EFFECT OF DIETARY SUPPLEMENTATION OF ORGANIC CHROMIUM IN LACTATING COWS

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

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DECLARATION

I hereby declare that the thesis entitled **"EFFECT OF DIETARY SUPPLEMENTATION OF ORGANIC CHROMIUM IN LACTATING COWS"** 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 **"EFFECT OF DIETARY SUPPLEMENTATION OF ORGANIC CHROMIUM IN LACTATING COWS"** is a record of research work done independently by **Dr. Hareesh. P.S** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Hareesh.P.S.

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Introduction

INTRODUCTION

Chromium is an integral component of the Glucose Tolerance Factor (GTF) which is an organometallic molecule potentiating the effect of insulin binding to receptors at the cell surface. With chromium acting as a cofactor of insulin, it is required for normal functioning of the ß cells in the pancreas, preventing hyperresponsiveness of insulin secretion to glucose stimulation. Glucose Tolerance Factor was first isolated from pork kidney and brewer's yeast and it has a much greater biological activity than do inorganic sources of chromium alone. Glucose Tolerance Factor consists of chromium (Cr^{+3}), organic components of nicotinic acid, glycine, glutamic acid and cysteine and without chromium at its core it is inactive. Chromium in plants is organically complexed with concentrations approximating 30 to 50 ppb reported in very limited studies. Good natural sources, in addition to brewer's yeast, include dark chocolate, black pepper and some processed meats. Higher concentrations of total chromium in diets would probably be due to contamination in feedstuffs, particularly forages, or high contamination in mineral supplements.

Circulating chromium is associated with the ß-globulin portions of plasma and in physiologic concentrations is transported to tissues bound to transferrin and possibly as a component of GTF (NRC, 1997). Unlike elements such as calcium and magnesium there is no equilibrium between tissue stores of chromium and plasma. Absorbed chromium is mainly excreted in the urine. Small amounts, however, are lost in perspiration, milk and bile (Pechova and Pavlata, 2007).

Inorganic chromium is very poorly absorbed within a range of 0.4 to 2 % while the availability of organic chromium is more than 10 times higher. Also the inorganic chromium must be converted to an organic complex, such as GTF to enable the physiological functioning of chromium. Conversion of inorganic chromium in the liver or kidneys to the bioactive form may be slow and therefore supplying chromium in the preformed organic complex form increases absorption, reduces variability in responses and negates the need for adequate dietary precursors like nicotinic acid, certain amino acids to aid inorganic chromium absorption and conversion to the bioactive form.

Chromium supplementation of cattle diets has affected carbohydrate and lipid metabolism in a number of studies using various forms of supplemental chromium which include chromium chloride, chromium tripicolinate, chromium nicotinic acid complex, chromium amino acid chelate, chromium propionate and high chromium yeast. The variation in responses observed between different studies may reflect differences in the bioavailability of these supplemental chromium sources and bioavailability of chromium in the control diet.

Supplemental organic chromium can increase the rate of gain anywhere from 0 to 30 % depending upon the level of stress or disease challenge. However, chromium does not actually increase the rate of gain; rather it prevents the depression in rate of gain which often occurs under stressful or other conditions leading to chromium deficiency. To be fully effective supplementation at an adequate level must begin early in the disease challenge or stress period.

Supplemental organic chromium may be needed or economically beneficial in the following circumstances:

a) During heat stress periods.
b) With poorly managed animals subject to more pathogenic, environmental and even nutritional stress.

c) In borderline or lower protein diets.
d) Rations containing high level of silages particularly legume silages which have excess non protein nitrogenous substances or soluble nitrogen leading to stress due to nutritional imbalance.
e) In low effective fibre diets

Fineness of silage or hay chop and level or type of non-structural carbohydrates have a major effect on rumen propionate, which may lead to mobilization of chromium from body stores and probably increase urinary chromium excretion. Administration of bovine somatotropin to dairy cows increases plasma glucose, insulin and non-esterified fatty acids which are expected to increase the dietary requirement of chromium. Another nutritional factor that may influence chromium depletion in ruminants is hyperammonemia or elevated blood ammonia concentration.

Chromium seemed to reduce blood cortisol concentrations during stress and promoted improved insulin or insulin like growth factor (IGF-1) sensitivity in target tissues such as muscle, mammary gland and the immune system. Supplemental organic chromium is found to improve the milk production of young dairy cattle during stress periods, reduce age related metabolic disorders like ketosis and also decrease the incidence of milk fever, retained placenta and even acidosis.

The more intensive system of farming with the objective of raising the milk production has increased the stress factors on the dairy cows. The transition period of late gestation through early lactation is a particularly crucial time for high producing dairy cows and during this period the cows are under great physical, nutritional, psychosocial and metabolic stresses which are reflected in altered hormone profiles and increased disease or disorder susceptibility. During this period high yielding animals are in a negative energy balance and they require a large amount and rapid supply of glucose for milk lactose synthesis which results in lower plasma glucose and insulin compared with later in lactation. The ability of insulin to control glucose utilization and partitioning determines milk production, fertility and health status of cows and therefore the need for chromium is of utmost importance during this critical period.

Hence the present study is undertaken to assess the effect of dietary supplementation of organic chromium on milk production and metabolic profile of crossbred cows in early lactation.

Review of Literature

2. REVIEW OF LITERATURE

2.1 EFFECT OF CHROMIUM ON PRODUCTION PERFORMANCE

2.1.1 Dry Matter Consumption and Growth Rate

Moonsie-Shageer and Mowat (1993) observed increase in average daily gain and dry matter intake in calves fed 0.2 and 1 ppm of supplemental chromium in the form of high chromium yeast.

Kitchalong *et al.* (1995) studied the effect of chromium tripicolinate at 250 ppb on the dry matter intake (DMI) and average daily gain (ADG) of growing lambs and found that there was no improvement in DMI, ADG, or nitrogen balance. Similar results were observed by Chang and Mowat (1992) in calves fed high chromium yeast at 0.4 ppm and Bunting *et al.* (1994) in calves, steers, and heifers fed chromium tripicolinate at 370 µg / kg.

Mooney and Cromwell (1995) when evaluated the effect of chromium picolinate on growth performance, carcass composition and tissue accretion rates in pigs observed an increase in the average daily gain but no effect on average daily feed intake or feed:gain ratio.

According to Kegley *et al.* (1997a) chromium nicotinic acid supplementation improved the average daily gain of growing steers regardless of whether they had been stressed by shipping. Depew *et al.* (1998) also noted that supplemental chromium tripicolinate had favouring effects on the metabolism and performance of conventionally managed dairy calves especially during the initial few weeks of life. However Bunting *et al.* (2000) observed no significant effect on body weight gain in calves on chromium propionate supplementation at a level of 0.5 ppm in the milk replacer and calf starter. Sahin *et al.* (2001) observed that chromium chloride supplementation at 0, 200, 400 ppb had no effect on average daily gain, feed intake or feed efficiency of the weaned rabbits. Similarly on chromium picolinate supplementation Besong *et al.* (2001) could not find any effect on dry matter intake and average daily gain of Holstein steers.

According to Hayirli *et al.* (2001) chromium methionine supplementation at levels of 0, 0.03, 0.06 and 0.12 mg in dairy cattle produced a linear and quadratic increase in dry matter intake and decreased body condition score loss in periparturient dairy cows. Similar results of linear increase in postpartum dry matter intake in cows were also reported by Smith *et al.* (2005) by supplementing chromium picolinate at 0, 0.03, 0.06 mg level. On chromium picolinate supplementation Lien *et al.* (2001) also observed improved growth performance, enhanced average daily gain, increased feed consumption and improved carcass characteristics of growing-finishing pigs.

Pechova *et al.* (2002) reported a significant effect on weight gain in fattening bulls following chromium supplementation as chromium enriched yeast at 5 mg / cow/ day. Kroliczewska *et al.* (2005) obtained increased weight gain in broilers following supplementation with chromium enriched yeast at 500 μg / kg of the diet.

Van-de-ligt *et al.* (2002) opined that maternal supplementation of chromium tripicolinate did not affect average daily gain, average daily feed intake and gain: feed in the weanling pigs which corroborated with the observations made by Matthews *et al.* (2003) in growing-finishing pigs. Similarly Khajarern *et al.* (2006) found that chromium bisglycinate-nicotinamide chelate supplementation in growing and finishing pigs did not affect the average daily gain and feed efficiency but dressing percentage increased significantly in chromium supplemented group.

Yildiz *et al.* (2004) found that organic chromium supplementation increased performance traits, particularly egg production and feed conversion ratio, serum insulin concentrations, egg yolk and albumen weights of laying quails. Chromium picolinate supplementation alleviated heat stress related depression in performance such as body weight gain, feed intake and carcass traits in broiler chicks (Toghyani *et al.*, 2006).

2.2 EFFECT ON HAEMATOLOGICAL PARAMETERS:

Abraham *et al.* (1980) studied the effect of potassium chromate on cholesterol induced atherosclerotic plaques in rabbits and found that daily intraperitoneal administration of 20 μg of potassium chromate had significant effect on the regression of these atherosclerotic plaques. Anderson *et al.* (1985) noted significantly increased serum chromium level following chromium supplementation in the form of chromic chloride at 200μg level as a reflection of the chromium intake, and also opined that serum chromium concentration, even that following a glucose load does not appear to be a meaningful indicator of chromium status. Decrease in serum cortisol levels and increase in blood hematocrit, serum calcium, magnesium levels in steer calves were observed by Moonsie-Shageer and Mowat (1993) on feeding chromium supplemented corn silage. Chang and Mowat (1992) also observed decreased serum cortisol levels by feeding chromium supplemented corn silage diets in transit steer calves. Bunting *et al.* (1994) reported that chromium tripicolinate reduced plasma cholesterol in calves. Bunting *et al.* (1994) and Kegley *et al.* (2000) reported enhanced glucose clearance rates and increased insulin response to an intravenous glucose tolerance test in growing calves supplemented with chromium tripicolinate while Subiyatno *et al.* (1996) observed reduced ratio of insulin to glucose and decreased plasma concentration of insulin and triglycerides in primiparous cows during the prepartum period when chromium was supplemented at 0.5 ppm.

Anderson (1998) revealed that supplemental chromium had been shown to have beneficial effects on people with varying degrees of glucose intolerance. According to Kitchalong *et al.* (1995) there were no differences in plasma concentrations of urea nitrogen, glucose, albumin, total protein, insulin, glucagon, triiodothyronine or thyroxin on chromium tripicolinate feeding.

Depew *et al.* (1998), Kegley and Spears(1999) and Bryan *et al.* (2004) reported that chromium supplementation decreased plasma non esterified fatty acids (NEFA) in calves, steers and cows respectively. These results indicated increased utilization of non esterified fatty acids by peripheral tissues and the mammary gland and the greatest impact on serum non esterified fatty acid concentration was during one week prepartum according to Bryan *et al.* (2004).

Sahin *et al.* (1999) noted that supplemental chromium had no effects on serum total protein, urea, triglycerides and cholesterol levels but increased serum, liver, kidney, lung and muscle zinc levels and decreased copper levels in rabbits.

Sahin *et al.* (2001) observed increased serum immunoglobulin level in all rabbits following chromium supplementation without any influence on serum total cholesterol, serum glutamic oxalate transaminase (SGOT), serum glutamic pyruvate transaminase (SGPT), calcium, phosphorus, sodium, potassium, or tissue chromium.

Guan *et al.* (2000) observed that high dietary chromium yeast supplementation improved glucose tolerance possibly through a decrease in hepatic extraction of insulin. Bunting *et al.* (2000) also observed that chromium propionate fed calves had higher glucose disappearance indexes whereas Besong *et al.* (2001) noted that the serum glucose, insulin, cholesterol and molar proportions of ruminal volatile fatty acids had no significant difference following chromium picolinate feeding in Holstein steers.

Lien *et al.* (2001) recorded reduced serum total cholesterol, triacylglycerol, insulin, glucose and urea concentrations in pigs fed supplemental chromium at 200 to 400 ppb levels.

Pechova *et al.* (2002a) observed in cows supplemented with chromium enriched yeast a significantly higher blood glucose concentrations post partum and lower concentrations of ketone bodies and bilirubin. Also the catalytic activities of aspartate amino transferase and lactate dehydrogenase were lower post partum. Studies in fattening bulls (Pechova *et al.*, 2002b) showed a higher concentration of protein, total cholesterol and copper in blood plasma whereas the phosphorus and magnesium levels were found to be lower without any significant difference on concentrations of glucose, urea, sodium, potassium and zinc. However in a similar study Pechova *et al.* (2003) observed no significant difference in the blood glucose, non esterified fatty acids, ß-hydroxybutyrate, total cholesterol, high density lipoprotein (HDL) cholesterol, triacylglycerols, bilirubin and aspartate amino transferase and a significant increase in the glutamyl transferase (GMT) activity in the cows supplemented with chromium chelate.

Sahin *et al.* (2002) studied the effect of chromium picolinate supplementation at various levels, in laying Japanese quails and noted a linear increase in serum insulin concentration whereas corticosterone and glucose concentration decreased linearly as dietary chromium increased. The study concluded that chromium supplementation at 1200 μg Cr / kg diet is useful in the protective rr practice in a quail diet especially to reduce the negative effects of heat s *et al.*(2004) observed a decrease in serum glucose and cholesterol cor while chromium, insulin and total protein concentrations increased linearl chromium level increased in laying quails. Also Toghyani *et al.* (2006) haemoglobin, mean corpuscular haemoglobin, mean corpuscular h concentration were increased by 1000 ppb chromium supplementation.

2.3 EFFECT ON MILK PRODUCTION

Kegley and Spears (1999) opined that in early lactation, cows are energy balance and supplemental chromium increased milk pro primiparous cows which may be due to increased gluconeogenesis. suggested that reduced insulin responsiveness during early lactation glucose from peripheral tissues thus shunting glucose toward lactose Hayirli *et al.* (2001) observed a quadratic increase in milk yield, fat perc lactose with increasing chromium methionine supplementation whereas I (2004) found no effect on milk yield, fat corrected milk, milk compositic components.

According to Pechova *et al.* (2002a and 2003) neither total milk y first 100 days of lactation nor mean values of milk yield during the first parturition were influenced by chromium supplementation. However n concentrations was lower in both primiparous and pluriparous anima concentration of fat in milk was higher in pluriparous animals of the supplemented group especially in the first month of lactation. Similarly n concentration was also lower in the treatment group compared to the contr

Smith *et al.* (2005) noted an increase in milk yield for cows supplemented with chromium methionine and the increase in yield was independent of prepartum dietary carbohydrate source.

2.4 EFFECT ON IMMUNE RESPONSE

Peak antibody titres to human red blood cells (HRBC) and immunoglobulin concentrations were higher for steer calves that received high chromium yeast supplemented corn-silage diet (Moonsie-Shageer and Mowat, 1993) which indicated that chromium supplementation improved humoral immune function in calves. Kegley and Spears (1995) and Kegley *et al.* (1996) could also observe enhanced cell mediated immune function in bull calves and steers on chromium supplementation. Heugten and Spears(1997) suggested that supplementation of organic and inorganic forms of chromium were not beneficial to alleviate immune stress in pigs. Mallard *et al.* (1999) noted that chromium exerts its immunomodulatory potential by its regulatory effect on cytokines particularly interleukin-2 thereby reducing the metabolic and physical stress during peak milk production and subsequent immune hyporesponsiveness. Dietary supplementation of chromium picolinate and vitamin C helped to alleviate the depressive effect of cold stress on poultry performance (Sahin *et al.*, 2001)

2.5 EFFECT ON REPRODUCTIVE PERFORMANCE

Pechova *et al.* (2003) observed a certain trend towards higher conception rates in chromium supplemented groups although other reproductive parameters such as incidence of metritis, ovarian cysts, anovulation, insemination interval, insemination index, open days and time to occurrence of first corpus luteum after parturition showed no significant difference. Also Bryan *et al.* (2004) noted that chromium methionine supplementation of early lactation dairy cattle tended to improve the pregnancy rates during the mating season. Stahlhut *et al.* (2006) observed that chromium supplementation reduced overall and postpartum body weight loss in two or three year old cows and also tended to have higher pregnancy rates especially in young beef cows. The decreased body weight loss post partum might have resulted in better fertility.

Materials and Methods

3. MATERIALS AND METHODS

3.1 EXPERIMENTAL ANIMALS

The investigation was carried out for a period of 100 days starting from the day of calving to 100 days of lactation in crossbred lactating cows at University Livestock Farm and Fodder Research and Development Scheme (ULF & FRDS), Mannuthy to assess the effect of organic chromium on production performance. Twelve crossbred cows having a peak yield of minimum eight litres in the previous lactation, were selected from the herd maintained at the ULF & FRDS, Mannuthy as experimental animals. The animals were divided into two groups of six each as uniformly as possible with regard to age, milk yield and parity and were randomly allotted to two dietary treatments T1 and T2.

3.2 HOUSING AND MANAGEMENT

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

3.3 EXPERIMENTAL RATION

The two dietary treatments used in the feeding trial were

T1- Basal concentrate mixture and paddy straw / grass as roughage.

T2- Basal concentrate mixture supplemented with organic chromium at 2 ppm level as chromium propionate and paddy straw / grass as roughage.

The ingredient composition of the concentrate mixture and chemical composition of the concentrate mixture, paddy straw and green grass are represented in Table 1 and 2 respectively.

3.4 FEEDING TRIAL

The experimental animals of the two dietary treatments T1 and T2 were maintained on their respective feeding regime from the first week of calving to 100 days of lactation. Rations were computed for individual animals as per ICAR standards (1985) and the experimental ration was revised fortnightly based on the individual body weight and milk yield. The animals had always free access to clean wholesome drinking water through automatic watering system. They were fed with the concentrate mixture twice daily, in the morning and in the afternoon before milking. Roughage part of the ration was fed in 3 divided lots every day to ensure minimum wastage, regularity and uniformity of feeding. The balance of the concentrate and roughage left behind by each animal was collected and weighed separately every day to calculate the actual dry matter intake.

3.5 MILK SAMPLES

Milk samples were collected at fortnightly intervals and were analysed for total solids, fat (IS: 1224, 1977), solids not fat (SNF) and milk urea nitrogen (MUN) (Bector *et al.* 1998). Data on milk production of individual animal were recorded daily throughout the experimental period.

3.6 HAEMATOLOGICAL PARAMETERS

Blood samples from the experimental animals were collected at the beginning and end of the feeding trial. These samples were used to determine haemoglobin (cyanmethaemoglobin method), serum glucose (GOD-PAP method), plasma inorganic phosphorus (phosphomolybdate method), plasma urea nitrogen (modified

Berthelot method), serum cholesterol (CHOD-PAP method) and triglycerides (GPO-PAP method) using the kits supplied by Agappe diagnostics, India. Serum calcium, magnesium and chromium were estimated by Atomic Absorption Spectrophotometer (Perkin Elmer 3110).

3.7 URINE SAMPLES

Urine samples were collected from individual cows at fortnightly intervals and analysed for presence of ketone bodies using Rothera's test.

3.8 DIGESTION TRIAL

Digestion trial involving seven days collection period was conducted to study the digestibility of nutrients towards the end of the experiment. Before the commencement of the actual collection period, animals were subjected to a preliminary period of seven days when they were fed from the same consignment of concentrate and with the same type of roughage as that of the collection period.

3.8.1 Sampling of Feeds

Representative samples of both concentrate and roughage offered and the balance left behind were taken everyday during the digestion trial for proximate analysis. Dry matter content of the feed was determined everyday and the composite samples were taken after pooling the samples collected on all the seven days of the trial. Proximate analysis of the feed and roughage samples were carried out as per standard procedure (AOAC, 1990).The acid detergent fibre (ADF) and neutral detergent fibre (NDF) was estimated by the method suggested by Van Soest *et al.* (1991). The calcium content of the samples was estimated by Atomic Absorption Spectrophotometer using hollow cathode tube and phosphorus content by Vanado-Molybdate method (AOAC, 1990).

3.8.2 Collection and Sampling of Dung

Dung voided by each animal was collected manually as and when it was voided and kept in individual containers on a continuous 24 hour basis during the digestion trial. All possible precautions were taken to ensure the quantitative collection of dung uncontaminated by urine, feed residue or dirt. The entire quantity of dung voided by each animal during the previous 24 hours was weighed separately at 10 A.M. on every day and representative samples ($1/100^{th}$ aliquots) were taken after thorough mixing and were kept under refrigeration. The process of collection, weighing, sampling and preservation of dung was continued till the end of digestion trial. Aliquots collected on all the seven days of the trial with respect to individual animal were pooled and composite samples were taken after thorough mixing for the determination of proximate principles, fibre fractions and minerals as per the standard methods. Another one percent aliquots of the total dung voided by each animal on all the seven days of the trial were stored under refrigeration in airtight polythene bags.

3.9 REPRODUCTION PARAMETERS

The cows were individually observed for signs of postpartum heat and the date of first post partum heat during the experimental period. Data on service period and number of artificial insemination (A.I.) per conception were also recorded.

3.10 INCIDENCE OF METABOLIC DISORDERS

The experimental animals were observed for incidence of metabolic disorders such as hypocalcaemia, hypomagnesaemia and ketosis during the feeding trial.

3.11 STATISTICAL ANALYSIS

The data gathered on various parameters during the course of the experiment were analysed statistically by methods described by Snedecor and Cochran (1994).

Table 1. Ingredient composition of concentrate mixture, %

Ingredient	Per cent composition
Yellow Maize	35.0
Wheat Bran	10.5
Black Gram Husk	10.0
Gingelly oil cake	20.0
Coconut cake	10.0
Soya meal	12.0
Shell grit	0.5
Mineral mixture	1.0
Salt	1.0

To every 100 kg of concentrate mixture 15 grams of Nicomix AB_2D_3K (Nicholas Piramal India Ltd, Mumbai) containing Vitamin A-82500 I.U, Vitamin D_3-12000 I.U, Vitamin B_2-50 mg, Vitamin K-10 mg per gram was added.

To every 100 kg of the above concentrate mixture 50 grams of Chromium propionate 0.4% (Kemtrace chromium, Kemin Nutritional Tech. (India) Pvt. Ltd.) was added to get 2 ppm which formed the concentrate mixture for T2.

Table 2. Chemical composition of the concentrate mixture, paddy straw and green grass, %

Parameter	Concentrate mixture	Paddy straw	Green grass
Dry matter	89.31	89.22	22.40
Crude protein	18.95	4.19	3.62
Ether extract	3.35	1.57	1.75
Crude fibre	9.52	32.16	24.72
Total ash	8.82	17.35	10.54
Nitrogen free extract	59.36	44.73	59.37
Acid insoluble ash	1.98	11.67	2.31
Neutral detergent fibre	26.61	72.93	70.58
Acid detergent fibre	13.89	45.34	33.65
Acid detergent lignin	4.28	4.79	4.23
Calcium	1.46	0.33	0.57
Phosphrous	0.64	0.06	0.21

Results

4. RESULTS

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

4.1 CHEMICAL COMPOSITION

The data on the chemical composition of the concentrate mixture, paddy straw and green grass used for the experiment is given in Table 2. The chemical composition of the dung of the experimental animals collected during the digestibility trial is given in Table 13.

4.2 BODY WEIGHT

The mean value of the fortnightly body weight of experimental animals in the two treatment groups recorded during the experimental period are listed in Table 3 and graphically represented in Fig. 1. The initial body weight of the animals in the two groups were 342.50 ± 12.50 and 337.50 ± 14.82 kg while the final weight was 367.17 ± 19.22 and 351.33 ± 14.52 kg respectively for T1 and T2.

4.3 DRY MATTER INTAKE

The average dry matter intake at the beginning of the feeding period was 11.00 ± 0.35 and 10.61 ± 0.46 kg respectively for the two treatment groups T1 and T2 which increased to 11.60 ± 0.17 and 12.54 ± 0.46 kg respectively towards the end of the feeding period. Significant difference was obtained during the sixth fortnight ($P<0.05$) between the two groups. The data on the fortnightly average daily dry matter intake are summarized in Table 4 and 5 and depicted graphically in Fig. 2.

4.4 MILK PRODUCTION

The fortnightly average of daily milk production of the experimental animals are given in Table 6 and represented in Fig. 3. The cows of both groups attained peak yield in the first fortnight itself and the cows in the T2 showed a greater persistency in milk production. Significant difference exist between the two groups ($P<0.05$) during the seventh fortnight and the total yield during 100 days of lactation showed significant difference between the two groups ($P=0.0516$).

4.5 MILK COMPOSITION

The data on composition of milk *viz.* milk fat, total solids, solids not fat and milk urea nitrogen collected from the cows of both the treatments at fortnightly intervals are given in Tables 7, 8, 9 and 10 respectively and depicted graphically in Fig. 4, 5, 6 and 7. The average milk fat percentage of the samples collected at the beginning and end of the experiment were 3.87 ± 0.06 and 4.67 ± 0.28 for T1 and 4.02 ± 0.34 and 4.28 ± 0.19 for T2 respectively. The initial total solids and solids not fat percentages for T1 and T2 were 12.47 ± 0.14 and 12.12 ± 0.22 and 8.61 ± 0.17 and 8.1 ± 0.19 while the final values were 12.66 ± 0.11 and 12.34 ± 0.15 and 7.99 ± 0.24 and 8.05 ± 0.20 respectively. The milk urea nitrogen concentrations (mg/100 ml) were 36.15 ± 1.98 and 39.27 ± 1.47 initially for T1 and T2 while the final concentrations were 45.17 ± 2.57 and 45.03 ±1.62 respectively for the two groups.

4.6 HAEMATOLOGICAL PARAMETERS

The data on haemoglobin concentration, plasma urea nitrogen, plasma glucose, serum cholesterol and serum triglycerides of the blood samples collected from the experimental animals at first, seventh and fourteenth week are given in Table 11 and depicted graphically in Fig. 8 and 9.

4.7 SERUM MINERALS

The serum calcium, phosphorus, magnesium and chromium concentrations of the animals in the two treatment groups collected at first, seventh and fourteenth week are given in Table 12 and represented in Fig. 10, 11, 12 and 13. Significant difference ($P<0.05$) exists in the serum chromium levels between the two treatments at seventh and fourteenth weeks of the experiment.

4.8 DIGESTIBILITY COEFFICIENTS OF NUTRIENTS

The data on digestibility coefficient of dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen free extract (NFE), neutral detergent fibre (NDF) and the acid detergent fibre (ADF) are given in Table 14 and represented graphically in Fig. 14.

4.9 INCIDENCE OF METABOLIC DISORDERS

Incidence of metabolic disorders such as hypocalcaemia, hypomagnesemia and ketosis were not observed in the experimental animals of T1 and T2 groups during the course of the experiment.

4.10 REPRODUCTIVE PARAMETERS

Data on the reproductive parameters such as period of first post partum heat, service period and number of services per conception of experimental animals of T1 and T2 are presented in Table 15.

4.11 ECONOMICS OF PRODUCTION

The total concentrate and roughage intake, DMI per 100 kg body weight and cost of feed per kg milk production are depicted in Table 16.

Table 3. Fortnightly average body weight of experimental animals, Kg

Fortnight	Body weight* kg	
	T1	T2
0	342.50 ± 12.50	337.50 ± 14.82
1	351.67 ± 14.87	343.00 ± 14.74
2	356.00 ± 14.91	348.33 ± 13.86
3	354.17 ± 15.87	348.50 ± 16.78
4	361.00 ± 19.22	350.67 ± 15.62
5	362.50 ± 18.40	352.83 ± 12.87
6	367.17 ± 19.22	351.33 ± 14.52
Average±SE	356.43 ± 2.84	347.45 ± 1.89

* Average of six values with SE

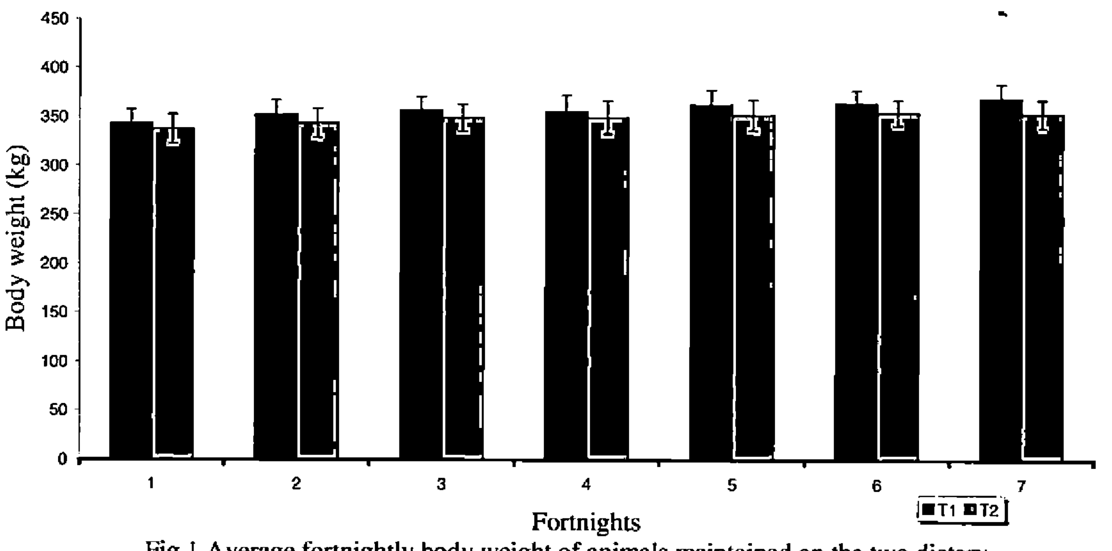

Fig.1 Average fortnightly body weight of animals maintained on the two dietary treatments

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

Fortnight	Dry matter intake*, kg	
	T1	T2
1	11.00 ± 0.35	10.61± 0.46
2	11.84 ± 0.25	11.88 ± 0.29
3	11.88 ± 0.19	12.60 ± 0.33
4	11.73 ± 0.22	12.42 ± 0.46
5	11.82 ± 0.21	12.68 ± 0.37
6	11.69 ± 0.19 [a]	12.89 ± 0.32 [b]
7	11.60 ± 0.17	12.54 ± 0.46
Average±SE	11.65 ± 0.11	12.23 ± 0.27

*Average of six values with SE

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

Table 5. Fortnightly dry matter intake as per cent of body weight

Fortnight	Dry matter intake (kg / 100 kg)	
	T1	T2
1	3.21	3.14
2	3.37	3.46
3	3.34	3.62
4	3.31	3.56
5	3.27	3.62
6	3.22	3.65
7	3.16	3.57
Average±SE	3.26 ± 0.03	3.52 ± 0.06

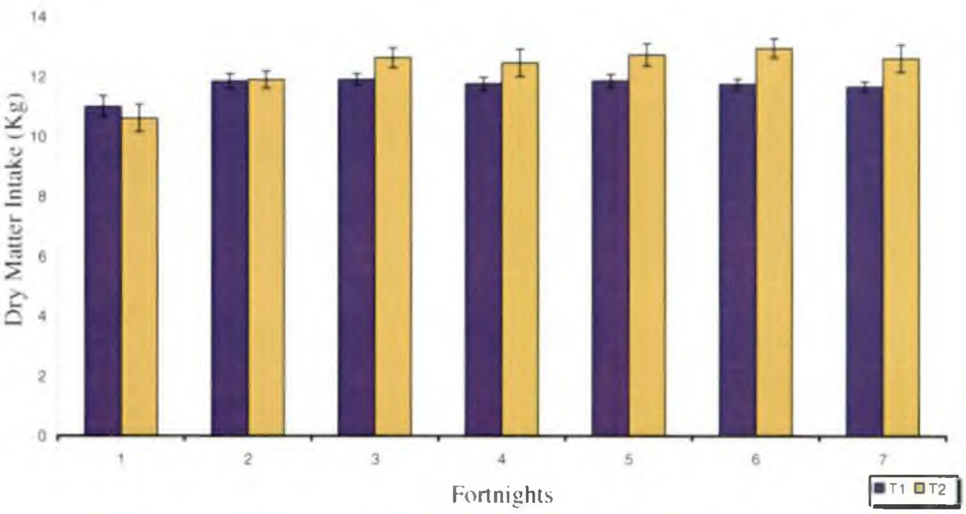

Fig.2 Average daily dry matter intake of animals maintained on the two dietary treatments

Table 6. Fortnightly average milk yield of experimental animals, kg

Fortnight	Milk yield*, kg	
	T1	T2
1	10.05 ± 0.82^{A}	11.25 ± 0.76^{A}
2	9.43 ± 0.60^{A}	11.26 ± 0.79^{A}
3	8.29 ± 0.43^{B}	11.07 ± 0.92^{A}
4	7.41 ± 0.72^{B}	10.50 ± 1.06^{A}
5	7.02 ± 0.70^{C}	9.50 ± 0.97^{B}
6	6.50 ± 0.62^{D}	8.89 ± 0.94^{C}
7	$6.00 \pm 0.53^{a,D}$	$8.45 \pm 0.84^{b,D}$
Average±SE	7.81 ± 0.53^{a}	10.13 ± 0.41^{b}

*Average of six values with SE

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

A,B,C,D – means with different superscripts in the same column differ significantly (P<0.05) between fortnights within groups.

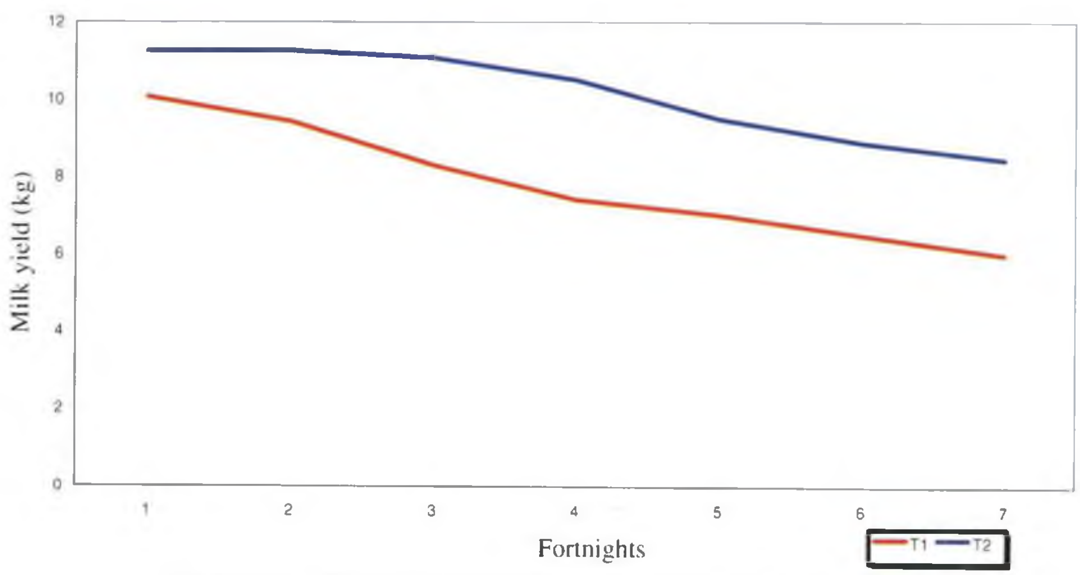

Fig.3 Average fortnightly milk yield of cows maintained on the two dietary treatments

Table 7. Fortnightly average milk fat of experimental animals

Fortnight	Milk fat* (per cent)	
	T1	T2
1	3.87 ± 0.06	4.02 ± 0.34
2	4.03 ± 0.15	4.00 ± 0.30
3	4.03 ± 0.11	4.05 ± 0.32
4	4.12 ± 0.13	4.18 ± 0.28
5	4.17 ± 0.19	4.38 ± 0.27
6	4.33 ± 0.33	4.38 ± 0.29
7	4.67 ± 0.28	4.28 ± 0.19
Average±SE	4.17 ± 0.09	4.18 ± 0.19

*Average of six values with SE

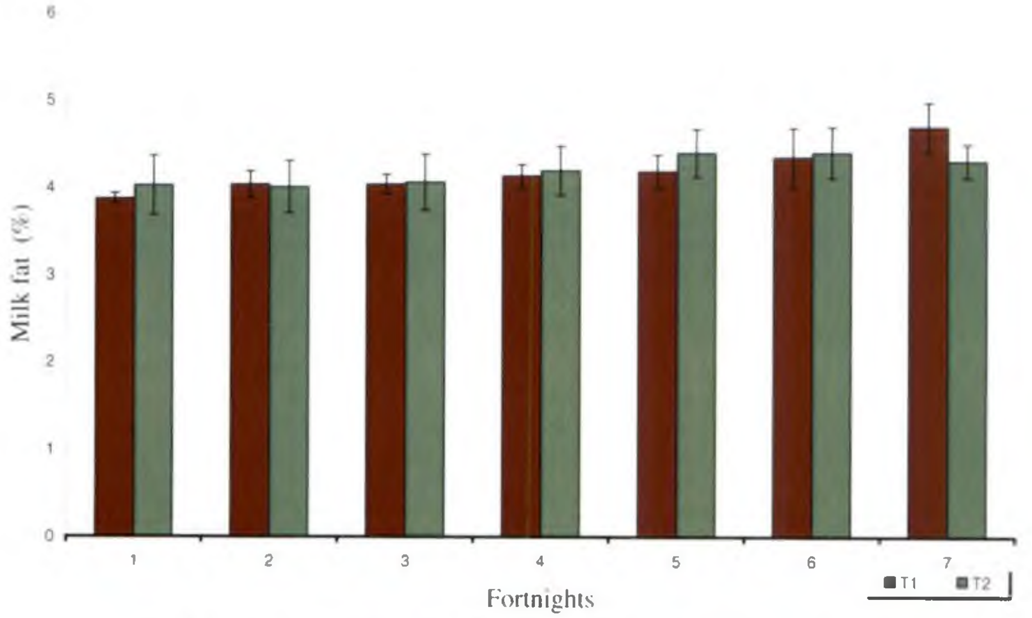

Fig.4 Average fortnightly milk fat of cows fed on the two dietary treatments

Table 8. Fortnightly average of total solids in milk of experimental animals

Fortnight	Total solids* (per cent)	
	T1	T2
1	12.47 ± 0.14	12.12 ± 0.22
2	12.61 ± 0.24	12.59 ± 0.21
3	12.57 ± 0.27	12.77 ± 0.24
4	12.70 ± 0.18	12.30 ± 0.20
5	12.47 ± 0.09	12.35 ± 0.29
6	12.43 ± 0.12	12.31 ± 0.21
7	12.66 ± 0.11	12.34 ± 0.15
Average±SE	12.56 ± 0.04	12.40 ± 0.15

*Average of six values with SE

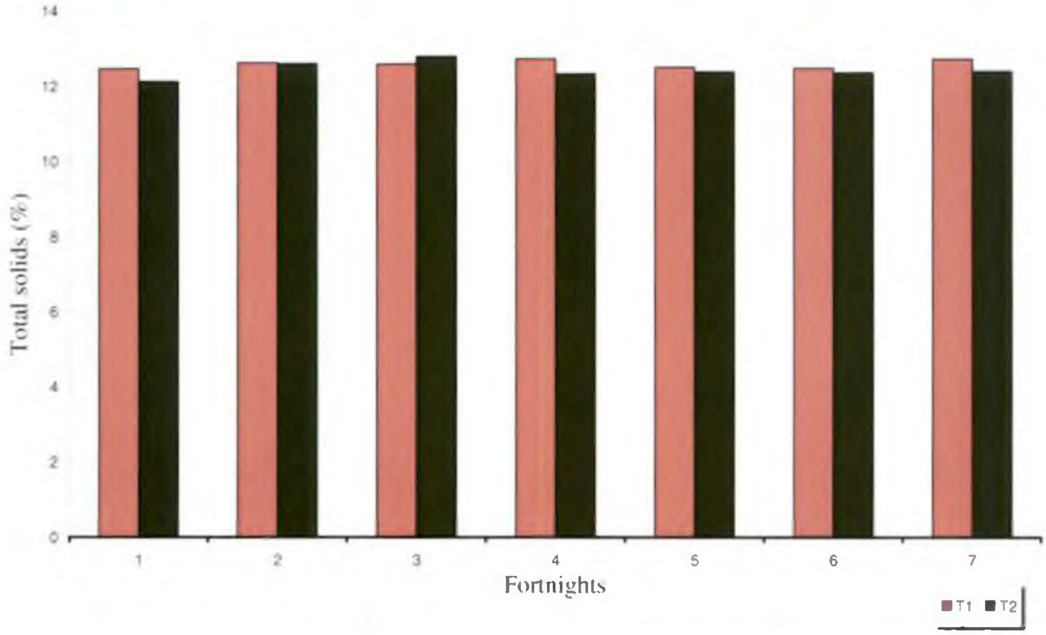

Fig 5. Average milk total solids in animals maintained on the two dietary treatments

Table 9. Fortnightly average of solids not fat in milk of experimental animals

Fortnight	Solids not fat* (per cent)	
	T1	T2
1	8.61±0.17	8.10±0.19
2	8.58±0.35	8.59±0.18
3	8.54±0.31	8.72±0.19
4	8.59±0.27	8.12±0.21
5	8.30±0.18	7.98±0.20
6	8.10±0.33	7.93±0.17
7	7.99±0.24	8.05±0.20
Average±SE	8.39±0.12	8.21±0.14

*Average of six values with SE

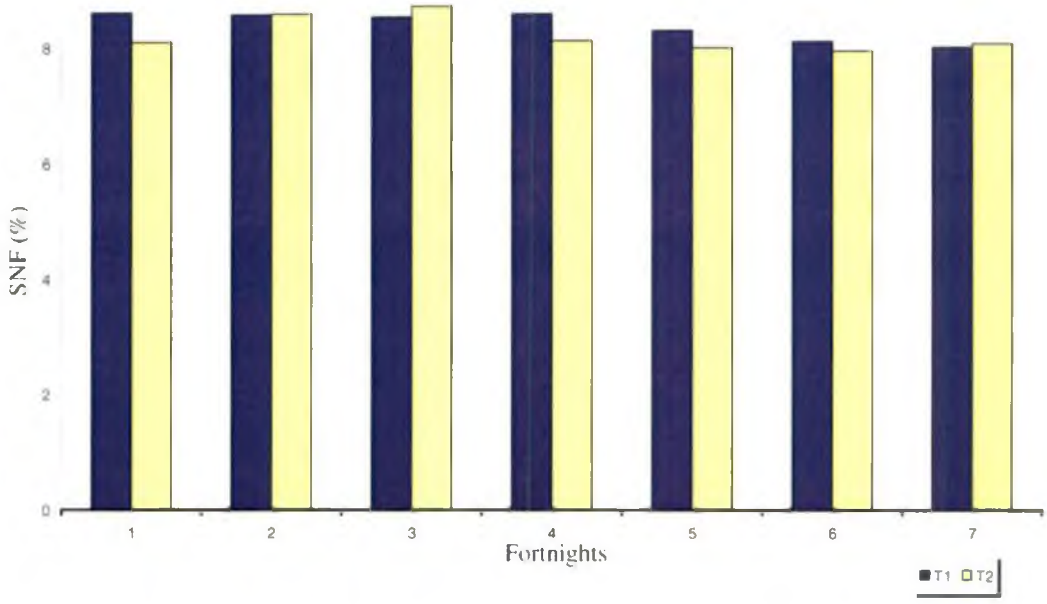

Fig 6. Average fortnightly SNF of animals maintained on the two dietary treatments

Table 10. Fortnightly average milk urea nitrogen concentration (MUN) of experimental animals, mg/100ml

Fortnight	MUN, mg/100 ml*	
	T1	T2
1	36.15 ± 1.98	39.27 ± 1.47
2	38.85 ± 2.00	41.03 ± 1.63
3	40.58 ± 1.92	42.03 ± 1.84
4	41.90 ± 1.84	43.48 ± 1.99
5	43.63 ± 1.62	44.00 ± 1.85
6	45.73 ± 2.44	45.12 ± 1.91
7	45.17 ± 2.57	45.03 ± 1.62
Average±SE	41.72 ± 1.21	42.85 ± 1.62

*Average of six values with SE

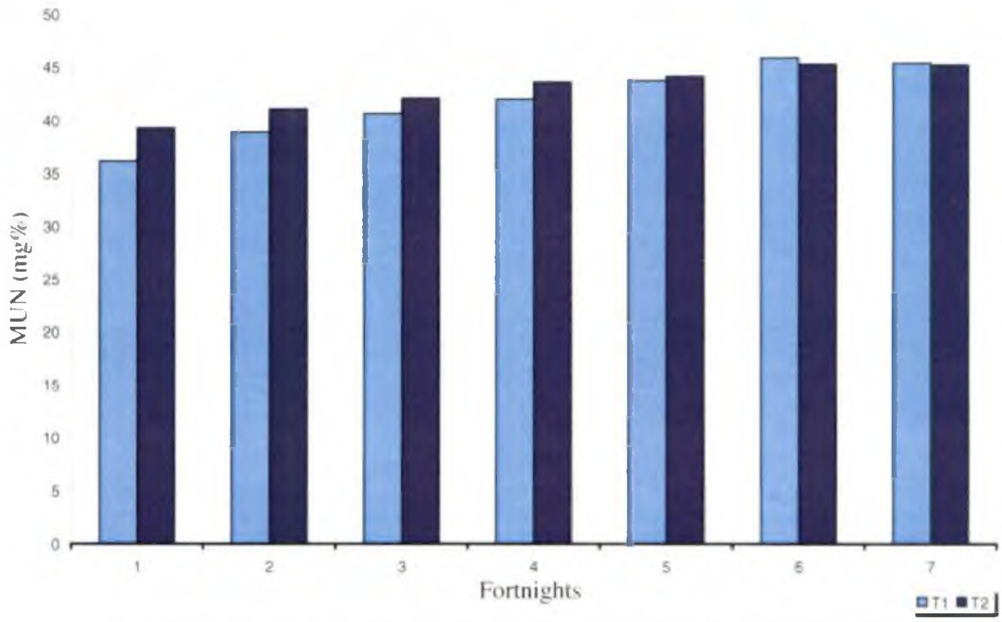

Fig 7. Milk urea nitrogen concentration in animals maintained on the two dietary treatments

Table 11. Hematological parameters* of experimental animals.

Parameter	Treatment groups	Week		
		1	7	14
Plasma Urea Nitrogen mg%	T1	24.00±3.12	29.65±3.74	34.02±2.64
	T2	21.78±1.75	28.99±2.44	33.19±2.50
Serum Glucose mg%	T1	44.06±2.22	41.26±2.97	46.84±3.23
	T2	40.82±1.20	41.54±1.84	47.34±0.95
Serum Cholesterol mg %	T1	99.48±8.82	118.13±8.70	110.91±8.40
	T2	82.42±8.58	114.40±8.70	112.73±6.23
Hemoglobin g%	T1	11.82±0.77	12.20±0.34	12.18±0.51
	T2	12.28±0.88	13.12±0.76	12.88±0.58
Serum Triglyceride mg%	T1	8.34±1.02	11.65±1.75	13.70±1.87
	T2	8.93±1.98	8.09±1.76	9.59±1.31

*Average of six values with SE

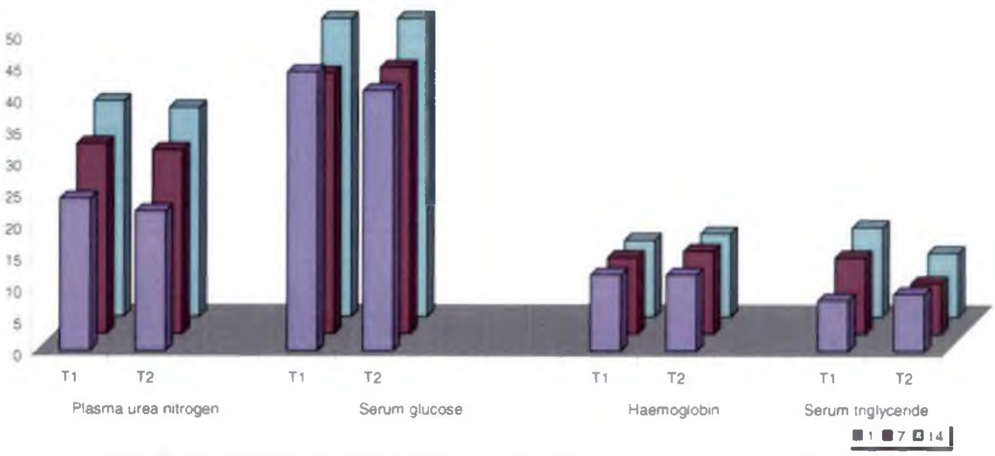

Fig 8. Haematological parameters of cows maintained on the two dietary treatments

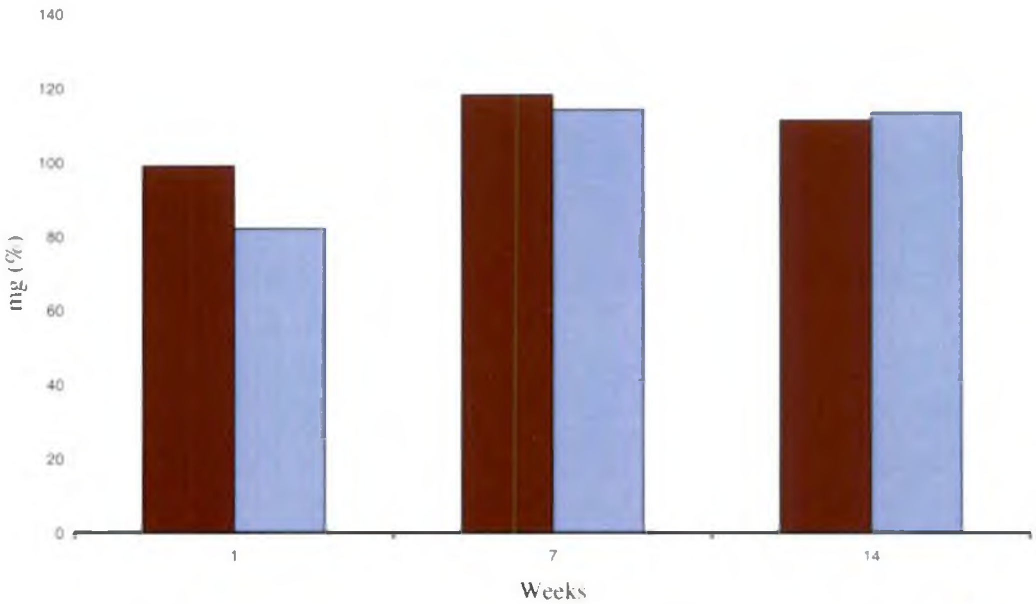

Fig 9. Average serum cholesterol concentration of animals maintained on the two dietary treatments

Table 12. Serum mineral concentrations of experimental animals, mg %

Parameter	Groups	Serum mineral concentrations* mg% Week		
		1	7	14
Calcium	T1	12.37±0.50	11.66±0.49	11.48±0.38
	T2	11.76±0.54	11.01±0.53	10.89±0.39
Phosphorus	T1	7.06±0.21	6.55±0.30	6.44±0.23
	T2	5.81±0.54	5.58±0.40	5.80±0.27
Magnesium	T1	3.76±0.03	3.61±0.06	3.62±0.07
	T2	3.66±0.06	3.48±0.06	3.43±0.06
Chromium	T1	0.18±0.010	0.19±0.008	0.21 ± 0.01^{a}
	T2	0.17±0.007	0.19±0.009	0.25 ± 0.01^{b}

*Average of six values with SE

a, b – means with different superscripts in the same column differ significantly ($P<0.05$)

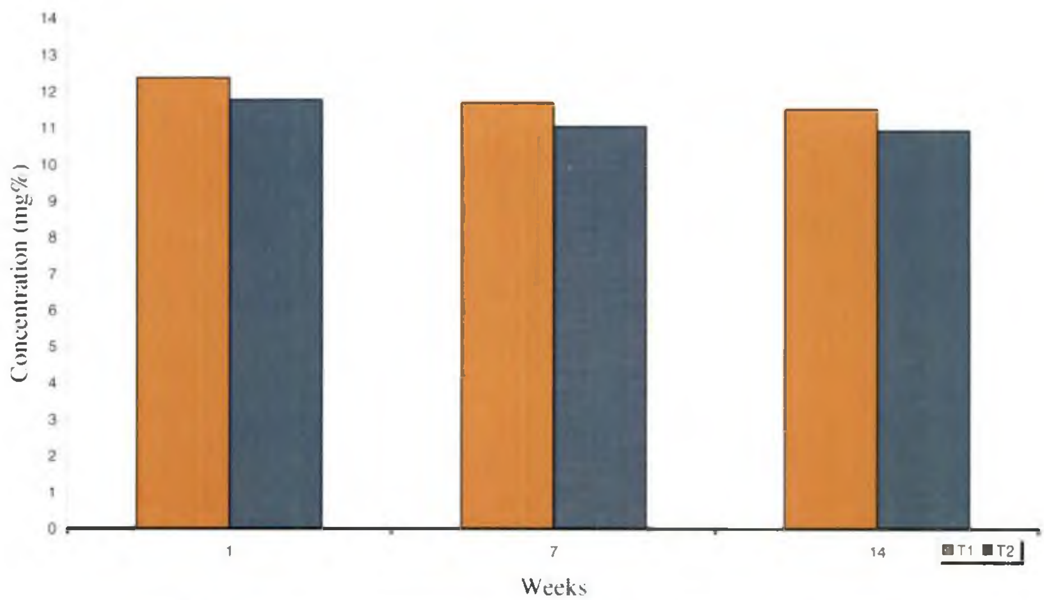

Fig 10. Serum calcium concentration in cows maintained on the two dietary rations

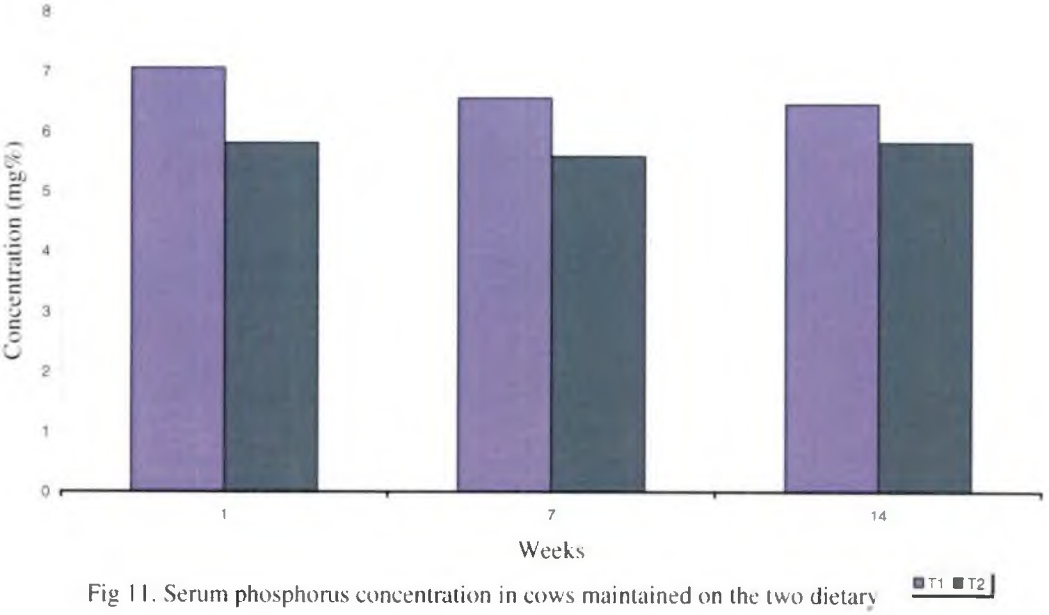

Fig 11. Serum phosphorus concentration in cows maintained on the two dietary rations

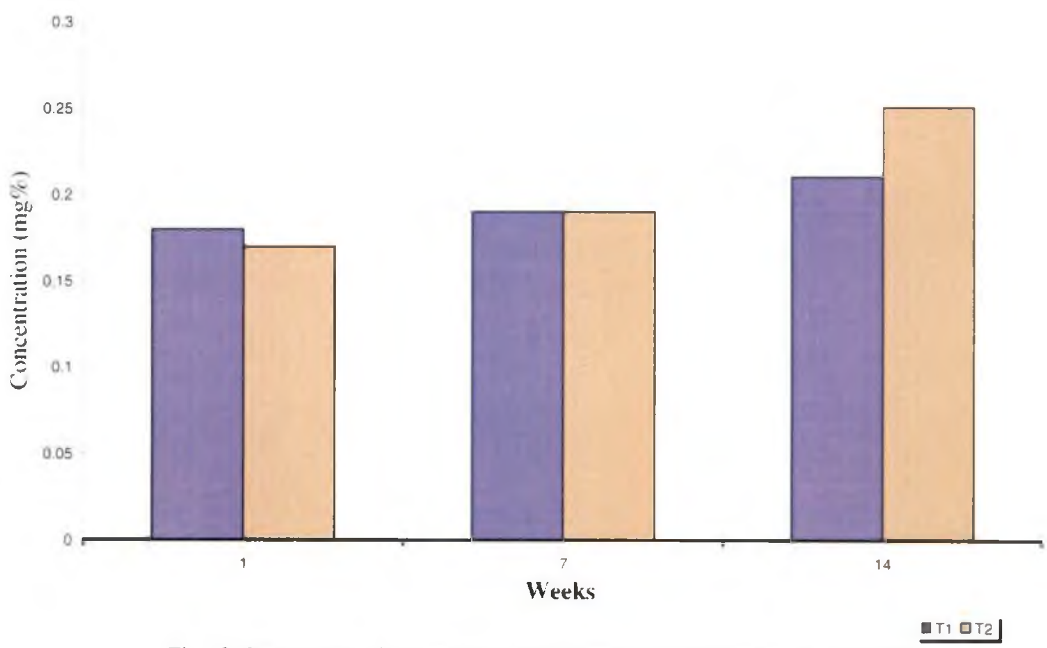

Fig 12. Serum chromium concentration in cows maintained on the two dietary rations

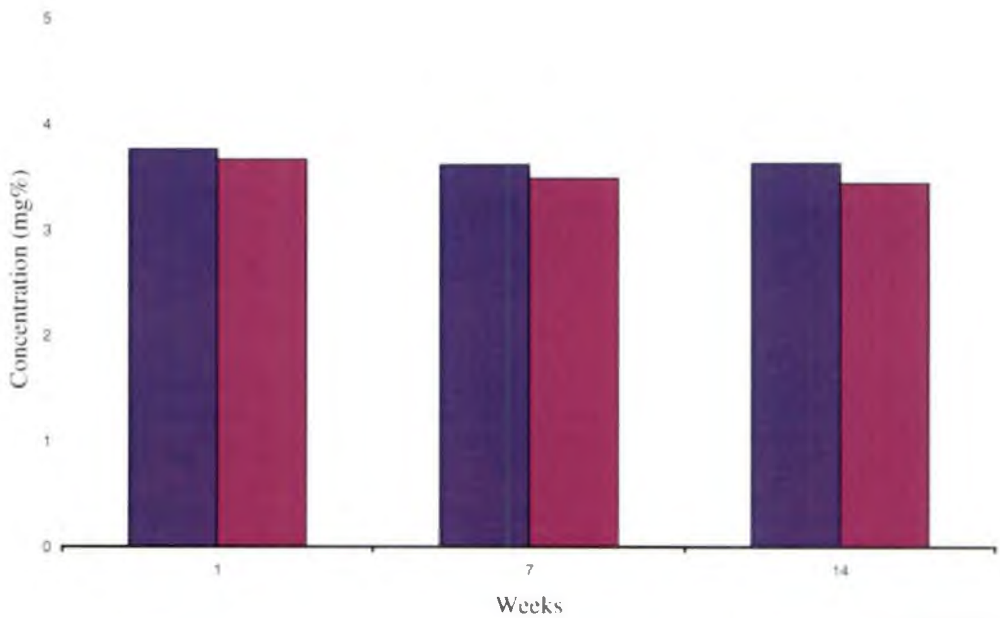

Fig.13 Serum magnesium concentration in cows maintained on the two dietary rations

Table 13. Chemical composition of the dung from experimental animals* , %

Nutrient	T1	T2
Dry matter	17.23 ± 0.21	17.21±0.30
Crude protein	11.32±0.72	11.37±0.31
Ether extract	1.59±0.25	1.61±0.45
Crude fibre	18.52±0.27	18.30±0.25
Total ash	19.35±0.23	19.22±0.17
Nitrogen free extract	49.23±0.63	49.34±0.62
Acid insoluble ash	12.12±0.36	12.02±0.23
Neutral detergent fibre	48.92±0.42	48.96±0.25
Acid detergent fibre	39.39±0.21	39.44±0.26

*Average of six values with SE

Table 14. Digestibility coefficient of nutrients of experimental rations

Nutrient	Digestibility coefficient*	
	T1	T2
Dry matter	60.68 ± 2.31	61.00±1.67
Crude protein	58.72±2.63	59.01±2.38
Ether Extract	74.06±3.36	72.69±3.39
Crude fibre	63.91±2.16	63.63±1.70
Nitrogen free extract	64.88±1.89	65.67±1.80
Neutral detergent fibre	62.89±1.97	61.92±1.48
Acid detergent fibre	46.74±2.58	44.21±1.91

*Average of six values with SE

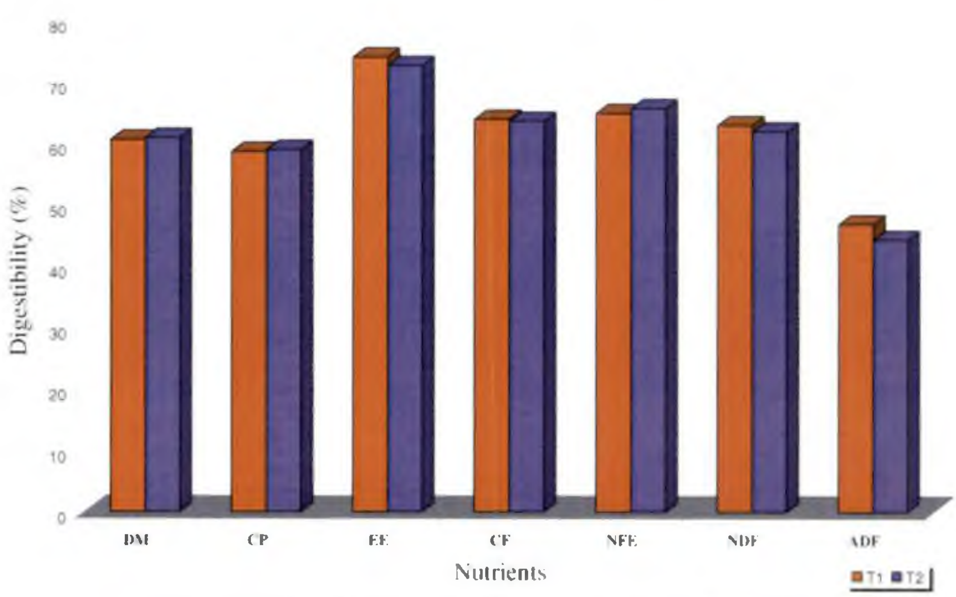

Fig 14. Digestibiliy coefficient of nutrients of experimental rations

Table 15. Reproductive parameters of experimental animals maintained on two different dietary treatments

Animal No.	Period of first post partum heat (days)	Service period (days)	Number of inseminations per conception
Treatment group (T1)			
169	90	198	1
101	50	-	
217	102	Not conceived*	
140	88	108	2
152	70	112	2
231	88	Not conceived*	
Average ± SE	81.33 ± 6.87	139.33 ± 22.29	1.66 ± 0.27
Treatment group (T2)			
115	44	114	1
094	86	133	1
102	70	156	1
222	78	181	2
191	53	133	2
235	54	Not conceived*	
Average ± SE	64.17 ± 6.09	143.40 ± 10.30	1.40 ± 0.21

- Culled one month after the experiment due to hoof problem

* Not conceived within six months after calving

Table 16. Total dry matter intake and cost per kg milk production of the experimental animals

Parameter	T1	T2
Total concentrate consumed in 100 days (kg)	3517	3896.25
Total green grass consumed in 100 days (kg)	14325.15	14629.70
Total paddy straw consumed in 100 days (kg)	1046.55	1051.69
Dry matter intake per 100kg body weight (kg)	3.26	3.52
Total milk produced in 100 days (kg)	4648.99	6067.72
Cost of one kg concentrate mixture*, (Rs)	9.41	9.51
Cost of one kg paddy straw used*, (Rs)	2.93	2.93
Cost of one kg green grass, (Rs)	1.00	1.00
Total cost of feed, (Rs)	50,486.12	54,774.86
Cost / kg milk produced, (Rs)	10.85	9.03

* Calculated using the rate contract values fixed for feed ingredients by College of Veterinary and Animal Sciences, Mannuthy.

** Cost of chromium propionate is calculated as Rs. 200/ kg

Discussion

5. DISCUSSION

5.1 BODY WEIGHT

The mean fortnightly body weight of the experimental cows maintained on the basal concentrate mixture and paddy straw/grass as roughage (T1) and the cows maintained on the basal concentrate mixture supplemented with organic chromium at 2 ppm level as chromium propionate and paddy straw/grass as roughage (T2) are set out in Table 3 and depicted graphically in Fig. 1. The average initial body weight of cows after calving were 342.50 ± 12.50 and 337.50 ± 14.82 kg. The average body weight on completion of the feeding trial was 367.17 ± 19.22 and 351.33 ± 14.52 kg respectively for T1 and T2. On scrutiny of the data on body weight recorded at fortnightly intervals, it was evident that all the animals recorded a gain in body weight during the experimental period of 100 days of lactation with a total gain of 25 and 14 kg for T1 and T2 respectively. The animals in both the groups were in good nutritional status as indicated by physical condition and body weight gain. The increase in body weight could be correlated with the increased dry mater intake during each fortnight. The average body weight on completion of feeding trial at 100 days of lactation was 367.17 ± 19.22 and 351.33 ± 14.52 kg respectively for T1 and T2.

Statistical analysis of the data on fortnightly body weight of the animals in the two groups showed no significant difference ($P>0.05$) between them during any of the fortnights studied. The literature on the influence of chromium supplementation on body weight in early lactating cows are rather scanty. Hayirli *et al.* (2001) reported a decreased body condition score loss in periparturient dairy cows supplemented chromium methionine and Pechova *et al.* (2002a) noted a significantly better weight gain in fattening bulls supplemented chromium enriched yeast.

Stahlhut *et al.* (2006) also recorded a decrease in post partum body weight loss, especially in young beef cows following chromium supplementation.

Improvement in average daily gain of calves and steers were observed by Moonsie-Shageer and Mowat (1993), Kegley *et al.* (1997a) and Depew *et al.* (1998). In contrast, Chang and Mowat (1992), Bunting *et al.* (1994, 2000) and Kegley *et al.* (1997b) noted no significant difference on body weight gain in calves on organic chromium supplementation.

5.2 DRY MATTER INTAKE

The average daily dry matter intake (DMI) of the animals in the two groups at fortnightly intervals are presented in Table 4 and 5 and graphically represented in Fig. 2. The average daily dry matter consumption of the cows in the first fortnight for groups T1 and T2 were 11.00 ± 0.35 and 10.61± 0.46 kg and the dry matter intake in the seventh fortnight were 11.6 ± 0.17 and 12.54 ± 0.46 kg respectively. The overall average daily dry matter intake by the animals of T1 and T2 during the experimental period of 100 days of lactation were 11.65 ± 0.11 kg and 12.23 ± 0.27 kg, the corresponding average dry matter intake when expressed as percent body weight were 3.26 ± 0.03 and 3.52 ± 0.06 for the two groups respectively. Data on the dry matter consumption obtained in the present study for T1 and T2 are comparable with the values reported by Ally (2003) and Syammohan (2003) for the cross bred lactating cows of Kerala. The values obtained for the dry matter intake expressed as percent of the body weight also agreed with the findings of Syammohan (2003). In the present study a linear increase in dry matter consumption could be observed for the two groups from the first fortnight to the seventh fortnight with the dry matter intake by the animals of T2 being comparatively better than the animals of T1. On statistical analysis a significant difference ($P < 0.05$) in dry matter intake was obtained between the 2 groups during the sixth fortnight, the values being 12.89 ±

0.32 kg for T2 and 11.69 ± 0.19 kg for T1. The higher dry matter intake recorded in the T2 animals could be attributed to organic chromium supplementation.

A similar observation was made by Hayirili *et al.* (2001) in dairy cattle, where dry matter intake increased linearly and quadratically during the pre partum and post partum periods respectively on chromium methionine supplementation. Smith *et al.* (2005) also noted a linear increase in post partum dry matter intake in cows supplemented with chromium picolinate. However, studies by Chang and Mowat (1992) in calves, Bunting *et al.* (1994) in calves, steers and heifers, Kitchalong *et al.* (1995) in growing lambs and Besong *et al.* (2001) in steers revealed no significant effect on dry matter intake of the animals by chromium supplementation.

5.3 MILK PRODUCTION

The fortnightly average of daily milk yield of the experimental cows of T1 and T2 presented in Table 6 and illustrated graphically in Fig.3. revealed that the cows of both groups attained peak yield in the first fortnight itself. The cows in T2 maintained the peak yield upto third fortnight whereas the animals in T1 showed a decline in peak yield from the second fortnight itself. The average milk yield for the animals in the T1 group during the first fortnight was 10.05 ± 0.82 and 6± 0.53 kg during the seventh fortnight while the values for the cows in T2 group were 11.25 ± 0.76 kg and 8.45 ± 0.84 kg respectively for first and seventh fortnight. The cumulative average milk yield for the T1 and T2 were 7.81± 0.53 kg and 10.13 ± 0.41 kg during the experimental period of 100 days of lactation and values agreed with that reported by Ally (2003) and Joseph (2005) for cross bred cattle of Kerala. On statistical analysis, significant reduction was observed from third fortnight onwards in the control group($P<0.05$) whereas the chromium supplemented group recorded a higher milk production during the first four fortnights without any significant difference. On comparing the total milk production during 100 days of lactation chromium supplemented T2 cows registered significantly better performance(P=0.0516).The increase in milk yield may be attributed to the increased dry matter intake which showed a linear increase during the course of the experiment. Scrutiny of the data on milk production during first 100 days of lactation further revealed the T2 cows supplemented with chromium propionate maintained the peak yield as well as persistency of milk production better than the cows in the control group (T1). The comparatively higher milk yield and better persistency observed in T2 maybe due to effect of organic chromium.

Hayirli *et al.* (2001) and Smith *et al.* (2005) noted an increase in milk yield in cows supplemented with chromium methionine. Contrary to this Bryan *et al.* (2004) and Pechova *et al.* (2002b and 2003) observed no influence on total milk yield on chromium supplementation.

5.4 MILK COMPOSITION

The values for the milk components viz. milk fat, total solids, solids not fat and milk urea nitrogen are given respectively in Tables 6, 7, 8 and 9 which is illustrated graphically in Fig 4, 5, 6 and 7. Average milk fat percentage during the seven fortnights ranged from 3.87 to 4.67 for T1 and 4.02 to 4.28 for T2 with a total average of 4.17 ± 0.09 and 4.18± 0.06 respectively. The values obtained for the fat content agreed with those recorded by Joseph (2005) for cross bred dairy cattle in Kerala; however Syammohan (2003) reported a slightly lower range of values for the milk fat from 3.33 to 3.98 for cross bred cows. Statistical analysis revealed no significant difference between the two groups (P>0.05) regarding the average fat percentages in the present study. No significant effect of organic chromium supplementation on milk fat is also reported by Bryan *et al.* (2004). In contrast

Hayirli *et al.* (2001) and Pechova *et al.* (2002a and 2003) noted an increase in milk fat percentage for the chromium supplemented group of cows.

The average total solids percentage of milk for the two groups T1 and T2 were 12.56 ± 0.04 and 12.40 ±0.07 respectively with a range of 12.47 to 12.66 for T1 and 12.12 to 12.34 for T2. The average total solids percentage values agreed with those reported by Joseph (2005) for cross bred cows in Kerala. The statistical analysis revealed no significant difference between the two groups (P>0.05).

The average solids not fat (SNF) values for T1 and T2 were 8.39 ± 0.12 and 8.21 ± 0.12 respectively and there was no significant difference between the two groups (P>0.05). The values obtained in this study correlated with the findings of Ally (2003) and Joseph (2005) with regard to the SNF values of the crossbred cows in Kerala.

The Milk Urea Nitrogen (MUN) concentrations recorded fortnightly ranged from 361.5 mg/100 ml to 45.17mg/100 ml for T1 and 39.27mg/100 ml to 45.03 mg/100 ml for T2. The overall average MUN concentration for the two groups was 41.72 ± 1.21 mg/100 ml and 42.85 ± 0.76 mg/100 ml which agrees with the values recorded by Ally (2003) and Joseph (2005) for crossbred cattle in Kerala. Bector *et al.* (1998) reported that MUN levels in lactating cows ranged between 22.8 to 92.4 mg per cent and the average being 53.36 mg per cent. In the present study, there was no significant difference (P>0.05) between the two groups with regard to the MUN concentrations. The Milk Urea Nitrogen concentrations were found to increase in both the groups towards the end of feeding period which according to Schepers and Meijer (1998) may be attributed to the rumen degraded protein balance in the ration.

5.5 HAEMATOLOGICAL PARAMETERS

The data on haematological parameters like haemoglobin, plasma urea nitrogen, serum glucose, cholesterol and triglycerides estimated during the first, seventh and fourteenth week of lactation are given in the Table 10 and illustrated in Fig. 8 and 9. None of the parameters studied were significantly affected (P>0.05) by organic chromium supplementation. It is noted that all the values obtained were within the normal levels specified for cows (Kaneko and Harvey,1997).

5.5.1 Serum Glucose

The serum glucose levels obtained during first, seventh and fourteenth week were 44.06 $\pm$ 2.22, 41.26 $\pm$ 2.97 and 46.84 $\pm$ 3.23 for T1 and 40.82 $\pm$ 1.20, 41.54 $\pm$ 1.84 and 47.34 $\pm$ 0.95 for T2 respectively at the end of the feeding period. There was no significant difference observed between the two groups (P>0.05) following chromium propionate supplementation. Kitchalong *et al.* (1995) reported that there was no difference between the dietary treatments in overall mean plasma glucose concentrations on feeding chromium tripicolinate. Besong *et al.* (2001) also noted that serum glucose concentration was not affected by chromium picolinate feeding in Holstein steers. Similar observations were also made by Lien *et al.* (2001), Pechova *et al.* (2002b) and Pechova *et al.* (2003) with reference to serum glucose concentrations in pigs, fattening bulls and cows respectively. However Sahin *et al.* (2002) and Yildiz *et al.* (2004) observed a decrease in serum glucose concentrations in laying quails while Pechova *et al.* (2002a) observed significantly higher blood glucose concentrations in post partum cows.

5.5.2 Plasma Urea Nitrogen

The average plasma urea nitrogen concentration of T1 and T2 cows were 24.00 $\pm$ 3.12, 29.65 $\pm$ 3.74 and 34.02 $\pm$ 2.64 and 21.78 $\pm$1.75, 28.99 $\pm$2.44 and

33.19 ±2.50 respectively for the first, seventh and fourteenth week (Table 10) of lactation. Statistical analysis of the data revealed no significant difference (P>0.05) between the two groups. This was in agreement with the findings of Kitchalong *et al.* (1995), Sahin *et al.* (1999), Lien *et al* (2001), Pechova *et al* (2002 b).

5.5.3 Serum Cholesterol

The serum cholesterol level of the experimental animals estimated at the first, seventh and fourteenth week of lactation were 99.48 ± 8.82, 118.13 ± 8.70 and 110.91 ± 8.40 for T1 and 82.42 ± 8.58, 114.40 ± 8.70 and 112.73 ± 6.23 for T2 respectively (Table 10) with no significant difference (P>0.05) between the two groups. In agreement with the present study similar finding was also reported by Pechova *et al.* (2003) in lactating cows, Sahin *et al.* (1999, 2001) in rabbits and Besong *et al.* (2001) in calves. On the other hand, Bunting *et al.* (1994), Lien *et al.* (2001) and Yildiz *et al.* (2004) observed a decrease in serum cholesterol levels in different species where as Pechova *et al.* (2002a) noted an increase in total cholesterol levels in fattening bulls and this may be due to variation in the physiological status of the animals, composition of diet and climatic conditions.

5.5.4 Serum Triglycerides

The mean serum triglyceride levels were 8.34 ± 1.02, 11.65 ± 1.75 and 13.70 ± 1.87 in T1 while the corresponding values for T2 being 8.93± 1.98, 8.09 ± 1.76 and 9.59 ± 1.31 mg percent respectively during the first, seventh and fourteenth week of experiment. The serum triglyceride levels were not significantly affected (P>0.05) with the two dietary treatments in this study which agreed with the findings of Sahin *et al.* (1999) in rabbits. Though not differed significantly comparatively lower serum triglyceride values were obtained for chromium supplemented cows (T2). Subiyatno *et al.* (1996) reported a reduced plasma concentration of triglycerides of primiparous cows during the prepartum period when chromium was supplemented at 0.5 ppm level.

5.5.5 Haemoglobin

The average haemoglobin values were 11.82 $\pm$ 0.77, 12.20 $\pm$ 0.34 and 12.18 $\pm$ 0.51 and 12.28 $\pm$ 0.88, 13.12 $\pm$ 0.76 and 12.88 $\pm$ 0.58 g per cent for T1 and T2 respectively during the first, seventh and fourteenth week of the lactation. Statistical analysis of the data revealed no significant difference between the two treatments while Toghyani *et al.* (2006) noted that haemoglobin concentration was increased by chromium supplementation in broiler chicks.

5.6 SERUM MINERALS

The serum mineral concentrations obtained in the blood at the first, seventh and fourteenth week of the experiment for T1 and T2 were 12.37 and 11.76, 11.66 and 11.01, 11.48 and 10.89 mg per cent for calcium; 7.06 and 5.81, 6.55 and 5.58, 6.44 and 5.80 mg per cent for phosphorus; 3.76 and 3.66; 3.61 and 3.48; 3.62 and 3.43 mg per cent for magnesium and 0.18 and 0.17; 0.19 and 0.19; 0.21 and 0.25 mg per cent for chromium respectively. The data were statistically analysed and significant difference was found on serum chromium levels during the fourteenth week of the experiment (Table 12). This may be attributed to the organic chromium supplementation in T2. An increase in serum chromium concentration was also observed by Anderson *et al.* (1985) where as serum calcium, phosphorus, sodium, potassium or tissue chromium levels were not influenced by chromium supplementation according to Sahin *et al.* (2001).

5.7 INCIDENCE OF METABOLIC DISORDERS

All the animals were well fed and in good nutritional status during the period of experiment and manifestations of symptoms of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis were not observed during the course of the study. The presence of ketone bodies in urine was tested using Rotheras test, at fortnightly intervals which proved to be negative. The serum levels of calcium and magnesium were well within the normal limits for healthy animals.

5.8 REPRODUCTIVE PERFORMANCE

Data on reproductive parameters like period of first post partum heat, service period and number of AI per conception of the experimental cows of T1 and T2 are presented in Table 15.

The first postpartum heat was exhibited by the cows in T1 and T2 at an average duration of 81.33 $\pm$ 6.87 and 64.17 $\pm$ 6.09 days respectively. This indicates that the cows in the chromium supplemented group showed post partum heat signs earlier compared to non supplemented cows. The average service period for the T1 and T2 were 139.33 $\pm$ 22.29 and 143. 40 $\pm$ 10.30 days respectively which are comparable with the values obtained by Syammohan (2003) for crossbred cows in Kerala. The average number of inseminations for successful conception taken by the animals of T1 and T2 were 1.66 $\pm$ 0.27 and 1.40 $\pm$ 0.21 respectively. The period of first post partum heat and number of AI per conception recorded for the two groups indicates that supplementation of organic chromium produced a favorable effect on the reproductive performance of the animals.

5.9 DIGESTIBILITY COEFFICIENTS OF NUTRIENTS

The digestibility coefficients of nutrients in the two experimental rations fed to animals of T1 and T2 is provided in Table 14 and illustrated in Fig.14

5.9.1 Dry Matter

Average dry matter digestibility of experimental rations was 60.68 $\pm$ 2.31 and 61.00 $\pm$ 1.67 per cent for T1 and T2 respectively. The statistical analysis revealed no significant difference in the dry matter digestibility for the two rations. Similar dry matter digestibility values for crossbred cows in Kerala was reported by Ally (2003) but Syammohan (2003) observed higher digestibility coefficients of 68.43 $\pm$ 1.17 and 72.52 $\pm$ 1.38 per cent for cross bred cows fed on concentrate mixture and green grass, which may be due to difference in ration composition.

5.9.2 Crude Protein

The average digestibility coefficients for crude protein in the animals of T1 and T2 were 58.72 $\pm$ 2.63 and 59.01 $\pm$ 2.38 per cent respectively. The average values for the digestibility coefficient of crude protein in the present study are in agreement with the values reported by Devasia (1989) for crossbred cows in Kerala. Ally (2003) observed higher digestibility of 70.28 $\pm$ 2.34 per cent for crude protein in early lactating crossbred cows fed on high protein ration where as the digestibility coefficient of crude protein agreed with the values obtained in the present study in the experimental cows fed on ration containing less than 20 per cent crude protein. Syammohan (2003) also reported higher values for digestibility of crude protein

5.9.3 Ether Extract

The ether extract digestibility of the experimental rations were 74.06 $\pm$ 3.36 and 72.69 $\pm$ 3.39 per cent respectively for T1 and T2 and there was no significant difference (P>0.05) in the digestibility values of ether extract when statistically analysed. The values for digestibility coefficient of ether extract reported for crossbred cows in third month of lactation by Syammohan (2003) was 68. 67 $\pm$ 1.45 per cent which is lower than the values obtained in the present study, whereas the digestibility of ether extract observed by Ally (2003) for early lactating cows was 71.33 $\pm$ 2.86 which is in agreement with the values obtained in the present study. Devasia (1989) obtained values of 57.66 and 56.35 per cent for the digestibility of ether extract on Jersey and Brown Swiss crossbred cows of Kerala.

5.9.4 Crude Fibre

Crude fibre digestibility for T1 and T2 ration was 63.91 $\pm$ 2.16 and 63.63 $\pm$ 1.70 per cent which did not differ significantly on statistical analysis. Hence it can be assumed that chromium supplementation could not influence the digestibility of crude fibre in the ration of experimental animals. The values obtained in the present study are comparable with the digestibility values of 58.89 $\pm$ 2.03 recorded by Syammohan (2003) and 55.67 $\pm$ 1.76 recorded by Ally (2003). No work could be traced on the influence of organic chromium on fibre digestibility in ruminants or other species.

5.9.5 Nitrogen Free Extract

The digestibility of nitrogen free extract in experimental rations for T1 and T2 was 64.88 $\pm$ 1.89 and 65.67 $\pm$ 1.80 per cent. The statistical analysis showed no significant difference (P>0.05) between the two groups. The average digestibility coefficients of nitrogen free extract obtained in the present study are in agreement with the values reported by Ally (2003) and Syammohan (2003) for early lactating crossbred cows in Kerala.

5.9.6 Neutral Detergent Fibre

The neutral detergent fibre digestibility values estimated from the digestion trial conducted towards the end of the experiment were 62.89 $\pm$ 1.97 and 61.92 $\pm$ 1.48 per cent respectively for T1 and T2. From the statistical analysis of the data it can be seen that the average digestibility coefficients of the neutral detergent fibre for the two ration did not differ significantly ($P>0.05$). The values obtained in the present study are agreeable with the neutral detergent fibre digestibility value of 55.92 $\pm$ 2.97 per cent obtained by Syammohan (2003) and higher than the digestibility of 45.02 $\pm$ 2.68 per cent reported by Ally (2003).

5.9.7 Acid Detergent Fibre

The average digestibility coefficient for acid detergent fibre obtained in the present study was 46.74 $\pm$ 2.58 and 44.21 $\pm$ 1.91 per cent respectively for T1 and T2, which did not differ significantly ($P>0.05$). The average digestibility values obtained in the present study are comparable with those reported by Ally (2003) in early lactating cows.

Results on the digestibility coefficient of nutrients indicates that the supplementation of organic chromium did not significantly influence the digestibility of the experimental ration. However Sahin and Sahin (2001) observed that the digestibility of dry matter, ash, organic matter, crude protein and ether extract was higher with chromium picolinate supplementation in laying hens.

5.10 ECONOMICS OF MILK PRODUCTION

Data on total concentrate and roughage intake, total milk yield in 100 days of lactation and cost of feed incurred under two dietary treatments are presented in Table 16. Cost per kg feed for T1 was Rs. 9.41 and for T2 was Rs. 9.51. The total milk produced for 100 days of lactation were 4648.99 and 6067.72 kg for the control (T1) and chromium supplemented group (T2) respectively. The total cost of feed during the experimental period of 100 days was Rs. 50,486.12 and 54,774.86 for T1 and T2 respectively. Cost of production when calculated in terms of feed cost per kg milk produced was comparatively lower for chromium supplemented group and the values being Rs. 9.03 for T2 and Rs. 10.85 for T1 respectively.

From the overall results obtained in the present study it could be concluded that the supplementation of organic chromium at 2 ppm as chromium propionate in the concentrate mixture of early lactating crossbred cows has improved the dry matter intake, increased the milk production, reduced the cost of production and has also favourably influenced the post partum reproductive performance.

Summary

6. SUMMARY

A study was conducted to assess the effect of dietary supplementation of organic chromium on milk production and metabolic profile of crossbred cows in early lactation. Twelve healthy crossbred cows having a peak yield of minimum eight litres in the previous lactation, were selected as the experimental animals. The animals were divided into two groups of six each as uniformly as possible with regard to age, milk yield and parity and were randomly allotted to two dietary treatments, T1 consisting of basal concentrate mixture and paddy straw/grass as roughages and T2 consisting basal concentrate mixture supplemented with organic chromium at 2 ppm level as chromium propionate and paddy straw/ grass as roughage. Rations were computed for individual animals as per ICAR standards (1985) and the animals were maintained on their respective feeding regimes from day of calving to 100 days of lactation. Individual records of daily intakes of concentrate and roughage, daily milk production and fortnightly body weight were maintained through out the experiment. Milk samples were collected at fortnightly intervals and were analysed for milk fat, total solids, solids not fat and milk urea nitrogen. Blood was collected at the first, seventh and fourteenth week of lactation for estimating haemoglobin, plasma urea nitrogen, plasma inorganic phosphorus, serum glucose, cholesterol and triglycerides. A digestion trial involving seven days collection period was conducted towards the end of the experiment to study the digestibility of nutrients. Incidence of metabolic disorders like hypocalcaemia, hypomagnesaemia and ketosis were also studied in all the experimental animals during the course of the experiment. Reproductive parameters such as period of first post partum heat, service period and number of AI per conception were also studied. The data obtained on various parameters were analysed statistically.

The average initial bodyweight of cows of T1 and T2 at the beginning of lactation was 342.50 and 337.50 kg. Thereafter there was an increase in body weight

for animals in both the groups and there was a total gain of 25 kg for T1 and 14 kg for T2 towards the end of the experiment. The final body weight on completion of 100 days of lactation was 367.17 kg and 351.33 kg respectively. The overall average dry matter intake for the animals of T1 and T2 were 11.65 and 12.23 kg respectively and the values differed significantly ($P< 0.05$) during the sixth fortnight. There was a linear increase in dry matter consumption by the animals of the two groups from the first fortnight to seventh fortnight with the dry matter intake by the animals of T2 were comparatively better than that of the animals of T1.

Average milk yield of T1 and T2 for the seventh fortnight and total 100 days of lactation differed significantly($P<0.05$).The animals of the chromium supplemented group maintained the peak milk yield up to the fourth fortnight while the peak milk yield for T1 showed a decline from the third fortnight itself. The milk yield of animals in T2 were higher with better persistency compared to those in T1 ($P<0.05$). The average milk fat percentage of T1 and T2 showed no significant difference in all the seven fortnights with the overall average values being 4.17 and 4.18 respectively for the two groups. The total solids and solid not fat percentages for the experimental cows in T1 and T2 were 12.56 and 12.40 per cent and 8.39 and 8.21 respectively. The milk urea nitrogen concentration also showed no significant difference during any of the seven fortnights and the average values obtained for T1 and T2 were 41.72 and 42.85 mg/100 ml. Statistical analysis of any of the haematological parameters studied did not seem to be influenced by the dietary treatments.

The average haemoglobin values at the first, seventh and fourteenth week of experiment were 11.82, 12.20 and 12.18 g/100ml for T1 and 12.28, 13.12 and 12.88 for T2 which did not differ significantly between the two groups. The average serum glucose for T1 and T2 were 44.06, 41.26, and 46.84 mg per cent and 40.82, 41.54 and 47.34 mg per cent respectively during the first, seventh and fourteenth week of lactation. The average plasma urea nitrogen values for T1 and T2 were 24, 29.65 and

34.02 mg percent and 21.78, 28.99 and 33.19 mg per cent. Average serum cholesterol levels at the start of the experiment were 99.48 and 82.42 mg per cent and towards the end of the experiment it was 110.91 and 112.73 mg per cent. The average serum triglyceride values during the first, seventh and fourteenth week of experiment were 8.34, 11.65, and 13.70 mg per cent for T1 and 8.93, 8.09 and 9.59 mg per cent for T2.

The serum mineral concentrations obtained in the blood at the first, seventh and fourteenth week of the experiment for T1 and T2 were 12.37 and 11.76, 11.66 and 11.01, 11.48 and 10.89 mg per cent for calcium; 7.06 and 5.81, 6.55 and 5.58, 6.44 and 5.80 mg per cent for phosphorus; 3.76 and 3.66; 3.61 and 3.48; 3.62 and 3.43 mg per cent for magnesium and 0.18 and 0.17; 0.19 and 0.19; 0.21 and 0.25 mg per cent for chromium respectively. Significant difference was observed ($P<0.05$) between the two groups with regard to serum chromium concentration at the fourteenth week of the experiment.

The digestibility coefficient of the nutrients *viz.,* dry matter, crude protein, ether extract, crude fibre, nitrogen free extract, neutral detergent fibre and acid detergent fibre were not found to be influenced by organic chromium supplementation. Period of postpartum heat recorded were 81.33 and 64.17 days for T1 and T2 respectively indicating a favorable influence of organic chromium supplementation on reproductive performance.

The economics of milk production calculated for the two groups T1 and T2 were Rs.10.85 and Rs.9.03 respectively with the milk production in the chromium supplemented groups being higher; the cost of production per kg milk produced for T2 was comparatively lower than the animals not supplemented with organic chromium.

From the results obtained in the present study, it could be concluded that the supplementation of organic chromium at 2ppm in the concentrate mixture improved the dry matter intake, total milk production and helped to maintain the peak yield as well as persistency of milk production in early lactating crossbred cows. It could be concluded that the post partum reproductive performance has also been influenced favourably by the supplementation of chromium propionate in the diet of cross bred cows.

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EFFECT OF DIETARY SUPPLEMENTATION OF ORGANIC CHROMIUM IN LACTATING COWS

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ABSTRACT

A study was conducted to assess the effect of dietary supplementation of organic chromium on the milk production and metabolic profile of the crossbred cows in early lactation. Twelve healthy crossbred cows having a peak yield of minimum eight litres in their previous lactation were divided into two groups of six each, as uniformly as possible with regard to age, milk yield and parity and were randomly allotted to two dietary treatments, T1 consisting of basal concentrate mixture and paddy straw/ grass as roughage and T2 consisting of basal concentrate mixture supplemented with organic chromium at 2 ppm level as chromium propionate and paddy straw / grass as roughage. All the experimental animals were fed as per ICAR standards (1985) and maintained on their respective feeding regime from the day of calving to 100 days of lactation. Average dry matter intake, body weight, milk yield, milk fat percentage, total solids, solids not fat, haematological parameters *viz.* haemoglobin, plasma urea nitrogen, serum cholesterol, glucose, triglycerides, serum minerals, incidence of metabolic disorders and reproductive performance were the criteria employed for evaluation.

Average body weight of animals revealed no significant difference for the both groups during all the fortnight studied. The average daily dry matter intake linearly increased as the lactation progressed in both the groups. Dry matter intake by the animals of T2 was comparatively better than the animals of T1 with a significant increase ($P<0.05$) during the sixth fortnight. Average daily milk yield increased significantly during the seventh fortnight and for 100 days of lactation in T2 ($P<0.05$). The animals in T2 maintained the peak yield for a longer duration compared to the T1. There was no significant difference in any of the milk composition parameters between the treatments.

The haematological parameters such as haemoglobin, plasma urea nitrogen, serum glucose, cholesterol, and triglycerides estimated at the first, seventh and

fourteenth week of lactation were not significantly affected by the two dietary treatments. The serum mineral concentrations of calcium, magnesium and phosphorus showed no significant difference while serum chromium levels showed a significant increase ($P<0.05$) between the two groups in the fourteenth week.

The digestibility coefficients of the nutrients *viz.* dry matter, crude protein, crude fibre, ether extract, nitrogen free extract, acid detergent fibre and neutral detergent fibre were not found to be influenced by the organic chromium supplementation. There was no incidence of metabolic disorders such as hypocalcaemia, hypomagnesaemia and ketosis in both groups of animals. The cows supplemented with organic chromium (T2) showed earlier postpartum heat signs which indicated that the postpartum reproductive performance was influenced by the supplementation.

It could be concluded from the results obtained in the present study, that organic chromium supplementation at 2 ppm in the concentrate mixture improved the dry matter intake, total milk production and helped to maintain the peak yield as well as persistency of milk production in early lactating crossbred cows. The study also revealed that the postpartum reproductive performance has also been influenced favourably by the supplementation of organic chromium in crossbred cows.