fed at 5 per cent level to cows 5-day post partum. West and Hill (1990) also reported that milk production was not changed by fat supplementation, but FCM yield increased from 25.9 to 27.1 kg when Holstein and Jersey cows consumed approximately 0.45 and 0.35 kg/day of CSFA respectively.

Schauff and Clark (1992) conducted feeding experiments in lactating dairy cows to investigate the effects of 3.5, 6 and 9 per cent levels of Ca-LCFA. Inclusion of 3 or 6 per cent Ca-LCFA showed no significant difference in milk production. Holter and Hayes (1994) reported that milk yield showed no significant difference in cows receiving CSFA supplementation immediately after calving and in cows in which supplementation was delayed until 57 days in milk. Production of milk and 4 per cent FCM yield was not significantly different among treatments although 4 per cent FCM yield tended to increase when cows were fed hydrogenated palm fatty acid compared with cows that were fed Ca-LCFA (Elliott *et al.*, 1996).

Perfield *et al.* (2002) observed that milk yield was unaffected when cows were fed with rumen protected conjugated linoleic acid during established lactation. Mandebvu *et al.* (2003) conducted feeding experiments in first lactation multiparous Holstein cows using Ca–LCFA from palm fatty acid distillate and soyabean oil and found no treatment differences in milk yield. DeFrain *et al.* (2005) reported that milk yield in multiparous Holstein cows remained unaffected by different dietary treatments such as 320 g/day of corn starch (as control), 120 g/day of propionate, 120g propionate plus 93g long chain fatty acid and 178g propionate plus 154g long chain fatty acid.

Inclusion of 9 per cent of Ca-LCFA decreased milk production and FCM yield (Schauff and Clark, 1992). Schauff *et al.* (1992) reported that production of milk and 4 per cent FCM decreased by feeding extruded whole soyabeans and 6 per cent Ca -LCFA.

2.2.2 Cereal Grains as Energy Source

McCaffree and Merril (1967) conducted trials in early lactating cows to evaluate high moisture corn as the primary concentrate energy source. Thirty six Holstein cows compared high moisture shelled corn; dry shelled corn and a multi ingredient pelleted dairy concentrate. Feeding high moisture shelled corn resulted in higher milk production. In the study conducted by Wilkerson *et al.* (1997), milk yield of cows fed diets containing high moisture corn was 2 kg/ day higher than that of cows fed diets containing dry corn. Similarly milk yield was higher (2.2 kg/day) for cows fed diets containing ground corn than for cows fed diets containing rolled corn. Ballard *et al.* (2001) reported that feeding an energy supplement containing beet pulp, sugarcane molasses, propylene glycol and Ca propionate to Holstein cows improved milk yield of lactating cows.

Clark and Harshbarger (1972) compared four diets viz. Diet 1. High moisture shelled corn (HMSC) + hay, Diet 2. HMSC + corn silage, Diet 3. Dry shelled corn (DSC) + hay and Diet 4. DSC + corn silage and found no significant difference in 4 per cent FCM produced. The 4 per cent FCM yields were 25.5, 20.6, 23.7 and 21.3 kg/day respectively for the above diets. No difference in milk yield was observed when wet or dry corn gluten feed was fed as a source of energy, protein and fiber to post partum Holstein cows (Bernard *et al.*, 1991). Delahoy *et al.* (2003) reported that production of milk and 3.5 per cent FCM did not differ between cows fed cracked corn or steam flaked corn.

2.3 ENERGY SUPPLEMENTATION ON DRY MATTER INTAKE

2.3.1 Fat as Energy Source

DePeters *et al.* (1987) reported significantly higher dry matter intake (DMI) for diets containing added fat at the rate of 3.5 and 7 per cent of total DM of diet. Holter and Hayes (1994) suggested that earlier fat supplementation tended to be associated with slightly higher DMI in first lactation cows and with slightly lower DMI in pluriparous cows. Garcia-Bojalil *et al.* (1998) reported that supplementing 15.7 per cent degradable intake protein (DIP) diet with Ca-LCFA stimulated DMI during 120 days post partum in lactating Holstein cows.

Kent and Arambel (1988) observed no significant difference in DMI of early lactating cows fed 223 g of Ca-LCFA along with 13.2 per cent of whole cotton seed on DM basis indicating that diets containing high amounts of cotton seed may mask the effect of energy provided by Ca-LCFA. Schauff and Clark (1989) reported that DM intakes were not affected by supplementing Ca salts of fatty acid or prilled fatty acid to the control diet. Similar DMI was reported in CSFA and control ration fed cows (Sklan and Moallem, 1991). Erickson *et al.* (1992) reported that DMI did not differ by feeding CSFA to lactating cows.

Elliott *et al.* (1996) reported that there was no significant difference in DMI when lactating cows in mid and late lactation were supplemented with Ca-LCFA and hydrogenated palm fatty acids. Perfield *et al.* (2002) reported that cows that received rumen protected conjugated linoleic acid supplement showed no difference in DMI when compared to cows that received Ca salts of palm oil fatty acids during established lactation.

Smith *et al.* (1978) reported higher DMI on control and medium fat diets when fed mixed diets containing 0 (control), 15 (medium fat) and 30 per cent (high fat) of protected tallow to Holstein cows during first 15 weeks of lactation. The DMI declined with increasing forage level and fat supplementation when 0 or 5 per cent of prilled fat and alfalfa silage were fed together at different forage to concentrate ratios (Jerred *et al.*, 1990). West and Hill (1990) reported that average daily DMI was 22.3 kg (control) and 21.6 kg (CSFA diet) when diets supplemented with CSFA were fed to Holstein and Jersey cows.

Lower organic matter intake (OMI) was reported by Andrew *et al.* (1991) when lactating cows were fed with Ca-LCFA from palm oil. Feeding extruded whole soyabeans and 6 per cent Ca-LCFA also decreased intake of DM (Schauff *et al.*, 1992). Schauff and Clark (1992) reported that DMI decreased linearly when increasing amounts of Ca -LCFA were added to the diet of lactating cows, but only the diet that contained 9 per cent Ca-LCFA extensively depressed intake. Simas *et al.* (1997) reported that compared with tallow, prilled fatty acids tended to decrease DMI when fat supplements were fed at the rate of 2.5 per cent of diet DM. Schroeder *et al.* (2002) reported that DMI from pasture decreased from 17.8 kg/ day for control cows to 13.6 kg/day for cows fed 1 kg of partially hydrogenated oil, whereas DMI from concentrate was higher for fat fed cows.

Reddy *et al.* (2003) evaluated the effects of feeding Ca soap of red palm oil at 0, 50, 100 and 150 g levels in sheep and found that the average DMI in sheep fed 150g Ca-LCFA was lower compared to those fed Ca-LCFA at 50 and 100g levels. The results showed that supplemental fat in the form of Ca soap of fatty acids can be included up to 100g in the straw based diets of sheep without affecting the DMI particularly from roughage source. Haddad and Younis (2004) studied the effects of adding ruminally protected fat to fattening Awassi lamb diets and observed that DMI was higher for the control diet than the high fat (5 per cent added fat) diet and intermediate for the low fat (2.5 per cent added fat) diet. The DMI decreased 0.90 and 0.97 kg/day when tallow and CSFA were fed at an average of 3.1 and 3.8 per cent of DM respectively and tended to decrease 0.6 kg/d while feeding SHTFA at an average of 3.6 per cent of DM.

Palmquist and Conrad (1978) compared different levels of fat in two trials. In trail I cows were assigned to the four diets as follows. Diet 1. Control with 3.2 percent EE, Diet 2. Ground raw soyabean with 5.9 percent EE, Diet 3. Hydrolyzed fat with 5.7 per cent EE and Diet 4. Hydrolyzed fat with 10.81 per cent EE. The DMI of Holstein cows were lowest with diet 2 and highest with diet 3. No significant difference in DMI was observed when two concentrations of ether extract and crude protein (of the total diet) were fed to cows in a second trail.

2.3.2 Cereal Grains as Energy Source

Bernard *et al.* (1991) opined that no difference in DMI occurred when wet or dry corn gluten feed was included in rations of Holstein cows as a source of energy, protein and fibre. Wilkerson *et al.* (1997) observed that DMI was similar and averaged 24.3 kg/day in cows supplemented with high moisture corn or dry corn either in the ground or rolled form. Ballard *et al.* (2001) evaluated the effect of feeding a dry energy supplement containing beet pulp, sugarcane molasses, propylene glycol, and calcium propionate to Holstein cows and found no significant difference in DMI among dry or lactating cows. They also found that when fed at low level the energy supplement increased DMI of dry cows. Delahoy *et al.* (2003) observed that pasture and total DMI did not differ for cows fed cracked corn or steam flaked corn.

A reduction in forage DMI was observed by Mc-Caffree *et al.* (1967) while feeding HMSC to early lactating Holstein cows. Total DMI was also observed to be significantly lower. Clark and Harshbarger (1972) compared four experimental rations in cows viz., Diet 1.HMSC + hay, Diet 2. HMSC + corn silage, Diet 3. DSC + hay and Diet 4. DSC + corn silage. The DMI of cows fed hay was greater than those offered corn silage.

2.4 ENERGY SUPPLEMENTATION ON MILK COMPOSITION

2.4.1 Fat as Energy Source

2.4.1.1 Milk Fat

Smith *et al.* (1978) reported that diets containing 15 and 30 per cent protected tallow increased milk fat when fed to Holstein cows during first 15 weeks of lactation. Jerred *et al.* (1990) also reported increased milk fat when cows at 5-day post partum were fed with 5 per cent prilled fat. West and Hill (1990) reported a 5.5 per cent increase in milk fat when Holstein and Jersey cows were fed diets supplemented with CSFA. Increased milk fat percentage was seen at 30 to 90 day post partum in cows fed with CSFA (Sklan and Moallem, 1991).

Schauff and Clark (1992) reported that when 3 or 6 per cent of Ca-LCFA was fed, milk fat percentage increased. Kim *et al.* (1993) observed that milk fat percentage was higher for cows fed Ca-LCFA diet than for those fed with extruded soyabean diet. Holter and Hayes (1994) reported that yield and content of fat was higher for primiparous cows receiving CSFA supplementation immediately after calving and lower for pluriparous cows in which supplementation was delayed until 57 days in milk. Elliott *et al.* (1996) observed that percentage and production of milk fat were greater in cows fed fat supplemented diets. Production of milk fat was greater when cows were fed hydrogenated palm fatty acids than when they were fed Ca-LCFA. Ashes *et al.* (1997) reported that when cows were fed oil seeds (canola and cotton seed) the fat content of milk increased.

Ballard *et al.* (2001) reported that cows fed calcium propionate produced more milk fat during 5 to 8 weeks post partum than cows previously fed the control diet. Schroeder *et al.* (2002) found that feeding 1 kg/ day of supplemental oil increased milk fat content from 3.44 to 3.78 per cent and milk fat yield from 0.87 to 1.03 kg/day in grazing dairy cows in early lactation. Milk fat yield increased 0.07 kg/ day or 0.06 kg/day when CSFA or SHTFA were fed at an average of 3.7 per cent of DM. (Onetti and Grummer, 2004). Sampelayo *et al.* (2004) suggested that supplementation of diets of lactating goats with 9 per cent polyunsaturated fatty acids rich protected fat improved the milk fat yield. These effects persisted after the supplement was withdrawn. DeFrain *et al.* (2005) determined the effects of feeding Ca and Na salts of propionate and Ca-LCFA on transition cow performance. Milk fat yield from cows fed propionate tended to be greater than those fed propionate plus fat.

Palmquist and Conrad (1978) observed no significant difference in milk fat when high fat diets (3.2 per cent, 5.9 per cent, 5.7 per cent and 10.8 per cent EE in total diets) were fed to early lactating Holstein cows. Feeding CSFA or prilled fatty acids did not alter milk fat percentage (Schuaff and Clark, 1989). Andrew *et al.* (1991) reported no treatment effects on milk fat yield when CSFA from palm oil was fed to Holstein cows.

Erickson *et al.* (1992) reported that fat content of milk did not differ by feeding CSFA at 3 per cent level. Sklan *et al.* (1992) examined the effects of dietary fat as cottonseed, fatty acids or CSFA in the rations of high yielding lactating cows receiving low forage. Dietary Ca soap of fatty acid and additional fat with cottonseed enhanced milk fat yields, but inclusion of fatty acids did not alter fat percentage. Garcia- Bojalil (1998) reported that mean concentration of milk fat was not affected by fat concentration of the diets.

Mandebvu *et al.* (2003) observed no difference in milk fat percentage when cows were fed Ca-LCFA from palm fatty acid distillate and soyabean oil. Strusinska *et al.* (2006) reported that during first 120 days of lactation diets supplemented with a fat protein supplement, (Megaproplus) had no significant effect on the levels of milk fat.

DePeters *et al.* (1987) reported decreased percentage of fat in the milk of cows fed 7 per cent of diet DM as animal fat. Kent and Arambel (1988) reported that percentage of milk fat tended to be lower for cows fed diets containing Ca-LCFA along with whole cottonseed. Schauff *et al.* (1992) observed reduction in milk fat by feeding extruded whole soyabeans and 6 per cent Ca-LCFA.

Perfield *et al.* (2002) during short term studies involving abomasal infusion of a mixture of rumen protected conjugated linoleic acid isomers demonstrated that supplements of conjugated linoleic acid reduced milk fat synthesis during established lactation in dairy cows. Onetti and Grummer (2004) reported that feeding tallow at an average of 3.1 per cent of diet DM decreased milk fat percentage by 0.19 per cent units and tended to decrease milk fat yield by 0.04 kg per day.

2.4.1.2. Milk Protein

West and Hill (1990) reported a 3.2 per cent increase in milk protein when Holstein and jersey cows were fed with diets supplemented with CSFA. Ballard *et al.* (2001) reported that cows fed calcium propionate produced more milk protein during 5 to 8 weeks post partum than cows previously fed the control diet. Sampelayo *et al.* (2004) suggested that supplementation of diets of lactating goats with 9 per cent polyunsaturated fatty acids rich protected fat improved the milk protein yield.

Palmquist and Conrad (1978) observed no significant difference in milk protein when high fat diets (3.2, 5.9, 5.7 and 10.8 per cent EE in total diets) were fed to early lactating Holstein cows. Feeding CSFA or prilled fatty acids did not alter milk protein percentage (Schuaff and Clark, 1989). Jerred *et al.* (1990) reported no difference in milk protein when cows at 5-day post partum were fed with 5 per cent prilled fat. Sklan and Moallem (1991) found no significant change in milk protein per cent when cows were fed with CSFA. Similarly Schauff and Clark (1992) also found no change in milk crude protein (CP) when 3 or 6 per cent of Ca-LCFA was fed to cows. Perfield *et al.* (2002) reported that when rumen protected conjugated linoleic acid isomers were infused into lactating dairy cows, milk protein remained unaffected.

Schroeder *et al.* (2002) found that feeding 1 kg/ day of supplemental oil did not affect the milk protein percentage and yield of cows. Mandebvu *et al.* (2003) observed no difference in milk protein percentage when cows were fed Ca-LCFA from palm fatty acid distillate and soyabean oil. Milk true protein showed no significant difference when Ca and Na salts of propionate and Ca-LCFA were fed to transition cows (DeFrain *et al.*, 2005). Strusinska *et al.* (2006) reported that during first 120 days of lactation diets supplemented with a fat protein supplement, (Megaproplus) had no significant effect on the levels of milk protein.

DePeters *et al.* (1987) observed decreased percentage of protein in the milk of cows fed 7 per cent of diet DM as animal fat. In another study, Kent and Arambel (1988) reported that percentage of milk protein tended to be lower for cows fed diets containing Ca- LCFA along with whole cottonseed. Erickson *et al.* (1992) reported that milk protein content decreased by feeding CSFA. Schauff and Clark (1992) reported that feeding 9 per cent of Ca-LCFA to cows decreased milk CP. A similar reduction in milk CP was observed by Schauff *et al.* (1992) when extruded whole soyabeans and 6 per cent Ca-LCFA was fed to cows. Skan *et al.* (1992) observed that inclusion of cotton seed along with Ca soap of fatty acid caused depression in milk protein percentage. Garcia-Bojalil (1998) reported a small reduction in mik protein percentage from 35-day post partum, which continued till the end of the study when Ca-LCFA was fed to cows. Onetti and Grummer (2004) observed that the milk protein response was -0.07, -0.12 and -0.08 per cent when tallow, CSFA and SHTFA were fed at an average level of 3.1, 3.8 and 3.6 per cent DM respectively.

2.4.1.3 Solids Not Fat

Holter and Hayes (1994) reported that percentage of solids not fat (SNF) was higher for primiparous cows receiving CSFA supplementation immediately after calving and lower for pluriparous cows in which supplementation was delayed until 57 days in milk.

Schauff and Clark (1992) suggested that there was no change in milk SNF when 3 or 6 per cent of Ca-LCFA were fed to cows.

Smith *et al.* (1978) reported that diets containing 15 and 30 per cent of protected tallow decreased yields of SNF when fed to Holstein cows during first 15 week of lactation. DePeters *et al.* (1987) observed decreased percentage of SNF in the milk of cows fed 7 per cent of diet DM as animal fat. Andrew *et al.* (1991) also reported a reduction in milk SNF when CSFA from palm oil was fed to cows. Feeding 9 per cent of Ca-LCFA to cows decreased milk SNF (Schauff and Clark, 1992). When extruded whole soyabeans and 6 per cent Ca-LCFA was fed to cows milk SNF decreased (Schauff *et al.*, 1992). Strusinska *et al.* (2006) reported that during first 120 days of lactation diets supplemented with a fat protein supplement,(Megaproplus) decreased milk SNF.

2.4.1.4 Milk Urea Nitrogen

Ballard *et al.* (2001) reported that milk produced by cows in 5 to 8 weeks post partum previously fed 908g/day of Ca propionate had a higher concentration of milk urea nitrogen (MUN) when compared with cows previously fed 454g/day Ca propionate.

Mandebvu *et al.* (2003) observed no difference in MUN when cows were fed Ca-LCFA from palm fatty acid distillate and soyabean oil. MUN showed no significant difference when Ca and Na salts of propionate and Ca-LCFA were fed to transition cows (DeFrain *et al.*, 2005)

2.4.2 Cereal Grains as Energy Source

2.4.2.1 Milk Fat

Clark and Harshbarger (1972) observed no significant difference in milk fat percentage when cows were offered with HMSC + hay (ration 1), HMSC+ corn silage (ration 2), DSC + hay (ration 3) and DSC + corn silage (ration 4). Wilkerson *et al.* (1997) found that milk fat percentage and milk fat yield of cows did not differ when fed high moisture corn or dried corn. Delahoy *et al.* (2003) reported that milk fat yield did not differ when cows were fed cracked corn or steam flaked corn (SFC).

McCaffree *et al.* (1967) reported that feeding HMSC to early lactating Holstein cows resulted in lower milk fat percentage. Bernard *et al.* (1991) observed that milk fat percentage was lower when dry corn gluten feed was fed.

2.4.2.2 Milk Protein

Wilkerson *et al.* (1997) found that milk protein percentages were greater for cows fed diets containing ground corn than for cows fed diets containing rolled corn. Also daily yield of milk protein was greater for cows fed diets containing high moisture corn than for cows fed diets containing dry corn.

Bernard *et al.* (1991) observed no difference in milk protein percentage when dry corn gluten feed was fed. Delahoy *et al.* (2003) reported that milk protein composition and yield did not differ when cows were fed cracked corn or steam flaked corn.

2.4.2.3 Solids Not Fat

Wilkerson *et al.* (1997) found that milk SNF percentages were greater for cows fed diets containing ground corn than for cows fed diets containing rolled corn. Bernard *et al.* (1991) on the other hand observed that milk SNF percentages showed no significant difference when cows were fed with dry corn gluten feed.

2.4.2.4 Milk Urea Nitrogen

Delahoy *et al.* (2003) reported that MUN decreased when cows were fed with SFC.

2.5 ENERGY SUPPLEMENTATION ON DIGESTIBILITY OF NUTRIENTS

2.5.1 Digestibility of Dry Matter

Haddad and Younis (2004) reported higher digestibilities of DM when fattening Awassi lambs were fed rumen-protected fat at 2.5 and 5 per cent levels.

Palmquist and Conrad (1978) reported that there was no significant difference in digestibility of DM when Holstein cows were fed with high levels of fat ranging from 3.2 to 10.8 per cent. DePeters *et al.* (1987) observed that digestibility of DM was not significantly affected by fat when cows were fed complete mixed diets containing 0, 3.5 or 7 percent of diet DM as animal fat. Schauff and Clark (1989) conducted experiments in lactating cows to investigate the effects of supplementing CSFA or prilled fatty acids on apparent total tract digestibility. They observed that CSFA and prilled fatty acids are inert in the rumen and do not greatly alter apparent total tract digestibility of DM when fed at recommended amounts of 3 to 4 per cent of the DM.

Prilled fat at 5 per cent level did not affect DM digestibility of cows 5-day post partum. (Jerred *et al*., 1990). Diets supplemented with CSFA fed to Holstein and Jersey cows also showed no change in apparent digestibility of the diet (West and Hill 1990). Andrew *et al.* (1991) observed that supplementation with CSFA did not affect the apparent digestibility of DM. Erickson *et al.* (1992) reported that DMI and digestibility were not affected when cows were fed CSFA.

Schauff and Clark (1992) reported that feeding Ca-LCFA at 3, 6 and 9 per cent levels to lactating cows did not change digestibilities of DM and OM. Elliott *et al.* (1996) observed no major difference in the apparent total tract digestibilities of DM when cows were fed supplemental fat sources such as Ca-LCFA and hydrogenated palm fatty acids.

Schauff *et al.* (1992) reported decrease in digestibilities of most dietary constituents when 16 per cent extruded whole soyabean plus 6 percent Ca salts of LCA were fed to cows. Simas *et al.* (1997) observed that total mixed ration (TMR) containing prilled fat had lower digestibility of DM and organic matter than did TMR containing cottonseed oil or tallow

Clark and Harshbarger (1972) conducted experiments in lactating cows to compare HMSC and DSC in combination with either corn silage or hay and observed that dry matter and organic matter digestibilities were higher for HMSC than for DSC diets. Apparent digestibility of DM was greatest when wet or dry corn gluten feed was fed to Holstein cows (Bernard *et al.*, 1991). Wilkerson *et al.* (1997) found that digestibilities of DM and OM were greater for cows fed diets containing high moisture corn than for cows fed diets containing dry corn.

2.5.2 Digestibility of Cell Wall Constituents

Schauff and Clark (1992) reported that cellulose digestibility was highest when diets contained 6 per cent Ca-LCFA, lowest for control diet and intermediate for diets that contained 3 or 9 per cent Ca-LCFA. Garcia- Bojalil *et al.* (1998) reported that cows fed diets containing Ca-LCFA digested more hemi cellulose. Onetti and Grummer (2004) observed that total tract neutral detergent fibre (NDF) digestibility increased when CSFA or SHTFA were supplemented at an average of 3.7 per cent of diet DM.

Palmquist and Conrad (1978) reported that there was no significant difference in digestibility of acid detergent fibre (ADF) and cellulose when Holstein cows were fed with high levels of fat ranging from 3.2 to 10.8 per cent. DePeters *et al.* (1987) observed that digestibility of fibre was not significantly affected by fat when cows were fed complete mixed diets containing 0, 3.5 or 7 per cent of diet DM as animal fat. Kent and Arambel (1988) opined that apparent NDF and ADF digestibilities did not differ between treatments when cows were fed diets containing Ca-LCFA along with whole cottonseed.

Schauff and Clark (1989) conducted experiments in lactating cows to investigate the effects of supplementing CSFA or prilled fatty acids on apparent total tract digestibility and observed that CSFA and prilled fatty acids do not greatly alter apparent total tract digestibilities of ADF and NDF when fed at recommended amounts of 3 to 4 per cent of the DMI. Andrew *et al.* (1991) observed that supplementation with CSFA did not affect the digestibility of NDF and components of NDF in lactating cows. Erickson *et al.* (1992) reported that NDF and ADF intakes and digestibilities were not affected when cows were fed CSFA.

Schauff and Clark (1992) reported that digestibilities of NDF and hemicelluloses were not changed by feeding Ca-LCFA at 3, 6 and 9 percent levels to lactating cows. Elliott *et al.* (1996) observed no major difference for the digestibility fibre fraction when cows were fed supplemental fat sources such as Ca-LCFA and hydrogenated palm fatty acids. Schroeder *et al.* (2002) suggested that supplemental fat in the form of partially hydrogenated oil did not affect the digestion of pasture fibre and partial hydrogenation of oil prevented detrimental effects of fat supplementation on ruminal digestion.

Onetti and Grummer (2004) observed a decrease in total tract NDF digestibility when tallow was supplemented at an average of 3.1 per cent of diet dry matter.

2.5.3 Digestibility of Ether Extract

Clark and Harshbarger (1972) observed that ether extract digestibilities were higher for HMSC than for DSC diets. Palmquist and Conrad (1978) reported that digestibility of EE was higher in all fat supplemented diets when Holstein cows were fed with high levels of fat ranging from 3.2 to 10.8 per cent. Reddy *et al.* (2003) reported a decrease in digestibility of organic nutrients except for EE due to addition of Ca soap of red palm oil to diets of Deccani sheep. Haddad and Younis (2004) reported higher digestibilities of ether EE when fattening Awassi lambs were fed rumen-protected fat at 2.5 and 5 per cent levels.

2.5.4 Digestibility of Crude Protein

Kent and Arambel (1988) opined that CP digestibility did not differ between treatments when cows were fed diets containing Ca-LCFA along with whole cottonseed. Schauff and Clark (1989) observed that CSFA and prilled fatty acids do not greatly alter apparent total tract digestibility of CP when fed at recommended amounts of 3 to 4 per cent of the DMI. Elliott *et al.* (1996) observed no major differences in the apparent total tract digestibility of CP when cows were fed supplemental fat sources such as Ca-LCFA and hydrogenated palm fatty acids.

Simas *et al.* (1997) observed that TMR containing prilled fat had lower digestibility of CP than did TMR containing tallow.

2.6 ENERGY SUPPLEMENTATION ON HEMATOLOGICAL PARAMETERS

2.6.1 Plasma Glucose

Garcia-Bojalil *et al.* (1998) reported that upon supplementing highly degradable protein diets with Ca-LCFA plasma glucose concentration increased from 76 to 82 mg/dl.

Palmquist and Conrad (1978) opined that there was no difference in plasma glucose when fed high fat diets (2.9 per cent to 10.8 per cent ether extract) to cows in early lactation. Smith *et al.* (1978) reported no difference in plasma glucose when Holstein cows were fed mixed diets containing 0 (control) 15 (medium fat) and 30 per cent (high fat) of a protected tallow supplement during the first 15 weeks of lactation. Sklan and Moallem (1991) reported that plasma glucose was 59.8± 3.1 and 59.4 ± 3.8 mg/dl in control and CSFA fed cows respectively and no temporal differences were observed. Erickson *et al.* (1992) observed no difference in glucose concentration when CSFA were fed to early lactating cows. Schroeder *et al.* (2002) found no significant difference in plasma levels of glucose by feeding 1 kg/ day of partially hydrogenated oil.

Ballard *et al.* (2001) observed no difference in plasma glucose levels when an energy supplement containing beet pulp, sugarcane molasses, propylene glycol and Ca propionate were fed to Holstein cows 21 days prepartum and 21 days post partum. Plasma glucose did not show any difference when cows were fed steam flaked corn and ground corn. (Delahoy *et al.*, 2003).

2.6.2 Plasma Urea Nitrogen

Garcia-Bojalil *et al.* (1998) reported that Plasma Urea Nitrogen (PUN) increased as days post partum increased because of increasing DMI post partum upon supplementing highly degradable protein diets with Ca-LCFA.

Blood Urea Nitrogen (BUN) showed no significant difference when Holstein and Jersey cows at 95 days in milk were fed with CSFA (West and Hill, 1990). Erickson *et al.* (1992) observed no difference in BUN concentration when CSFA were fed to early lactating cows. Schroeder *et al.* (2002) found no significant difference in plasma levels of urea nitrogen by feeding 1 kg/ day of partially hydrogenated oil.

Kim *et al.* (1993) reported that urea concentration in serum were lower for supplemental fat diets when fed diets containing supplemental fat from extruded soyabean or Ca-LCFA. PUN was decreased suggesting improved utilization of nitrogen when cows were fed steam flaked corn and ground corn. (Delahoy *et al.*, 2003).

2.6.3 Plasma Calcium and Phosphorus

Blood parameters like plasma Ca and P showed no significant difference when CSFA were fed to Holstein and Jersey cows at 95 days in milk (West and Hill 1990).

2.7 ENERGY SUPPLEMENTATION ON REPRODUCTIVE PERFORMANCE

Staples *et al.* (1998) suggested that supplemental fat might allay partially negative energy status during the early post partum period and fat supplementation of about 3.5 per cent of dietary dry matter has often positively influenced the reproduction status of dairy cows.

Filley *et al.* (2000) observed that supplementing CSFA at the rate of 0.23 kg/day for the first 30 days post partum did not affect days to first estrous with ovulation, pregnancy rate and calving interval in beef heifers. Ballard *et al.* (2001) evaluated the effect of a dry energy supplement containing beet pulp, sugarcane molasses, propylene glycol and Ca propionate for 21 days postpartum and 21 days pre partum on performance of Holstein cows and found that days to first service were similar among treatments. Mandebvu *et al.* (2003) observed no significant difference in days to first ovulation, days to first service and first service conception rate when cows were fed Ca-LCFA from soyabean oil and palm fatty acid distillate.

Sklan & Moallem (1991) reported that cows fed Ca soaps of fatty acids commenced ovarian cyclicity later than controls. However once cyclicity commenced more fat fed cows had normal cycle length. Conception rate was higher in cows fed Ca soaps 2nd to 4th AI. A higher proportion of cows were pregnant at 150 days after calving and number of open days was reduced.

Materials and Methods

3. MATERIALS AND METHODS

The investigation was carried out at field level in a farm located at Pattikad 12 kilometers away from the Kerala Agricultural University head quarters.

3.1 Animals

Thirty, early lactating crossbred cows in the farm were selected for the experiment and were maintained under identical conditions of feeding and management. The animals were divided into three experimental groups as uniformly as possible with regard to days in milk, the average being 40 days. The experiment was conducted for a period of three months (90 days) from September 2007 to December 2007.

3.2 Experimental rations

The early lactating cows of the three experimental groups were randomly allotted to the dietary treatments T_1, T_2 and T_3. The entire animals received routine farm ration comprising a concentrate feed mix and paddy straw as roughage. The feed mix was prepared by mixing different feed ingredients with a definite quantity of water. Ingredient composition of the feed mix is presented in Table1. The oil cakes were first soaked in a tank two to three hours before feeding. At the time of feeding, other feed ingredients were added into the mix. Maize waste, maize bran, tapioca starch waste and beer waste were added in the wet form. Then the whole mixture was mixed thoroughly and was fed in a semisolid form. The quantity of this basal feed mix fed to each animal was based on the quantity of milk produced. Animals of the dietary treatments T_2 and T_3 received 1kg maize and 100 g protected fat (EnerFAT^{TM} –manufactured by Kemin containing highly palatable form of rumen protected saturated and unsaturated long chain fatty acids, organic chromium and biosurfactant) respectively over and above the basal concentrate feed mix.

The three dietary treatments were:

T_1-concentrate mix + paddy straw.

T_2- concentrate mix + paddy straw + 1kg ground maize.

T_3- concentrate mix + paddy straw +100 g protected fat.

Representative samples of the feed mix, maize and paddy straw used for feeding were analyzed for their proximate principles.

3.3 Methods

Animals were fed four times daily i.e., 5 AM, 1 PM, 6 PM and 10 PM. Ground maize was fed to cows in the dietary treatment T_2 and protected fat to cows in the dietary treatment T_3 along with 1 PM feeding. Paddy straw was given at the rate of 650 g/animal during each time of feeding. Drinking water was made available through out the day using automatic waterers. Daily feed intake and milk yield of animals were recorded. From the data on milk yield and milk composition, 4 per cent fat corrected milk (FCM) yield, fat yield and protein yield were calculated.

3.4 Milk analysis

Milk samples were collected at 0, 6 and 12 weeks of the experiment and were analysed for total solids, fat (IS: 1224, 1977), SNF and milk urea nitrogen (MUN) (Bector *et al.*, 1998) and milk protein (Kjeldhal method).

3.5 Digestion trial

A digestion trial was carried out towards the end of the feeding experiment using four animals from each group allowing a collection period of five days.

Representative samples of feed mix, maize and paddy straw were taken during the trial for analysis. The dry matter content of the feed was determined every day. After the collection period, the feed samples collected were pooled and sub-samples were taken for analysis. About 100 g dung was collected manually from four animals of each group after the 1 PM feeding. The collection was done from the upper portion of voided dung to ensure that it was uncontaminated by urine, feed residue or dirt. The dung samples collected each day from each animal of each group were pooled and mixed thoroughly and sub samples were taken for analysis.

Feed samples and dung samples were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), total ash, acid insoluble ash, acid detergent fibre (ADF) and neutral detergent fibre (NDF) as per standard procedures (A.O.A.C., 1990).

Data obtained from the digestion trial were used for the calculation of digestibility of DM, CP, EE, NFE, NDF and ADF. Using the digestibility, total digestible nutrients (TDN) and digestible crude protein (DCP) intake of animals were calculated.

3.6 Hematological studies

Blood samples were collected in the beginning, middle and towards the end of the experiment in sterile tubes containing required quantity of heparin as anticoagulant and the plasma was separated immediately. These samples were used to determine haemoglobin (cyanmethaemoglobin method), plasma inorganic phosphorus (phosphomolybdate method), plasma urea nitrogen (modified Berthelot method) and plasma glucose (GOD-PAP method) using the kits supplied by Agappe diagnostics, India. Plasma calcium was estimated by atomic absorption spectrophotometer (Perkin Elmer 3110).

3.7 Reproductive performance

The animals were carefully observed for the signs of behavioral oestrus and those that showed the signs were inseminated regularly. The conception rate and number of inseminations required per conception were recorded.

3.8 Economics

The cost of feed for producing one kilogram of milk was calculated using the data on total feed consumption and total milk yield during the experimental period.

3.9 Statistical analysis

The data obtained were subjected to statistical analysis using standard statistical procedures of Snedecor and Cochran, 1994.

Table 1. Ingredient composition of the feed mix on DM basis ,%

Ingredient	Per cent composition
Maize	2.4
Maize waste	16.0
Maize bran	10.2
Beer waste	45
Tapioca starch waste	2.4
Cotton seed cake oiled	2.4
Cotton seed cake deoiled	2.4
Coconut cake	4.3
Rice bran	6
Soya husk	7.2
Salt	0.2
Mineral mixture	1.5
Total	100

Results

4. RESULTS

The results obtained from the present study are presented under the following headings.

4.1 CHEMICAL COMPOSITION

The chemical composition of the concentrate mix, paddy straw and maize used for feeding the animals are given in the Table 2. The gross energy of the feed ingredients used in the concentrate mix is given in Table 3. The chemical composition of the dung of experimental animals, collected during the digestibility trial is presented in Table 11.

4.2 DRY MATTER INTAKE (DMI)

The data on the fortnightly average of daily DMI of animals of the three treatment groups T_1, T_2 and T_3 are given in Table 4 and Fig. 1. The average daily dry matter intake at the beginning of the feeding period was 14.35 ± 0.48, 13.74 ± 4.58 and 13.39 ± 0.46 kg respectively for the treatment groups T_1, T_2 and T_3 which decreased to 13.47 ± 0.56, 13.64 ± 4.54 and 13.09 ± 0.84 kg respectively towards the end of the feeding period. The average DMI per 100 kg body weight was 3.22, 3.65 and 3.61 respectively for the cows under the three treatments T_1, T_2 and T_3.

4.3 TOTAL DIGESTIBLE NUTRIETNS (TDN) AND DIGESTIBLE CRUDE PROTEIN (DCP) INTAKE

The TDN and DCP intake of the experimental animals and their requirements are presented in Table 5. The TDN intake of experimental animals of the three treatments T_1, T_2 and T_3 were 7.06, 7.84, and 7.67 kg, respectively while the digestible crude protein (DCP) intake of animals of the three groups were 1.14, 1.17 and 1.02 kg.

4.4 MILK PRODUCTION

The fortnightly average of daily milk production of the experimental animals is given in Table 6 and illustrated in Fig. 2. The mean initial milk yield of the experimental animals of the three groups was 13.50 ± 1.41, 13.58 ± 1.05 and 11.08 ± 1.19 kg, while the final yield was 15.35 ± 1.42, 14.78 ± 1.07 and 12.88 ± 1.22 kg respectively, for T_1, T_2 and T_3.

4.5 MILK COMPOSITION

The data on composition of milk viz. percentage of total solids, milk fat, solids not fat and milk protein collected from experimental animals at 0, 6th and 12th week of the experiment are given in Table 7 and graphically presented in Fig. 3, 4,5 and 6. The milk urea nitrogen (MUN) concentration is presented in Table 8 and depicted in Fig.7.

4.6 YIELD OF FOUR PER CENT FAT CORRECTED MILK (FCM), MILK FAT AND MILK PROTEIN

The data on the yield of 4 per cent FCM, milk fat and milk protein during the entire period of the experiment (90 days) is given in Table 9 and graphically presented in Fig. 8 and 9. The average 4 per cent FCM yield was 1315.12, 1265.43 and 1346.41 kg respectively for animals of T_1, T_2 and T_3. The mean yield of milk fat was 53.36, 50.54 and 55.10 kg while the mean milk protein yield was 37.19, 35.75 and 34.79 kg respectively for the animals of T_1, T_2 and T_3.

4.7 HAEMATOLOGICAL PARAMETERS

The data on hemoglobin concentration, plasma glucose, plasma urea nitrogen, calcium and phosphorus of the blood samples collected from the experimental animals during 6th week and 12th week of the experiment are presented in Table 10 and depicted graphically in Fig. 10. The average initial haemoglobin and plasma glucose levels for the animals of the three groups T_1, T_2 and T_3 were 9.22, 8.4, 9.1 g/dl and 46.22, 64.24 and 50.44 mg/dl respectively. The initial plasma urea nitrogen levels were 25.22, 24.71 and 20.29 mg/dl. The initial plasma Ca and P concentrations were 11.48, 9.93, 11.46 and 6.57, 8.0 and 8.3 mg/dl respectively for the animals of the three groups.

4.8 DIGESTIBILITY OF NUTRIENTS

The percentage digestibility of dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF) and nitrogen free extract (NFE) of the three experimental rations is given in Table 12 and illustrated in Fig.11.

4.9 REPRODUCTIVE PERFORMANCE

The data on the reproductive performance of the experimental animals viz, conception rate and number of inseminations per conception are presented in Table 13. The average period for first post partum heat was 89.10, 73.80 and 58.40 days respectively for animals of T_1, T_2 and T_3.

4.10 ECONOMICS OF PRODUCTION

The total DMI from concentrate and roughage, total milk production and cost of feed per kg of milk production are depicted in Table 14. The cost of feed per kg of milk produced was Rs.5.97, 6.20 and 7.13 respectively for the three treatments T_1, T_2 and T_3.

Table 2. Chemical composition of the concentrate mix, maize and paddy straw, %

Parameter	Concentrate mix	Paddy straw	Maize
Dry matter	20.00	89.20	87.89
Crude protein	17.50	4.20	9.22
Ether extract	4.55	1.60	1.57
Crude fibre	11.41	32.24	1.10
Total ash	8.08	16.98	1.69
Acid insoluble ash	1.73	11.7	.09
Nitrogen free extract	58.46	45.00	86.42

Table 3. Gross energy[1] of feed ingredients of the concentrate mix, (cal/g)

Ingredient	Gross energy (cal/g)
Beer waste	4716.06
Tapioca starch waste	3379.51
Soya husk	3251.16
Maize waste	4081.51
Cotton seed cake	4284.53
Cotton seed cake (deoiled)	4007.33
Rice bran	3666.10
Maize bran	4049.81
Maize	4112.65
Coconut cake	4563.77
EnerFat™*	7533.51

*Rumen protected fat from Kemin

[1]Gross energy determined using Bomb calorimeter (Parr Instrument Company, U.S.A)

Table 4. Fortnightly average of daily dry matter intake of experimental cows, kg

Fortnight	Dry matter intake *,kg			P
	T_1	T_2	T_3	
1	14.35 ± 0.48	13.74 ± 0.58	13.39 ± 0.46	NS
2	14.17 ± 0.40	13.58 ± 0.52	13.22 ± 0.53	NS
3	13.88 ± 0.55	13.40 ± 0.46	12.85 ± 0.82	NS
4	13.68 ± 0.52	13.52 ± 0.50	12.95 ± 0.83	NS
5	13.51 ± 0.56	13.65 ± 0.55	13.09 ± 0.84	NS
6	13.47 ± 0.56	13.64 ± 0.54	13.09 ± 0.84	NS

*Mean of ten values ±SE

NS- Nonsignificant (P>0.05)

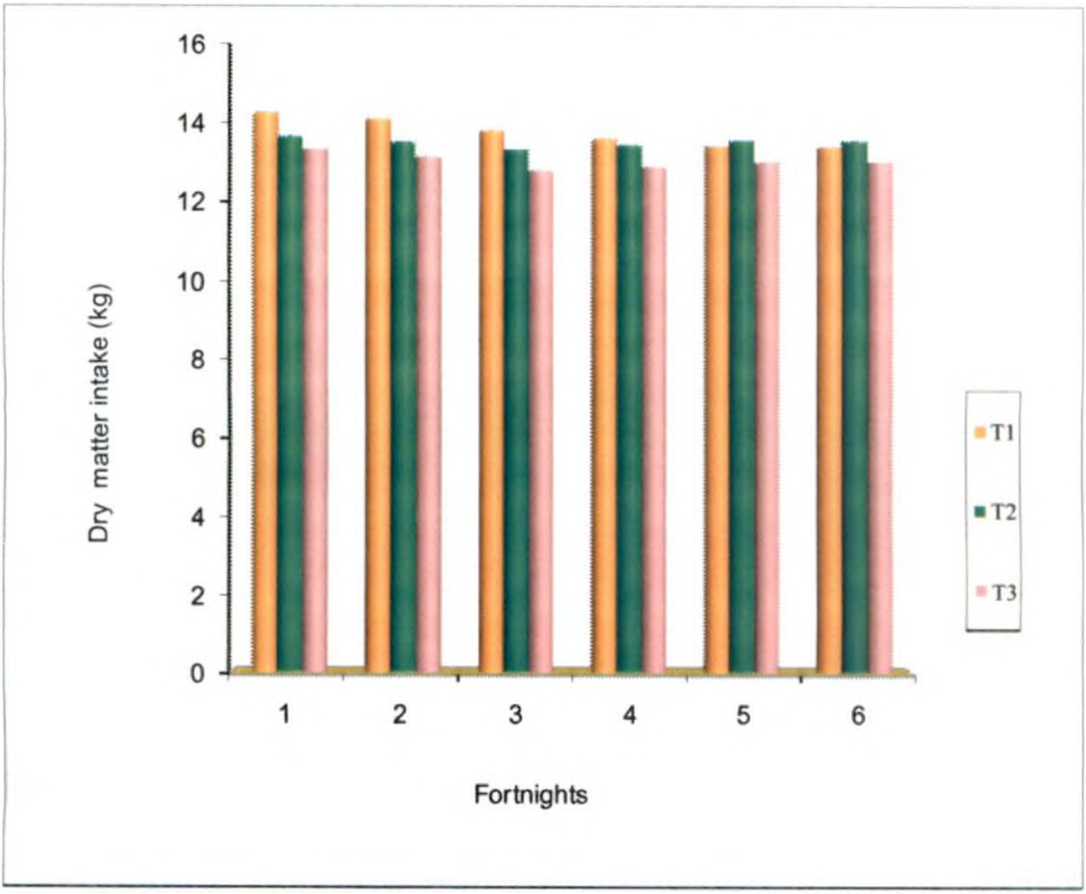


Fig 1. Average fortnightly dry matter intake of animals maintained on the three dietary treatments.

Table 5.Total digestible nutrients (TDN) and digestible crude protein (DCP) intake and requirement of experimental animals, kg

Treatment	TDN* (kg)			DCP* (kg)		
	Requirement	Intake	Deficit/ Excess (%)	Requirement	Intake	Excess (%)
T_1	8.81 ± 0.43	7.06 ± 0.23	-19.86	1.07 ± 0.06	1.14 ± 0.03	+6.5
T_2	8.34 ± 0.38	7.84 ± 0.12	-6.0	1.08 ± 0.07	1.17 ± 0.02	+14.7
T_3	7.34 ± 0.51	7.67 ± 0.38	+4.5	0.88 ± 0.06	1.02 ± 0.10	+15.9

* Mean of ten values ± SE

Table 6. Fortnightly average of daily milk production of experimental animals*, kg

Fortnight	Treatments			P
	T_1	T_2	T_3	
0	13.50 ± 1.41	13.58 ± 1.05	11.08 ± 1.19	NS
1	14.04 ±1.05	14.02 ± 1.05	13.22 ± 1.20	NS
2	15.01 ±1.45	14.41± 1.05	13.28 ± 1.46	NS
3	15.41 ±1.44	14.28 ± 1.04	13.29 ± 1.52	NS
4	15.07 ± 1.37	13.45 ± 1.08	13.10 ± 1.34	NS
5	15.44 ± 1.29	14.81 ± 1.02	13.18± 1.19	NS
6	15.35 ± 1.42	14.78 ± 1.07	12.88± 1.22	NS

*Mean of ten values ± SE

NS – Nonsignificant (P>0.05)

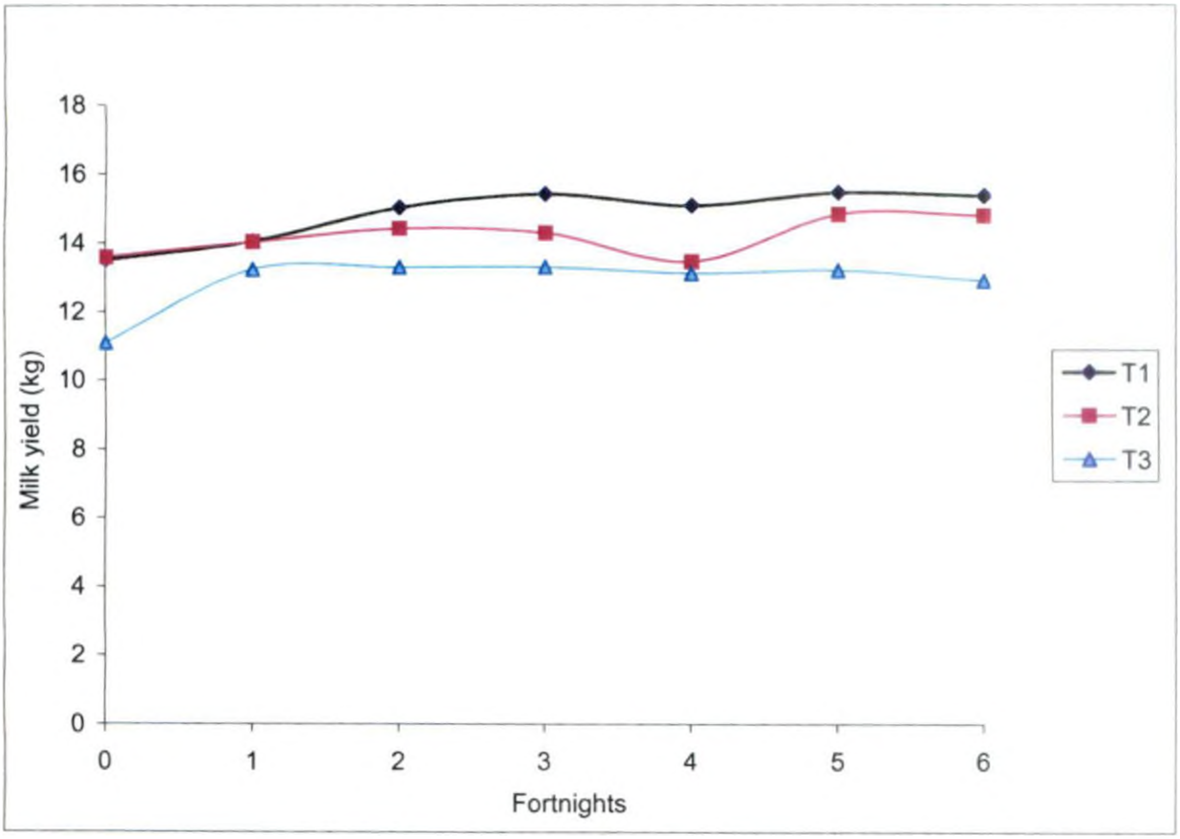


Fig 2. Average fortnightly milk yield of cows maintained on the three dietary treatments

Table 7. Composition of milk collected from animals maintained on the three experimental rations*, %

Parameter	Treatment	Period (week)			P
		0	6^{th}	12^{th}	
Total solids, %	T_1	13.08 ± 0. 53	13.72 ± 0. 81	13.50 ± 0. 64	NS
	T_2	13.08 ± 0. 48	14.27 ± 0. 86	12.63 ± 0. 43	
	T_3	14.14 ± 0. 63	13.72 ± 0. 53	13.67 ± 0. 56	
Milk fat, %	T_1	3.75 ± 0. 31	3.58 ± 0 .43	4.20± 0.57	NS
	T_2	3.26 ± 0. 29	4.45 ± 0. 62	4.88 ± 0. 35	
	T_3	4.83 ± 0. 73	3.98 ± 0. 76	5.30 ± 0. 49	
Solids not fat, %	T_1	9.65 ± 0.84	8.98 ± 0.35	8.51 ± 0.40	NS
	T_2	9.33 ± 0.42	9.14 ± 0.66	7.58 ± 0.43	
	T_3	10.11 ± 0.51	10.14 ± 0.84	8.52 ± 0.29	
Milk protein, %	T_1	2.73 ± 0.23	2.71 ± 0.11	2.92 ± 0.03	NS
	T_2	2.97 ± 0.14	2.79 ± 0. 09	2.84 ± 0.09	
	T_3	2.77 ± 0.16	2.84 ± 0.15	2.94 ± 0.12	

*Mean of ten values ± SE

NS – Nonsignificant (P>0.05)

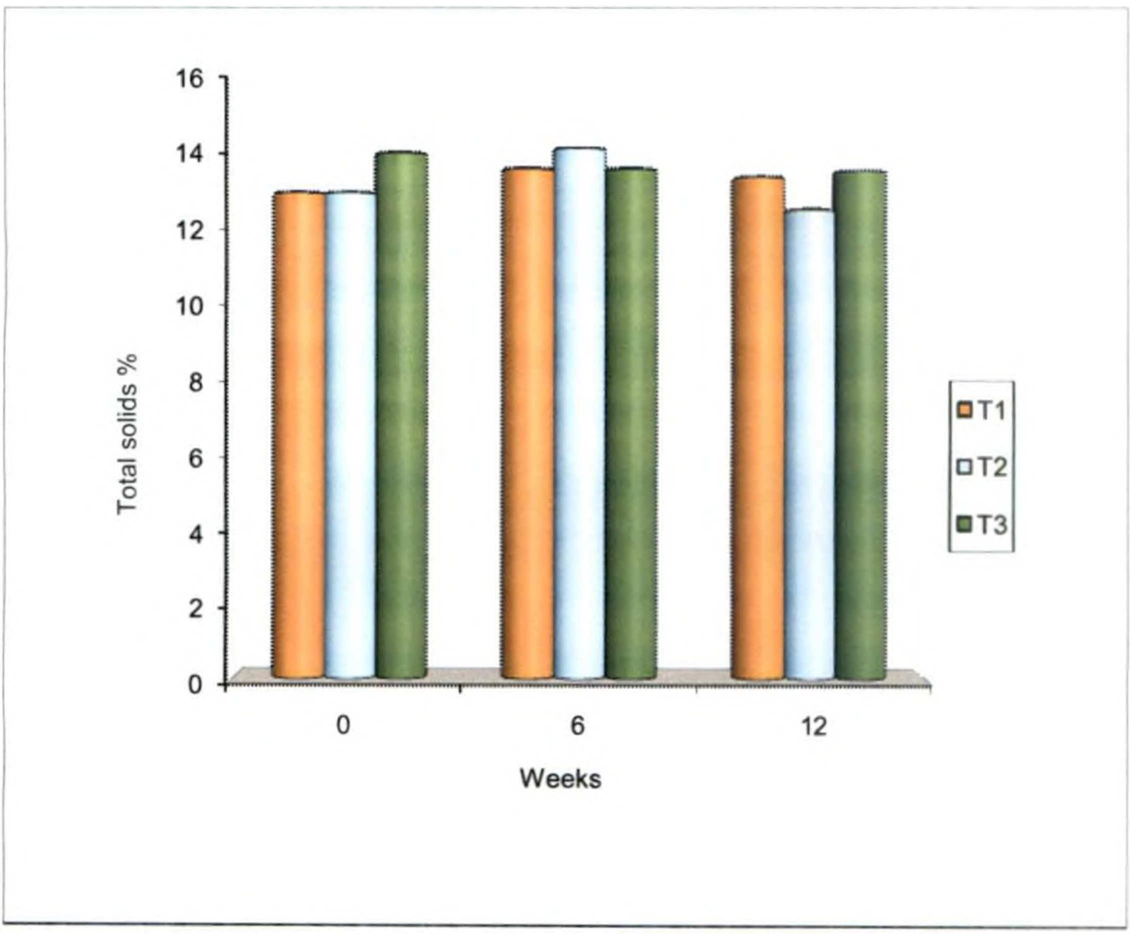


Fig 3. Average milk total solids of animals maintained on the three dietary treatments

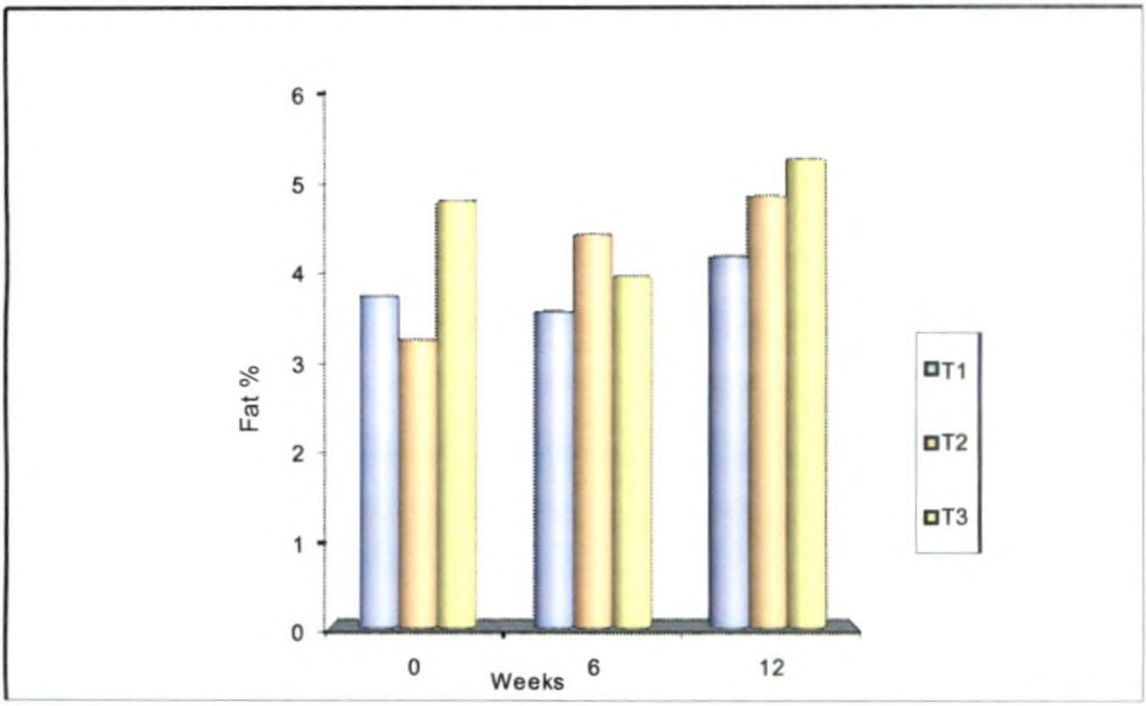
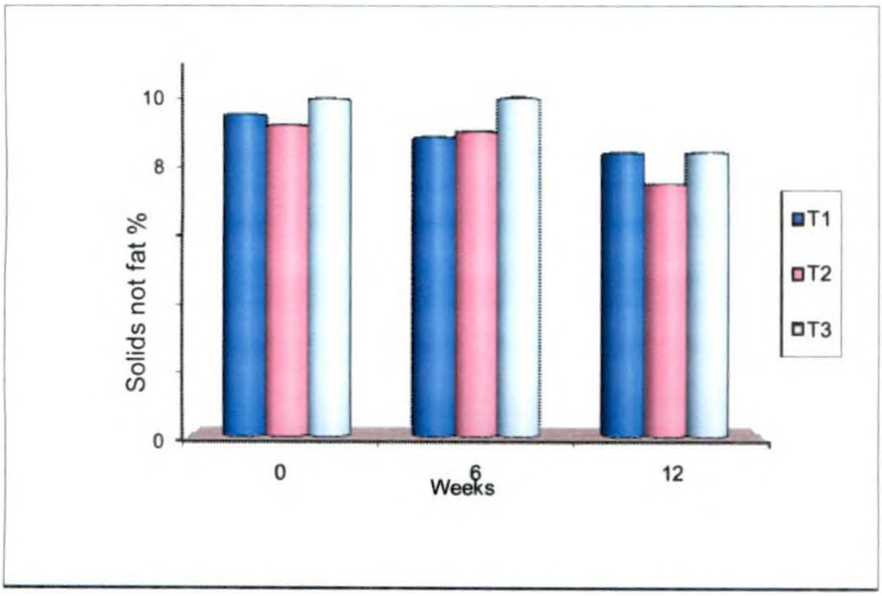


Fig 4. Average milk fat of cows maintained on the three dietary treatments



Fg 5. Average milk solids not fat (SNF) of cows maintained on the three dietary treatments

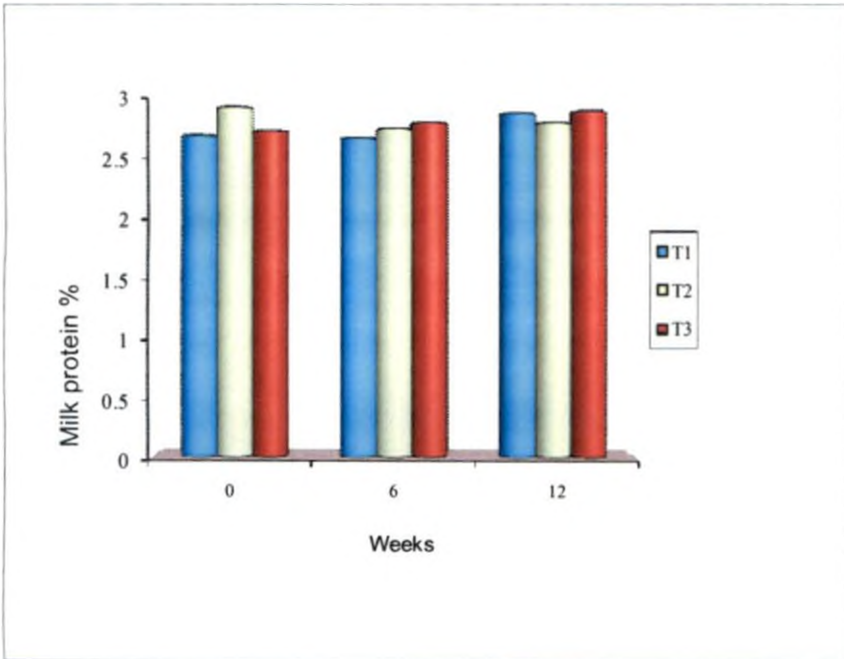


Fig 6. Average milk protein of cows maintained on the three dietary treatments

Table 8. Milk urea nitrogen concentration (MUN) * of animals maintained on the three experimental rations, mg/100ml

Parameter	Treatments	Period (weeks)			P
		0	6	12	
MUN (mg/100ml)	T_1	46.13 ± 7.38	58.68 ± 4.47	25.84 ± 2.31	NS
	T_2	44.69 ± 2.58	54.88 ± 3.43	29.88 ± 0.79	
	T_3	40.57± 4.24	55.94 ± 2.15	28.97 ± 2.08	

* Mean of ten values ± SE

NS – Nonsignificant (P>0.05)

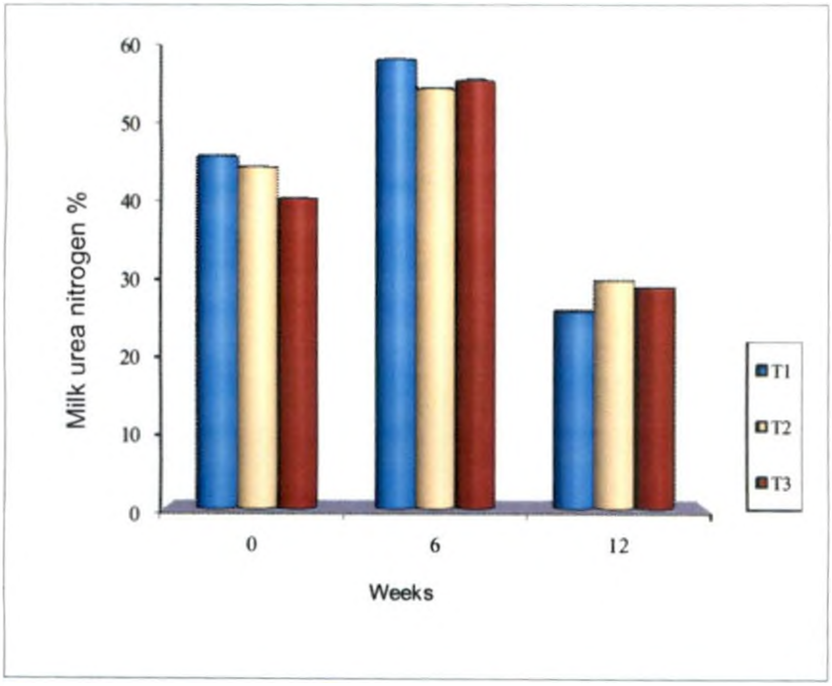


Fig 7. Average milk urea nitrogen of cows maintained on the three dietary treatments

Table 9.Yield of Four per cent FCM, milk fat and milk protein* of animals maintained on the three experimental rations, kg

Parameter	Treatments			P
	T1	T2	T3	
4 per cent FCM, kg	1315.12 ± 39.06	1265.43 ± 106.18	1346.41 ± 80.74	NS
Milk fat, kg	53.36 ± 3.40	50.54 ± 3.90	55.10 ± 4.10	NS
Milk protein, kg	37.19 ± 5.86	35.75 ± 1.35	34.79 ± 2.20	NS

*Mean of ten values ± SE

NS – Nonsignificant (P>0.05)

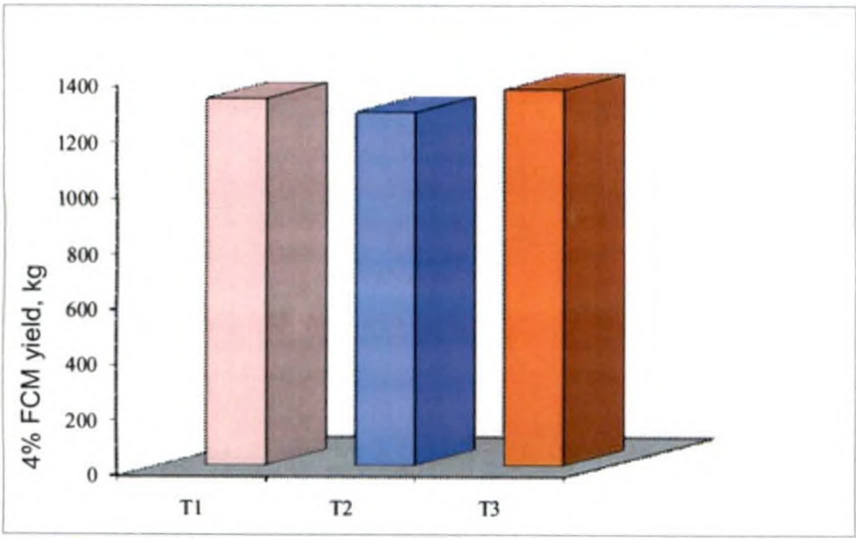


Fig 8. Four per cent FCM yield of cows fed on the three dietary treatments

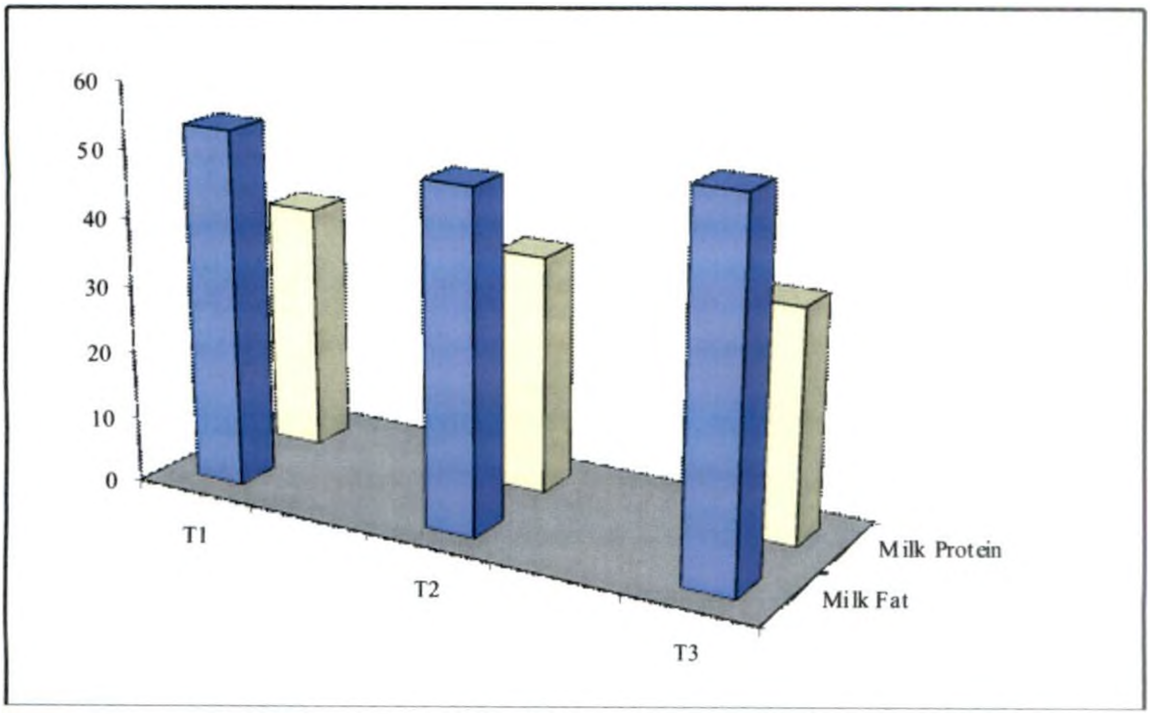


Fig 9.Total yield of milk fat and protein (kg) of cows maintained on the three dietary treatments

Table10. Haematological parameters of experimental animals*

Parameter	Treatments	Period (weeks)	
		6	12
Haemoglobin, g %	T1	7.97 ± 0.29	10.03 ± 0.32
	T2	7.81 ± 0.40	10.08± 0.48
	T3	8.36 ± 0.73	9.73 ± 0.66
Plasma Glucose, mg %	T1	58.19 ± 5.64	49.60 ± 1.97
	T2	54.39 ± 5.80	52.46 ± 0.85
	T3	57.18 ± 3.01	59.91 ± 5.57
Plasma Urea Nitrogen, mg %	T1	19.44 ± 0.26	27.43 ± 2.21
	T2	19.29 ± 0.22	23.56 ± 2.15
	T3	19.22 ± 0.35	29.95 ± 3.69
Plasma Calcium, mg %	T1	9.65 ± 0.60	10.62 ± 0.75
	T2	10.01 ± 1.15	10.46 ± 1.16
	T3	9.53 ± 1.01	9.45 ± 0.50
Plasma Phosphorus, mg%	T1	4.91 ± 0.35	5.44 ± 0.39
	T2	5.23 ± 0.55	5.79 ± 0.39
	T3	4.90 ± 0.46	5.18 ± 0.33

*Mean of ten values ± SE

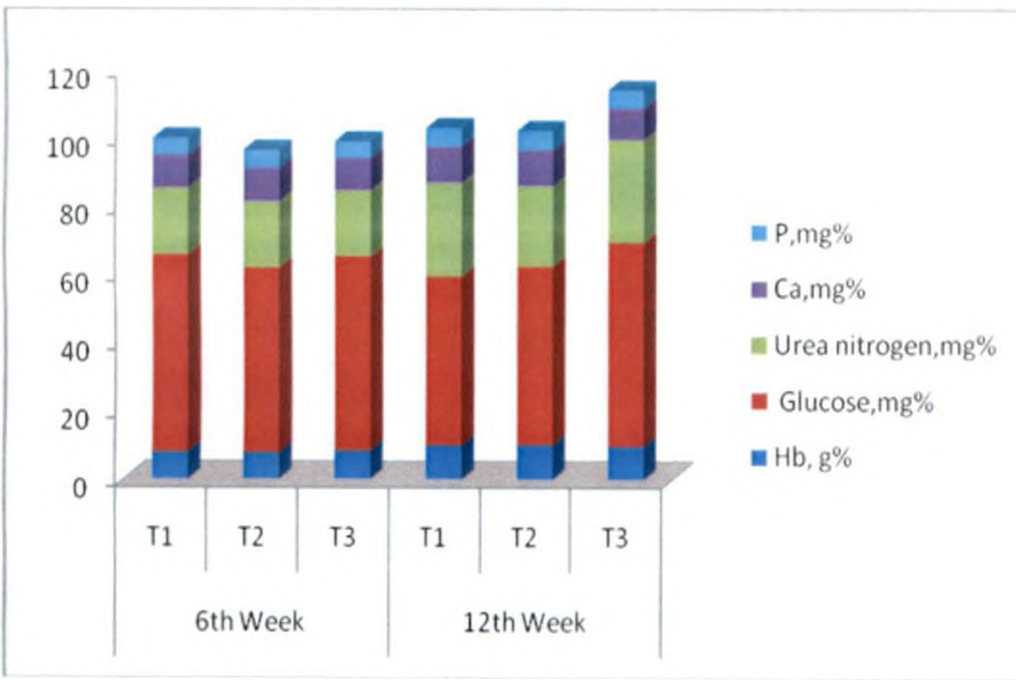


Fig 10.Hematological parameters of cows maintained on the three dietary treatments

Table 11. Chemical composition of the dung from experimental animals*, %

Nutrient	Treatments		
	T_1	T_2	T_3
Dry matter	22.60 ± 1.25	22.68 ± 1.04	20.81 ± 0.55
Crude protein	10.35 ± 0.58	10.55 ± 0.65	10.56 ± 0.25
Ether extract	3.67 ± 0.38	3.2 ± 0.43	2.89 ± 0.28
Crude fibre	24.57 ± 0.95	25.92 ± 0.63	25.82 ± 0.42
Total ash	12.08 ± 0.21	12.62 ± 0.45	13.23 ± 0.55
Nitrogen free extract	49.32 ± 0.95	47.72 ± 0.63	47.44 ± 0.41
Acid insoluble ash	8.31 ± 0.24	8.45 ± 0.43	8.80 ± 0.36
Neutral detergent fibre	55.95 ± 1.17	57.43 ± 1.23	57.12 ± 0.75
Acid detergent fibre	48.58 ± 0.48	49.28 ± 1.80	46.18 ± 0.56

*Mean of four values ± SE

Table 12. Digestibility of nutrients of experimental rations*, %

Nutrient	Digestibility, %		
	T1	T2	T3
Dry matter	50.99 ± 1.48	55.24 ± 2.21	56.48 ± 1.88
Crude protein	62.25 ± 1.18	67.02 ± 3.17	65.75 ± 1.98
Crude fibre	44.13 ± 3.68	31.88 ± 4.92	38.08 ± 2.64
Ether extract	56.36 ± 5.35	65.24 ± 5.59	72.28 ± 2.62
Nitrogen free extract	52.22 ± 1.17	63.20 ± 1.56	63.54 ± 2.19
Neutral detergent fibre	49.64 ± 0.86	52.01 ± 2.53	55.34 ± 1.84
Acid detergent fibre	32.30 ± 2.12	31.90 ± 4.72	33.26 ± 3.38

*Mean of four values ± SE

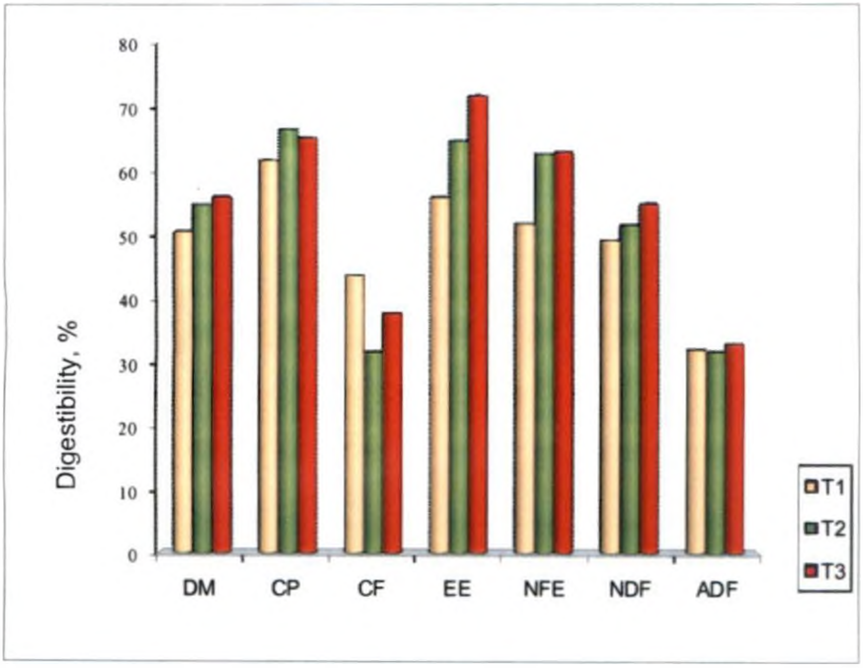


Fig 11. Digestibility of nutrients of experimental rations

Table 13. Reproductive performance of animals of the three experimental groups

Parameters	Treatments		
	T1	T2	T3
Average 1st post partum heat (days)	89.1	73.8	58.4
Number of animals conceived	9	7	7
Average number of AI/conception	1.55	1.57	1.7

Table 14. Economics of milk production of animals maintained on the three experimental rations

Parameter	Treatments		
	T1	T2	T3
Dry matter intake (DMI) from concentrate mix, kg	1214.173	1193.003	1146.471
Dry matter intake (DMI) from straw, kg	210.6	210.6	210.6
Total cost of feed, Rs.	8273.138	8132.78	8343.72
Total milk produced in 90 days, kg	1384.33	1312.71	1170.59
Cost /kg milk produced, Rs.	5.97	6.20	7.13

Discussion

5. DISCUSSION

5.1 DRY MATTER INTAKE (DMI)

The average daily DMI of animals in the three groups at fortnightly intervals is presented in Table 4 and graphically represented in Fig.1. The average DMI per 100 kg body weight was 3.22, 3.65 and 3.61 kg respectively for the cows under the three treatments T_1, T_2 and T_3. The daily DMI and DMI per 100 kg body weight did not show any significant difference ($P>0.05$) between the treatment groups. This is in agreement with Kent and Arambel (1988) who observed no significant difference in DMI of early lactating cows fed 223 g of Ca salts of fatty acids (Ca–LCFA) along with 13.2 per cent of whole cotton seed on dry matter (DM) basis. They stated that diets containing high amounts of cotton seed may mask the effect of energy provided by Ca-LCFA. Wilkerson *et al.* (1997) also observed similar DMI in cows supplemented with high moisture corn or dry corn either in the ground or rolled form.

Higher dry matter intake (DMI) was reported by DePeters *et al.* (1987) in cows fed diets containing added fat at the rate of 3.5 and 7 per cent of total DM of diet. Holter and Hayes (1994) suggested that earlier fat supplementation tended to be associated with higher DMI in first lactation cows.

McCaffree and Merril (1967) on the other hand, observed a reduction in forage DMI while feeding high moisture shelled corn (HMSC) to early lactating Holstein cows. Schauff and Clark (1992) also reported that DMI decreased linearly when increasing amounts of Ca-LCFA were added to the diet of lactating cows, but only the diet that contained 9 per cent of Ca- LCFA extensively depressed intake.

5.2 TOTAL DIGESTIBLE NUTRIENTS (TDN) AND DIGESTIBLE CRUDE PROTEIN (DCP) INTAKE

The TDN and DCP intake of the experimental animals and their requirements are presented in Table 5.The TDN intake of experimental animals of the three treatments T_1, T_2 and T_3 were 7.06, 7.84, and 7.67 kg, respectively. The TDN requirements calculated using the ICAR standards, 1985 were 8.8, 8.34, and 7.34 kg respectively for the three groups. The present study concludes that the TDN intake of animals of T_3 was up to the requirement, which was due to the supplementation of protected fat in T_3. The intake was less than the requirement for animals in the maize supplemented and control groups, the deficit being –6.0 and –19.86 per cent respectively.

The digestible crude protein (DCP) intakes of animals of the three groups were 1.14, 1.17 and 1.02 kg. The DCP requirements of animals of T_1, T_2 and T_3 calculated using the ICAR standards, 1985 were 1.07, 1.02 and 0.88 kg respectively indicating that the animals of all the three treatment groups received sufficient DCP to meet their requirements.

Kumar *et al.* (2006) reported that TDN and DCP content of the rations were not significantly different among the four rations with 0, 5, 10 and 15 per cent of calcium soap of red palm oil. The TDN and DCP required per kg FCM revealed non significant differences between the groups when ration with different energy levels were fed to lactating cows (Chavan *et al.*, 2006).

5.3 MILK PRODUCTION

The fortnightly average of daily milk yield of experimental cows of T_1, T_2 and T_3 are presented in Table 6 and illustrated in Fig.2. The mean initial milk yield of experimental animals of the three groups was 13.5, 13.53 and 10.75 kg, while the final yields were 15.35, 14.78 and 12.88 kg respectively for the groups T_1, T_2 and T_3.

The animals of the three groups showed 13.7, 9.23 and 19.81 per cent increase respectively from their initial yields. Thus percentage increase in milk yield was higher in the fat supplemented group than that of the control group, whereas the increase in the maize supplemented group was less than that of the control group. This may be due to the lesser quantity of roughage fed and the additional ground maize fed might have produced sub acute acidosis in those animals. The milk yield of animals of T_3 showed greater persistence than that of other two groups. On statistical analysis, there was no significant difference ($P>0.05$) between the fortnightly average milk yields of animals of T_1, T_2 and T_3.

Smith *et al.* (1978) also reported similar milk yields in Holstein cows fed mixed diets containing 0, 15 and 30 per cent of protected tallow supplement during the first 15 weeks of lactation. Similarly Kent and Arambel (1988) reported that feeding Ca-LCFA along with whole cottonseed had no effect on actual milk yield. Schauff and Clark (1992) also reported that inclusion of 3 or 6 per cent Ca-LCFA showed no significant difference in milk production. The maize supplemented group also showed no significant difference in milk production (Delahoy *et al.*, 2003), which agrees well with the results of the present study.

Higher milk production was reported by McCaffree and Merril (1967) and Wilkerson *et al.* (1997) in cows supplemented with high moisture corn while Schauff and Clark (1992) observed a reduction in milk production in cows fed diets supplemented with 9 per cent of Ca-LCFA

5.4 MILK COMPOSITION

The data regarding the milk components viz. total solids, milk fat, solids not fat (SNF) and milk protein are presented in Table 7 and illustrated in Fig.3, 4, 5 and 6 respectively. The data on milk urea nitrogen (MUN) is given in Table 8 and graphically depicted in Fig.7.

5.4.1 Total Solids

The average percentage of total solids of milk obtained at the end of the present investigation was 13.5, 12.63 and 13.67 for animals of the three treatments T_1, T_2 and T_3 respectively. There was no significant difference (P>0.05) in total solids between the three groups.

5.4.2 Milk Fat

The average milk fat percentage in the beginning of the experiment was 3.75, 3.26 and 4.8, respectively for the animals of T_1, T_2 and T_3. Milk fat percentage increased from 3.75 (first week) to 4.20 (twelfth week) in group I, the corresponding values, being 3.26 to 4.83 in group II and 4.8 to 5.30 in group III respectively. Statistical analysis revealed no significant difference (P>0.05) between the three groups regarding the milk fat percentage. Clark and Harshbarger (1972) also observed no significant difference in milk fat percentage when cows were offered with high moisture shelled corn (HMSC) or dry shelled corn (DSC) which is in agreement with the results obtained in the present study. No significant effect of supplementing fat in the form of calcium salts of fatty acids (CSFA) was observed by Schuaff and Clark (1989). Erickson *et al.* (1992) also reported that fat content of milk did not differ by feeding Ca-LCFA at 3 per cent level.

In contrast to these findings West and Hill (1990) reported a 5.5 per cent increase in milk fat when Holstein and Jersey cows were fed diets supplemented with Ca salts of fatty acids. Sklan and Moallem (1991) also observed an increase in milk fat in cows fed with CSFA.

A reduction in milk fat was reported by McCaffree and Merril (1967) in cows fed with HMSC. DePeters *et al.* (1987) also reported decreased percentage of fat in the milk of cows fed 7 per cent diet dry matter as animal fat. Kent and Arambel

(1988) also reported that percentage of milk fat tended to be lower for cows fed diets containing Ca-LCFA along with whole cotton seed.

5.4.3 Solids Not Fat

The solids not fat (SNF) percentage of milk of experimental animals of the three groups T_1, T_2 and T_3 respectively were 9.65, 9.33 and 10.11 at the beginning of the experiment and 8.51, 7.58 and 8.52 at the end. A reduction in the SNF percentage was seen at the end of the experiment in all the three groups, which may be due to increase in milk fat percentage. On statistical analysis there was no significant difference ($P>0.05$) in milk SNF percentage between the three groups. This is in agreement with Schauff and Clark (1992) who observed no change in milk SNF when 3 or 6 per cent of Ca-LCFA were fed to cows. On the other hand Holter and Hayes (1994) reported higher milk SNF for primiparous cows receiving CSFA supplementation immediately after calving. Increase in milk SNF percentage was also recorded by Wilkerson *et al.* (1997) in cows fed ground corn.

5.4.4 Milk Protein

The milk protein percentages were 2.73, 2.97 and 2.77 respectively for the three groups at the beginning of the experiment. The values obtained during sixth week and twelfth week are presented in Table 7. There was no significant difference ($P>0.05$) in milk protein percentage upon energy supplementation in the animals. Delahoy *et al.* (2003) also reported that milk protein composition did not differ when cows were fed cracked corn or steam flaked corn. Mandebvu *et al.* (2003) observed no difference in milk protein percentage when cows were fed Ca-LCFA from palm fatty acid distillate and soyabean oil.

However a 3.2 per cent increase in milk protein was reported by West and Hill (1990) when Holstein and Jersey cows were fed diets supplemented with

CSFA. Higher milk protein percentages were recorded in cows fed with diets containing ground corn (Wilkerson *et al.*, 1997) and in cows fed high starch supplements (Sayers *et al.*, 2003).

5.4.5 Milk Urea Nitrogen

The milk urea nitrogen (MUN) concentration of T_1, T_2 and T_3 recorded in the 0, 6^{th} and 12^{th} week of the present study showed no significant difference (P>0.05) between the three treatments (Table 8). Bector *et al.* (1998) reported that MUN in lactating cows ranged from 22.8 to 92.4 mg per cent. Mandebvu *et al.* (2003) also observed no difference in MUN when cows were fed Ca-LCFA from palm fatty acid distillate and soyabean oil. Feeding Ca and Na salts of propionate and Ca-LCFA to transition cows showed no significant difference in MUN (DeFrain *et al.*, 2005).

However Ballard *et al.* (2001) reported that milk produced by cows in 5 to 8 weeks post partum previously fed 908g/day of Ca propionate had a higher concentration of MUN when compared with cows previously fed 454g/day Ca propionate.

Delahoy *et al.* (2003) reported a reduction in MUN when cows were fed with steam flaked corn (SFC).

5.5 FOUR PER CENT FAT CORRECTED MILK (FCM) YIELD AND YIELD OF MILK FAT AND PROTEIN

The data on the yield of 4 per cent FCM, milk fat and milk protein is given in Table 9 and graphically presented in Fig. 8 and 9. The mean 4 per cent FCM yield of animals of T_1, T_2 and T_3 were 1315.12, 1265.43 and 1346.41 kg, respectively. The 4 per cent FCM yield tended to increase in the fat supplemented group. But there was no significant difference between the treatments. Kent and Arambel (1988) reported that feeding calcium salts of long chain fatty acids (Ca- LCFA) along with whole cottonseed had no effect on yield of 4 per cent FCM. Andrew *et al.* (1991) also observed that there were no treatment effects on yields of 4 per cent FCM on feeding 2.95 per cent of Ca-LCFA in lactating cows. The result in the present study was in accordance with the findings of Elliott *et al.* (1996) reported that 4 per cent FCM yield was not significantly different among treatments although 4 per cent FCM yield tended to increase when cows were fed hydrogenated palm fatty acid compared with cows that were fed Ca- LCFA.

However Sklan and Moallem (1991) and Erickson *et al.* (1992) observed that cows fed Ca soaps of fatty acids produced more FCM. Schroeder *et al.* (2002) reported that feeding 1 kg/day of supplemental fat in the form of partially hydrogenated oil increased FCM yield from 23.4 to 26.3 kg per day in grazing dairy cows in early lactation.

Decreased 4 per cent FCM yield was reported by (Schauff and Clark, 1992) and Schauff *et al.* (1992) by feeding Ca-LCFA at 9 per cent and 6 per cent levels respectively.

The mean milk fat yield of animals of the three groups T_1, T_2 and T_3 was 53.36, 50.54 and 55.10 kg respectively which showed no significant difference between the treatment groups. Andrew *et al.* (1991) also observed no treatment effects on milk fat yield when calcium salts of fatty acids(CSFA from) palm oil was fed to Holstein cows. However increased milk fat yield was reported by Sampelayo *et al.* (2004) in lactating goats fed poly unsaturated fatty acids rich protected fat and in cows fed propionate (DeFrain *et al.*, 2005).

The average yield of milk protein for animals of T_1, T_2 and T_3 was 37.19, 35.75 and 34.79 kg respectively. No significant difference in milk protein yield was observed between treatment groups which were in agreement with the findings of

Schroeder *et al.* (2002) where supplementation of oil did not affect the yield of milk protein. Similarly milk protein yield did not differ when cows were fed cracked corn or steam flaked corn (Delahoy *et al.*, 2003).

5.6 HAEMATOLOGICAL PARAMETERS

The data on the haematological parameters viz. Haemoglobin, plasma glucose, plasma urea nitrogen, plasma Ca and plasma P are given in Table10 and graphically represented in Fig.10. All the values obtained were within the normal levels specified for cows (Kaneko and Harvey, 1997). None of the parameters showed significant difference between the treatment groups.

5.6.1 Haemoglobin

The average haemoglobin concentration of the groups T_1, T_2 and T_3 were 10.03, 10.08 and 9.73 g/dl at twelfth week. Haemoglobin concentration showed no significant difference (P>0.05) between the groups following energy supplementation. Values higher than those obtained in the present study were reported by Hareesh (2007). The values were 12.18 and 12.88 g/dl for different treatments.

5.6.2 Plasma Glucose

The plasma glucose levels of experimental animals of three groups were 49.60, 52.46 and 59.91 mg/dl at twelfth week. There was no significant difference (P>0.05) between the plasma glucose levels of the three groups which was in agreement with the findings of Palmquist and Conrad (1978) and Smith *et al.* (1978). Delahoy *et al.* (2003) also reported no significant difference in plasma glucose levels when cows were fed with steam flaked corn and ground corn.

However Garcia-bojalil *et al.* (1998) reported an increase in plasma glucose level upon supplementing highly degradable protein diets with calcium salts of fatty acids.

5.6.3 Plasma Urea Nitrogen

The plasma urea nitrogen concentrations changed from 19.44 (sixth week) to 27.43 mg/dl (twelfth week), 19.29 to 23.56 mg/dl and 19.22 to 29.95 mg/dl respectively, in the groups T1, T2 and T3 respectively. No significant difference (P>0.05) in plasma urea nitrogen could be seen between the treatments. A similar observation was made by West and Hill (1990) who reported that blood urea nitrogen showed no significant difference when Holstein and Jersey cows at 95 days in milk were fed with CSFA. Erickson *et al.* (1992) also observed no difference in plasma urea nitrogen in cows fed with calcium salts of fatty acids.

On the other hand Kim, *et al.* (1993) reported that serum urea concentration was lower when cows were fed diets containing supplemental fats from extruded soybean or Ca-LCFA. Similarly plasma urea nitrogen decreased in cows supplemented with steam flaked corn and ground corn (Delahoy *et al.*, 2003).

5.6.4 Plasma Calcium and Phosphorus

The average plasma calcium levels of the three groups were 10.62, 10.46 and 9.45 mg/dl while the plasma phosphorus levels were 5.44, 5.79 and 5.18 mg/dl respectively, for the cows of T_1, T_2 and T_3 respectively at twelfth week. Neither of these parameters showed significant difference (P>0.05) between the treatments. West and Hill (1990) reported that plasma calcium and phosphorus showed no significant difference when calcium salts of fatty acids were fed to Holstein and Jersey cows.

5.7 DIGESTIBILITY OF NUTRIENTS

The chemical composition of dung of experimental animals and percentage digestibility of nutrients of the three experimental rations are presented in Tables 11 and 12 respectively. The data regarding the digestibility of nutrients is illustrated in Fig.11.

5.7.1 Dry Matter

The average dry matter digestibility of the three experimental rations T_1, T_2 and T_3 was 50.99, 55.24 and 56.48 per cent respectively. In the present study it was observed that the addition of ground maize (T_2) and protected fat (T_3) increased the DM digestibility compared to T1. A higher digestibility of dry matter was reported by Haddad and Younis (2004) when fattening Awassi lambs were fed rumen protected fat at 2.5 and 5 per cent levels. Feeding corn increased the digestibility of DM and organic matter (Wilkerson *et al.*1997).

However Jerred *et al.* (1990) reported that feeding prilled fat at 5 per cent level did not affect dry matter digestibility of cows. Erickson *et al.* (1992) also reported a similar finding when cows were fed with CSFA.

Lower dry matter digestibilities were reported by Schauff *et al.* (1992) and Simas *et al.* (1997) upon supplementing Ca-LCFA and prilled fat respectively.

5.7.2 Crude Protein

The percentage crude protein digestibilities of the three rations T_1, T_2 and T_3 were 62.25, 67.02 and 65.75 respectively. The digestibility of maize supplemented group was numerically higher. Similar observations were made by Schauff and Clark (1989), Kent and Arambel (1988) and Elliott *et al.* (1996) where supplementation of CSFA showed no significant difference in digestibility of crude protein. On the other hand Simas *et al.* (1997) observed that total mixed ration (TMR) containing prilled fat had lower digestibility of crude protein.

5.7.3 Crude Fibre

The crude fibre digestibilities were 44.13, 31.88 and 38.08 per cent for the three treatment rations T_1, T_2 and T_3 respectively. The crude fibre digestibility was numerically the lowest for maize supplemented group. DePeters *et al.* (1987) observed that digestibility of fibre was not significantly affected by fat when cows were fed complete mixed diets containing 0, 3.5 or 7 per cent of diet DM as animal fat. Elliott *et al.* (1996) observed no major difference for the digestibility of fibre fraction when cows were fed supplemental fat sources such as Ca-LCFA and hydrogenated palm fatty acids.

5.7.4 Ether Extract (EE)

The digestibility of EE for T_1, T_2 and T_3 were 56.36, 65.24 and 72.28 per cent respectively in the present study. The digestibility of EE of T_2 and T_3 rations were higher than that of the control. The EE digestibility of T_3 ration was the highest revealing that fat supplementation improved ether extract digestibility. Higher EE digestibility was reported by adding fat in the diets of Holstein cows (Palmquist and

Conrad, 1978). Reddy *et al.* (2003) and Haddad and Younis (2004) also reported higher EE digestibilitis by the addition of red palm oil and rumen protected fat respectively in the ruminant rations. Similarly, addition of high moisture shelled corn also increased EE digestibility (Clark and Harshbarger, 1972) which is also in tune with the results obtained in the present study.

5.7.5 Nitrogen Free Extract (NFE)

The percentage NFE digestibilities were 52.22, 63.20 and 63.54 respectively for the dietary treatments T_1, T_2 and T_3 the values being higher for maize supplemented and fat supplemented rations than the control ration. Similar values were reported by Hareesh (2007).

5.7.6 Neutral Detergent Fibre (NDF)

The average NDF digestibilities were 49.64, 52.01 and 55.34 per cent respectively for the treatments T_1, T_2 and T_3 respectively. The values obtained in the present study are agreeable with that obtained by Ally (2003). Results from the present study show a numerically higher digestibility of NDF for fat supplemented ration. Onetti and Grummer (2004) reported that total tract NDF digestibility increased when CSFA or selected hydrolyzed tallow fatty acids (SHTFA) were supplemented at an average of 3.7 per cent of diet dry matter. The NDF digestibility values obtained by DePeters and Taylor (1984) for corn supplemented diets were higher when compared to barley supplemented diets. However lower NDF digestibility was reported by Grummer (1988) in lactating dairy cows fed prilled fat supplement.

5.7.7 Acid Detergent Fibre (ADF)

The ADF digestibility obtained in the present study was 32.30, 31.90 and 33.26 per cent for the three rations, T_1, T_2 and T_3, respectively. There was a numerical increase in ADF digestibility of T3 ration compared to the other two. Palmquist and Conrad (1978) and Kent and Arambel (1988) also found no difference in digestibility of ADF upon fat supplementation.

Higher values than those observed in the present study were obtained by Bernard and Mc Neil (1991) for diets supplemented with soybean hulls as energy supplement. The values were 53.3, 61.8 and 45.4 and 52 per cent for different dietary treatments. Higher values were also reported by Sunil (2001) for diets supplemented with maize at 0, 0.5 and 1 kg levels. The values obtained were 42.35, 46.47 and 47.17 for the three treatments.

5.8 REPRODUCTIVE PERFORMANCE

The data regarding the reproductive performance of animals of the three groups viz. Average days of 1st post partum heat, number of animals conceived and number of AI/conception are given in Table 13. Average period for the first post partum heat in days was 89.1, 73.8 and 58.4 respectively, for the three groups. Results show that animals of the fat supplemented group attained post partum heat earlier. There was no difference in the number of AI/conception between the three groups. However conception rate was higher in the control group. Staples *et al.* (1998) suggested that supplementation of fat at the rate of 3.5 per cent of diet dry matter had positive influence on the reproductive status of early lactating cows. Mandebvu *et al.* (2003) observed no difference in days to first ovulation, days to first service and first service conception rate when cows were fed Ca-LCFA from soyabean oil and palm fatty acid distillate.

5.9 ECONOMICS OF MILK PRODUCTION

Economical assessment of the dietary treatments as cost /kg of milk produced reveals that the cost was slightly higher for the maize and fat supplemented groups, the cost being Rs.5.97, 6.20 and 7.13 respectively for the rations T_1, T_2 and T_3.

An overall evaluation of the results obtained during the present investigation revealed no significant effect of energy supplementation on actual milk yield, 4 per cent FCM yield, and milk and blood composition. However energy supplementation in the form of protected fat could meet the energy requirements of early lactating cows improved the digestibility of ether extract, DM, NDF, and ADF and positively influenced the first post partum heat.

Summary

6. SUMMARY

An investigation was carried out to assess the effect of energy supplementation in the form of ground maize and rumen protected fat on production performance of cows under field condition. Thus, the study was conducted at field level in a farm outside the Kerala Agricultural University.

Thirty, early lactating cross bred cows of the farm were selected and divided into three experimental groups as uniformly as possible with regard to days in milk, the average being 40 days. The animals were randomly allotted to the three dietary treatments T_1, T_2, and T_3. The three dietary treatments were:

T_1 – The basal concentrate mix prepared in the farm +paddy straw.

T_2 – Concentrate mix + paddy straw +1 kg ground maize

T_3 – Concentrate mix + paddy straw + 100 g protected fat.

The experiment was carried out for a period of 90 days under similar managemental conditions. Feeding was done four times daily and supplementation of maize and fat was done with afternoon feeding. Individual records of daily intakes of concentrate and roughage and daily milk production of the experimental animals were maintained. Milk samples collected at 0, 6th and 12th week of the experiment were analyzed for total solids, milk fat, solids not fat (SNF), milk protein and milk urea nitrogen (MUN). Four per cent fat corrected milk (FCM) yield, total yield of fat and protein were also calculated. The blood samples were analysed for hemoglobin, plasma glucose, plasma urea nitrogen and plasma Ca and P at 0, 6th and 12th weeks of the experiment. Towards the end of the experiment, a digestion trial was carried out using four animals from each group and digestibility coefficients found out by the

indicator method using acid insoluble ash as the indicator. Using the digestibility coefficients, the total digestible nutrients (TDN) and digestible crude protein (DCP) intake of animals were calculated. The animals were carefully observed for behavioral oestrous and those which showed the signs were inseminated regularly. The conception rate and number of AI required for conception were noted.

The animals maintained on rations T_1, T_2, and T_3 showed an average milk yield of 15.38, 14.58 and 13.01 kg respectively. Though the percentage increase in milk yield of animals of T_3 was higher, there was no significant difference between the three groups.

The fortnightly average of daily dry matter intakes were 13.47, 13.64, and 13.09 kg respectively for the animals of the three groups. The dry matter intake (DMI)/100kg body weight was 3.22, 3.65, and 3.61 kg respectively, for the animals of T_1, T_2, and T_3. The average daily DMI and DMI/100 kg body weight remained unaffected by energy supplementation.

The average TDN intakes of animals were 7.06, 7.84 and 7.67 kg for the three groups, while the requirements of the same were 8.81, 8.34 and 7.34 kg, respectively. The TDN intake was up to the requirement in animals of T_3 only while the DCP intakes could meet the requirement in all the three groups.

The milk composition parameters such as percentage of total solids, milk fat, solids not fat (SNF), milk urea nitrogen and milk protein remained similar in all the three treatment groups. Energy supplementation had no effect on four per cent FCM yield, yield of milk fat and milk protein of the three groups. The blood parameters viz hemoglobin, plasma glucose, plasma urea nitrogen, plasma Ca and P remained unaffected by energy supplementation in the animals of T2 and T_3.

The digestibility of dry matter was 50.99, 55.24 and 56.48 per cent respectively, for the three groups. The DM digestibility was higher for T_3. The crude protein (CP) digestibility was 62.25, 67.02 and 65.75 per cent, for the three groups. A numerically higher digestibility of CP was seen in T_2. The digestibility of crude fibre was 44.13, 31.88, and 38.08 per cent for the three groups. The ether extract (EE) digestibility of T_3 was higher than T_2 and T_1. The percentage digestibilities of EE for the three groups were 56.36, 65.24 and 72.28. The digestibility of nitrogen free extract for T_1, T_2 and T_3 were 52.22, 63.2 and 63.54 per cent, respectively. A numerically higher digestibility of neutral detergent fibre (NDF) and acid detergent fibre (ADF) was observed in T_3 than in T_1 and T_2, the digestibility of NDF being 49.64, 52.01 and 55.34 per cent and that of ADF 32.3, 31.9 and 33.26 per cent respectively for the three groups.

Post partum heat was attained within an average of 58.4 days of calving in animals of T_3 while it was 89.1 and 73.8 days for animals of T_1 and T_2. Conception rate was similar for the energy supplemented groups. Average number of AI/conception was similar for the three groups.

The cost of feed / kg milk produced was Rs. 5.97, 6.20 and 7.13 respectively for T_1, T_2 and T_3.

From the evaluation of results obtained during the course of the investigation under filed condition it could be concluded that energy supplementation of early lactating cows had no influence on the milk production, dry matter intake, yield of 4 per cent FCM, milk protein and fat and on any of the milk and blood parameters studied. However, supplementation of energy in the form of protected fat could meet the energy requirement of early lactating cows and had a beneficial effect on digestibility of EE, DM, NDF, and

ADF. The first post partum heat was also earlier in fat supplemented group than that of maize supplemented and control groups.

References

REFERENCES

Ally, K. 2003. Influence of level and degradability of dietary protein on early lactation in crossbred cows. Ph.D. thesis, Kerala Agricultural University, Thrissur, p.142.

Andrew, S.M., Tyrrell, H.F., Reynolds, C.K. and Erdman, R.A. 1991. Net energy for lactation of calcium salts of long-chain fatty acids for cows fed silage-based diets. *J. Dairy Sci.* 74:2588-2600.

AOAC. 1990. *Official Methods of Analysis*, Fifteenth edition. Association of Official Analytical Chemists. Washington D.C. p.587.

Ashes, J.R., Gulati, S.K. and Scott, T.W. 1997. Potential to alter the content and composition of milk fat through nutrition. *J. Dairy Sci.* 80:2204-2212.

Ballard, C.S., Mandebvu, P. and Sniffen., C.J. 2001. Effect of feeding an energy supplement to dairy cows pre and post partum on intake, milk yield and incidence of ketosis. *Anim. Feed Sci. Technol.* 93:55-69.

Bector, B.S., Ram, M. and Singhal, O.P. 1998. Rapid platform test for the detection of added urea in milk. *Indian Dairyman.* 50(4):59-62.

Bernard, J.K., Delost, R.C., Mueller, F.J., Miller, J.K. and Miller, W. 1991. Effect of wet or dry corn gluten feed on nutrient digestibility and milk yield and composition. *J. Dairy Sci.* 74:3913-3919.

Bernard, J.K., and Mc Neill, W.W. 1991. Effect of high fibre energy supplements on nutrient digestibility and milk production of lactating dairy cows. *J. Dairy Sci.* 74:991-995.

Chavan, S.S., Jagadale, S.D., Kank, V.D., Patil, M.B., Hol, B.G. and Gadegaonkar G.M. 2006. Effect of different levels of energy on milk production and its fat content in crossbred lactating cows. *The journal of Bombay veterinary college.* 14(1-2).

Clark, J.H. and Harshbarger, K.E. 1972. High mositure corn versus dry corn in combination with either corn silage or hay for lactating cows. *J. Dairy Sci.* 55:1474-1480.

DeFrain, J.M., Hippen, A.R., Kalscheur, K.F. and Patton, R.S. 2005. Effects of feeding propionate and calcium salts of long-chain fatty acids on transition dairy cow performance. *J. Dairy Sci.* 88:983-993.

Delahoy, J.E., Muller, L.D., Bargo, F., Cassidy, T.W. and Holden, L. A. 2003. Supplemental carbohydrate sources for lactating dairy cows on pasture. *J. Dairy Sci.* 86:906-915.

DePeters, E.J. and Taylor, S.J. 1984. Effects of feeding corn or barley on composition of milk and diet digestibility. *J. Dairy Sci.* 68:2027-2032.

DePeters, E.J., Taylor, S.J., Finley, C.M. and Famula, T.R. 1987. Dietary fat and nitrogen composition of milk from lactating cows. *J. Dairy Sci.* 70:1192-1201.

Elliott, J.P., Drackley, J.K., and Weigel, D.J. 1996. Digestibility and effects of hydrogenated palm fatty acid distillate in lactating dairy cows. *J. Dairy Sci.* 79:1031-1039.

Erickson, P.S., Murphy, M.R. and Clark, J.H. 1992. Supplementation of dairy cow diets with calcium salts of long-chain fatty acids and nicotinic acid in early lactation. *J. Dairy Sci.* 75:1078-1089.

Filley, S.J., Turner, H.A. and Stormshak, F. 2000. Plasma fatty acids, prostaglandin F2α metabolite, and reproductive response in postpartum heifers fed rumen bypass fat. *J. Anim Sci. 78:139*-144.

Garcia-Bojalil, C.M., Staples, C.R., Risco, C.A., Savio, J.D. and Thatcher, W. W. 1998. Protein degradability and calcium salts of long-chain fatty acids in the diets of lactating dairy cows: productive responses. *J. Dairy Sci.* 81:1374–1384.

Grummer, R.R. 1988. Influence of prilled fat and calcium salt of palm oil fatty acids on ruminal fermentation and nutrient digestibility. *J. Dairy Sci.* 71:117-123.

Haddad, S.G. and Younis, H.M. 2004. The effect of adding ruminally protected fat on nutrirent intake,digestibility and growth performance of Awassi lambs. *Anim. Feed Sci. Technol.* 113: 61-69.

Hareesh, P.S. 2007. Effect of dietary supplementation of organic chromium in lactating cows. M.V.Sc. thesis, Kerala Agricultural University, Thrissur, pp 37, 46.

Holter, J.B. and Hayes, H.H. 1994. No advantage to delaying the introduction of calcium soaps of palm oil fatty acids to early lactation dairy rations. *J. Dairy Sci.* 77:799-812.

I.C.A.R. 1985. Nutrient requirement of livestock and poultry. Indian Council of Agricultural Research, New Delhi.

I.C.A.R. 1998. Nutrient requirement of livestock and poultry. Indian Council of Agricultural Research, New Delhi.

I S: 1224. 1977. *Determination of fat by Gerber's method.* Part 1. Milk (First revision). Indian Standards Institution. New Delhi, p.18.

Jerred, Y.J., Carroll, D.J., Combs, D.K. and Grummer, R.R. 1990. Effects of fat supplementation and immature alfalfa to concentrate ratio on lactation performance of dairy cattle. *J.Dairy Sci.* 73:2842-2854.

Kaneko, J.J. and Harvey, J.W. 1997.*Clinical Biochemistry of Domestic Animals*. Fifth edition. Academic press, California, p.905.

Kent, B.A. and Arambel, M.J. 1988. Effect of calcium salts of long-chain fatty acids on dairy cows in early lactation. *J. Dairy Sci.* 71:2412-2415.

Kim, Y.K., Schingoethe, D.J., Casper, D.P. and Luden, F.C.1993. Supplemental dietary fat from extruded soyabeans and calcium soaps of fatty acids for lactating dairy cows. *J. Dairy Sci.* 76:197-204.

Kumar, R., Sivaiah, K., Reddy, Y.R., Ekambaran, B., Reddy, T.J. and Reddy, G.V.N. 2006. Effect of supplementation of dietary protected lipids on intake and nutrient utilization in deccani lambs. *Trop. Anim. Health Prod.* 38(2). p 151.

Mandebvu, P., Ballard, C.S., Sniffen, C.J., Carter, M.P., Wolford, H.M., Sato, T., Yabuuchi, Y., Block, E. and Palmquist, D.L. 2003. Effect of feeding calcium salts of long chain fatty acids, from palm fatty acid distillate or soybean oil, to high producing dairy cows on milk yield and composition, and on selected blood and reproductive parameters. *Anim. Feed Sci. Technol.* 108: 25-41.

McCaffree, J.D. and Merril, W.G. 1967. High moisture corn for dairy cows in early lactation. *J. Dairy Sci.* 54:553-560.

Neville, Jr. W.E. 1974. Comparison of energy requirements of non-lactating and lactating Hereford cows and estimates of energetic efficiency of milk production. *J. Anim Sc.* 38:681-686.

NRC. (2001). Nutrient requirements of dairy cattle. 7th rev.edn. National Research Council, National Academy Press ,Washington, D.C. p 260.

Onetti, S.G. and Grummer, R.R. 2004. Response of lactating cows to three supplemental fat sources as affected by forage in the diet and stage of lactation: a meta analysis. *Anim. Feed Sci.Technol.* 115:65-82.

Palmquist, D.L. and Conrad, H.R. 1978. High fat rations for dairy cows. Effects on feed intake, milk and fat production, and plasma metabolites. *J. Dairy Sci.* 61:890-901.

Paul, S.S., Asit, B., Mandal, A.B. and Pathak, N.N. 2002. Feeding standards for lactating riverine buffaloes in tropical conditions. *J. Dairy Res.* 69: 173-180.

Perfield, J.W., Bernal-Santos, H.G., Overton, T.R. and Baumann, D.E. 2002. Effects of dietary supplementation of rumen-protected conjugated linoleic acid in dairy cows during established lactation. *J. Dairy Sci.*85:2609-2617.

Reddy, Y.R., Krishna, N., Rao, E.R. and Reddy, T.J. 2003. Influence of dietary protected lipids on intake and digestibility of straw based diets in Deccani sheep. *Anim. Feed Sci.Technol.* 106: 29-38.

Sampelayo, M.R.S., Alonso, J.J. M., Perez, L., Extremera, F.G. and Boza, J. 2004. Dietary supplements for lactating goats by polyunsaturated fatty acid-rich protected fat. Effects after supplement withdrawal. *J. Dairy Sci.* 87:1796-1802.

Sayers, H.J., Mayne, C.S. and Bartram, C.G. 2003. The effect of level and type of supplement offered to grazing dairy cows on herbage intake, animal performance and rumen fermentation characteristics. *Anim. Sci.* 76:439-454.

Schauff, D.J. and Clark J.H. 1989. Effects of prilled fatty acids and calcium salts of fatty acids on rumen fermentation, nutrient digestibilities, milk production, and milk composition. *J. Dairy Sci.* 72:917-927.

Schauff, D.J. and Clark J.H. 1992. Effects of feeding diets containing calcium salts of long-chain fatty acids to lactating dairy cows. *J. Dairy Sci.* 75:2990-3002.

Schauff, D.J., Clark, J.H. and Drackley, J.K. 1992. Effects of feeding lactating dairy cows diets containing extruded soybeans and calcium salts of long-chain fatty acids. *J. Dairy Sci.* 79:3003-3019.

Schroeder, G. F., Gagliostro, G. A., Becu-villalobos, D. and Lacau-mengido, I. 2002. Supplementation with partially hydrogenated oil in grazing dairy cows in early lactation. *J. Dairy Sci.* 85:580–594.

Sharma, P., Gupta, R.S. and Baghel, R.P.S. 2007. Energy requirements of lactating murrah buffaloes. *Buffalo Bulletin.* 26(4): 134-137.

Simas, J.M., Huber, J.T., Theurer, C.B., Chen, K.H., Santos, F.A.P. and Wu, Z. 1997.Influence of fat source and sorghum grain treatment on performance and digestibilities of high yielding dairy cows. *J. Dairy Sci.* 80:2907–2912.

Sklan, D., Ashkenazi, R., Braun, A., Devorin, A. and Tabori, K. 1992. Fatty acids, calcium soaps of fatty acids, and cottonseeds fed to high yielding cows. *J. Dairy Sci.* 75:2463-2472.

Sklan, D. and Moallem, U. 1991. Effect of feeding calcium soaps of fatty acids on production and reproductive responses in high producing lactating cows. *J. Dairy Sci.* 74:510-517.

Smith, N.E., Dunkley, W.L. and Franke, A.A. 1978. Effects of feeding protected tallow to cows in early lactation. *J. Dairy Sci.* 61:747-756.

Snedecor, G.W. and Cochran, W.G. 1994. *Statistical Methods*. Eighth edition. The Iowa state University press, Ames, Iowa p.313.

Staples, C.R., Burke, J.M. and Thatcher, W.W. 1998. Influence of supplemental fats on reproductive tissues and performance of lactating cows. *J. Dairy Sci.* 81:856-871.

Strusinska, D., Minakowski, D., Pysera, B. and Kaliniewicz, J. 2006. Effects of fat-protein supplementation of diets for cows in early lactation on milk yield and composition. *Czech J. Anim. Sci.* 51 (5): 196–204.

Sunil, W. 2001. Effect of energy supplementation on growth of cross bred heifers. M.V.Sc. theis, Kerala Agricultural University, Thrissur.p 38.

West, J.W. and Hill, G.M. 1990. Effect of a protected fat product on productivity of lactating Holstein and Jersey cows. *J. Dairy Sci.* 73:3200-3207.

Wilkerson, V.A., Glenn, B.P. and Mcleod, K.R. 1997. Energy and nitrogen balance in lactating cows fed diets containing dry or high moisture corn in either rolled or ground form. *J. Dairy Sci.* 80:2487–2496.

ENERGY SUPPLEMENTATION ON PRODUCTION PERFORMANCE OF COWS UNDER FIELD CONDITION

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ABSTRACT

A study was conducted to assess the effect of energy supplementation in the form of maize and rumen protected fat in early lactating cows under the field condition. Thirty, early lactating cross bred cows were selected and divided into three groups uniformly with regard to days in milk, the average days in milk being 40 days. The animals were randomly allotted to the dietary treatments T_1, T_2 and T_3. The concentrate mix made in the semi liquid form and paddy straw formed the T_1 ration. The animals of T_2 and T_3 were supplemented with 1 kg ground maize and 100 g of rumen protected fat respectively, over and above the control ration.

The animals maintained on the three dietary treatments T_1, T_2 and T_3 showed an average milk production of 15.38, 14.58 and 13.01 kg respectively during the 90 day period of the experiment. Statistical analysis showed no significant difference ($P>0.05$) in milk yield between the three treatment groups. The average daily DMI and DMI/100 kg body weight remained similar for all the three groups.

The TDN intake was up to the requirement in animals maintained on T_3 ration while T_1 and T_2 rations could not meet the requirements of the animals of the respective groups. The DCP intake was optimum from the three rations.

The energy supplementation did not affect milk composition such as percentage of total solids, milk fat, solids not fat (SNF) and milk protein, and milk urea nitrogen (MUN). The 4 per cent FCM yield, total yield of milk fat and protein remained unaffected by energy supplementation. Animals in all the three groups showed similar blood parameters such as haemoglobin, plasma glucose, plasma urea nitrogen and plasma Ca and P.

The digestibility of EE, DM, NDF and ADF was higher for the T3 ration than that of T_1 and T_2. The digestibility of crude protein (CP) was higher for T_2 than T_1 and T_3 rations.

Animals maintained on T_3 ration showed earlier post partum heat. The cost of feed for producing 1 kg milk was higher for the dietary treatments T_2 and T_3.

An overall assessment of the results obtained in the present study showed that energy supplementation in the form of either maize or rumen protected fat could not influence dry matter intake, milk yield and 4 per cent FCM yield. There was no change in the composition of milk and blood parameters studied, among the experimental animals. However, energy supplementation in the form of protected fat could meet the energy requirement of early lactating animals, improved the digestibility of EE, DM, NDF and ADF and positively influenced the first post partum heat.