EFFECT OF ENERGY SUPPLEMENTATION ON GROWTH OF CROSSBRED HEIFERS

By
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THESIS

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DECLARATION

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

Mannuthy
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CERTIFICATE

Certified that the thesis, entitled **"EFFECT OF ENERGY SUPPLEMENTATION ON GROWTH OF CROSSBRED HEIFERS"** is a record of research work done independently by Dr. Sunil Wilson under my guidance and supervision and it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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SUNIL WILSON

To My Parents

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

1. INTRODUCTION

Milk production has trebled during the last thirty years, making India the largest milk producer in the world. Since crossbreeding programme has led to the improvement in the genetic make up of our cattle and within a herd, approximately 25 per cent of improvement in milk production is due to heredity and 75 per cent being governed by nutrition and management, further improvement in the productive capacity of our animals can be achieved only through good nutrition and management.

Lack of energy is the most common deficiency of dairy rations which can lead to delayed maturity, reduced conception rate and poor milk production in animals. In Kerala, non-availability of good quality roughages in required quantities, forces the dairy farmers to depend mainly on the commercially available compounded cattle feeds and paddy straw to meet the requirement of animals. The nutritive quality of commercially available compounded feeds is almost solely judged by the chemical composition. The available energy value of a feed cannot be determined routinely as it does not involve a simple procedure as that of a chemical analysis. The available energy content of various commercial feeds can be highly variable depending on the nature of ingredients used and their nutrient digestibility.

Long years of practical experience of dairy farmers using commercial feeds shows that addition of energy supplements such as tapioca flour, rice gruel, tamarind seed and ground maize to the diets of growing and producing cattle is beneficial in promoting early maturity and better milk production. The beneficial effects of energy supplementation point to the fact that the animals were not receiving their required energy from commercial cattle feed and paddy straw. This can be either due to deficiency of energy in the compounded cattle feeds or due to the inadequate quantity of feeds received, both concentrate and roughage, this being especially true in the case of growing heifers.

Hence this study was planned to monitor the effect of energy supplementation in the form of ground maize on growth, feed efficiency, digestibility of nutrients and reproductive performance of crossbred heifers.

Review of Literature

2. REVIEW OF LITERATURE

2.1 Energy requirements of heifers

The energy requirements of dairy heifers of different body weights gaining at different rates are reported by Agricultural Research Council (1980), Indian Council of Agricultural Research (I.C.A.R., 1985) and National Research Council (N.R.C., 1989). The energy requirement of heifers weighing 200 kg and gaining at the rate of 550 g/day is 3.14 kg total digestible nutrients (TDN) (I.C.A.R., 1985). The corresponding values for 200 kg heifers gaining at the rate of 500 g/day are 9.56 Mcals of ME (A.R.C., 1980) and 2.99 kg TDN or 11.25 Mcals of ME (N.R.C., 1989).

Sivaiah and Mudgal (1982) calculated the requirements of energy for maintenance and growth of buffalo heifers using linear multiple regression and the values were 22.9 kcal of DE/kg $w^{0.75}$ and 1.68 kcal of DE/gram of body mass per day. When calculated from the live weight change data, the values were 230 kcal and 2.7 kcals of DE, respectively per kg $w^{0.75}$ and per gram of body mass increase.

Udeybir and Mandal (2001) determined the requirements for maintenance and gain separately using multiple regression analysis. The TDN requirement for growing cattle weighing 200 kg was 37.3 g per kg $w^{0.75}$ for maintenance and 1.54 g for gain.

2.2 Energy supplementation and growth

Supplementing energy to growing animals is found to improve the rate of growth. Gardner *et al.* (1977) was able to accelerate the growth rate of Holstein heifers weighing 91 kg by about 38 per cent by providing a high energy diet compared to that of a standard diet. Beal *et al.* (1978) reported a significantly higher body weight gain (0.33 kg/day) in heifers of 18 to 20 months of age fed a high energy ration with a NE intake of 9 Mcal/day as against those receiving a low energy ration with 3.9 Mcal of NE/day. Lippke (1980) in his attempts to relate the forage characteristics to the intake, digestibility of nutrients and body weight gain of ruminants concluded the weight gain to be solely a function of DE intake.

Mohan and Ranjhan (1982) studied the effect of different energy (75, 100 and 125 per cent of NRC recommendations) and protein (75 and 100 per cent of NRC recommendations) levels on growth performance of crossbred heifer calves. Their results suggested that growth rate was positively influenced by the energy levels. Body weight gains of 0.79 kg $head^{-1}$ day^{-1} and 0.21 kg $head^{-1}$ day^{-1} were observed by Day *et al.* (1986) in prepubertal heifers fed a control and an energy deficient diet. The onset of puberty was delayed in the energy deficient heifers. A significant increase in the body weight was reported by Harrison and Randel (1986) in heifers of 20 to 26 months of age maintained on 180 per cent of NRC recommendations for energy as against those maintained on 75 per cent level. Quigley *et al.* (1986) observed an increase of 0.2 kg/day in daily gain of dairy heifers when the total digestible nutrient level was increased by 10 per cent levels, from 85 to 115 per cent, of NRC recommendations. Kertz *et al.* (1987) reported that the growth rate of Holstein calves can be accelerated upto 1 kg/day from 3 to 12 months of age without excessive fattening. They also suggested that for achieving higher gain, the ration should contain 15 per cent crude protein and 6 to 8 per cent more energy than the NRC recommendations.

Borotone *et al.* (1994) conducted a switch over trial in 89 heifers of 3 months of age using diets containing nutrients at 100 and 115 per cent of NRC recommendations. After attaining 12 months of age the diets were switched over among the two groups of animals. They observed an increased gain in weight when they were fed at 115 per cent NRC level irrespective of age. Similarly, Pirlo *et al.* (1997) reported that prepubertal heifers which received 110 per cent of the NRC requirements of energy had improved average daily gain without any detrimental effect on their subsequent lactation. Malik *et al.* (1998) also observed a significantly higher daily body weight gain in crossbred one year old heifers when fed at 20 and 40 per cent above NRC recommendations for energy and protein.

Growth rates of female calves of 10 months of age maintained at NRC recommended levels recorded a higher gain than those maintained on the military farm ration which was lower in crude protein and nitrogen free extract than that of NRC (Singh and Kumar, 1998). Rajagopal *et al.* (1999) reported a higher body weight gain in 14 to 15 months old Hariana heifer calves which were fed 25 per cent more of NRC recommendations. However, significantly higher growth rate was observed by Girdhar and Singh (2000) for Freiswal bull calves of 8 to 9 months of age fed at levels recommended by NRC compared to a roughage based diet and concluded that the NRC recommendations are optimum and economical for Freiswal calves.

Verma and Mudgal (1971) reported that the difference in weight gain was not significant among the Sahiwal male calves of 1½ to two years of age fed at 20 per cent higher and lower in energy than that of Morisson's standards. Iso-energetic diets fed to prepuberal heifers with and without 50 per cent protected tallow also made no significant difference in body weight gain (Rhodes *et al.*, 1978). No significant difference was observed by Pachauri and Negi (1980) in the body weights of cows and bullocks when supplemented with raw molasses at the rate of one kilogram/head/day as an extra energy source. Remond *et al.* (1991) studied the effect of slow release somatotropin in dairy cows fed at two levels of energy concentrates (high level group received 2.5 Mcal $NE_{lactation}$ over recommendations while low level group received 4.2 Mcal $NE_{lactation}$ under the recommended amounts) and they reported that the level of energy had no effect on the body weight and body condition scores.

Fluharty and Loerch (1996) conducted feeding experiments using isocaloric diets with different energy sources in newly arrived feedlot calves. A higher average daily gain was obtained when diets containing corn silage was used as energy source as against dry corn based diets. Oka *et al.* (1999) observed a higher average daily gain in body weight for fattening steers fed a diet with 30 per cent roughage compared to the one with 60 per cent roughage.

In contrary to the above, Miyakoshi *et al.* (1999) observed a higher body weight gain in Holstein steers fed a low energy diet with 73 per cent than those fed a high energy diet with 77 per cent TDN in early period of fattening.

2.3 Dry matter intake

Verma and Mudgal (1971) reported that the dry matter intake was higher in male Sahiwal calves maintained at 120 per cent of Morrison's standards when compared with those fed at 100 and 80 per cent levels. They observed a maximum dry matter consumption of 2 kg per 100 kg body weight. Padgett *et al.*, (1978) reported that the mean feed intake per day was 4.36 kg on dry basis for steers fed the ration containing whole cattle blood as protein supplement. A dry matter intake of 1.876 ± 0.052 per cent of body weight and 80.8 g/kg metabolic body size was observed by Jayaraman *et al.* (1979) in growing Murrah buffaloes.

Sangwan *et al.* (1987) reported a significantly higher dry matter intake in cattle (1.79 kg/100 kg body weight) than buffaloes (1.65 kg/100 kg body weight) fed different rations having three fibre (wheat straw, sorghum straw, oat hay) and two protein (cluster bean meal and GNC) sources in 4x4 Latin square design.

Gill *et al.* (1978) from their observations in lactating Angus cows fed diets containing thimoty-orchard grass silage and alfalfa pellets reported a dry matter intake ranging from 11.6 to 17.3 kg/day with a mean value of 15.3 kg/day for 22 animals. Rhodes *et al.* (1978) observed a reduced feed consumption in Holstein heifers fed 20 per cent protein protected lipid.

Pachauri and Negi (1980) reported that the dry matter consumption in crossbred cattle remained unaffected by different dietary treatments such as wheat straw + groundnut cake (GNC), wheat straw + GNC + molasses, alkali treated wheat straw + GNC and alkali treated wheat straw + GNC + molasses.

A significant relationship between weight gain and dry matter intake was established by Lippke (1980) in yearling steers fed different varieties of Sorghum and Sudan hay. Quigley *et al.* (1986) reported a negative correlation between DM intake and acid detergent fibre and neutral detergent fibre content of the feed. They also observed an increase in the dry matter consumption with an increase in energy of upto 105 per cent of TDN recommended by NRC.

Lubis *et al.* (1990) reported a reduction in the dry matter consumption and milk production in dairy cows fed a diet containing 8 per cent calcium tallowate. The dry matter consumed by steers was reduced by 8.9 and 4 per cent respectively, when fed 4 per cent tallow in the diets containing the combination of ionophores, Monensin-Tylosin and Lasalocid-Monensin-Tylosin. However the dry matter intake remained similar when 4 per cent tallow was fed without ionophores (Clary *et al.*, 1993).

Sagathevan (1995) reported an average daily dry matter consumption of 5.05, 5.12, 5.05 and 5.04 kg/day in crossbred calves of 6 to 9 months of age maintained on 20 and 16 per cent crude protein diets containing dried spleen at 0 and 0.1 per cent, respectively. The feed efficiency and protein efficiency were 8.09 and 1.15, 7.55 and 1.13, 8.71 and 1.07, 8.74 and 1.07, respectively, for the four treatment groups. Daily dry matter intake of 3.3 kg per 100 kg body weight was observed by Subramanian (1995) in crossbred calves above 5 months fed diets containing fish meal upto 10 per cent.

Fluharty *et al.* (1994) obtained 8.7 per cent improvement in the feed efficiency by feeding a high energy diet. Singh and Kumar (1998) also reported a better feed to gain ratio for growing female calves fed at NRC level as against a lower plane of nutrition. However, Malik *et al.* (1998) reported that the dry matter intake, feed to gain ratio and protein efficiency of crossbred heifers maintained at 20 and 40 per cent levels above NRC recommendations remained similar compared to those fed at NRC level. The feed to gain ratio and protein efficiency were 10.37 and 1.52, 10.49 and 1.61 and 10.65 and 1.7, respectively, for the heifers fed at levels of 100, 120 and 140 per cent of NRC.

2.4 Digestibility of nutrients

Verma and Mudgal, (1971) reported that the digestibilities of dry matter, crude fibre and nitrogen free extract were not affected by the energy levels. But the crude protein and ether extract digestibilities decreased with an increase in the energy levels. Venkatayan *et al.* (1981) reported on the basis of rumen ammonia nitrogen values that the protein of ration containing maize was better utilised when fed to steers. No significant difference in the digestibility of nutrients was observed when whole cattle blood was substituted for peanut meal on protein basis at different levels of 0, 5, 10, 14 and 18 per cent in the ration of steers. The nitrogen balance of the animals fed the diets were 27.4, 28.1, 28.2, 36.9 and 30 g per day respectively for the above five levels (Padgett *et al.*, 1978).

Gill *et al.* (1978) observed a negative relationship between body weight of Angus cows and apparent crude protein digestibility as calculated by lignin ratio technique. However, they established a positive correlation between the average daily gain of calves and digestibilities of dry matter, acid detergent fibre and gross energy in Angus cows fed diets containing orchard grass silage and alfalfa pellets. The average digestibility coefficients of dry matter, crude protein, acid detergent fibre and gross energy were 49.7, 41.8, 41.6 and 48.3, respectively.

Jayaraman *et al.* (1979) reported the dry matter digestibility as 60.64 ± 1.03 per cent in Murrah buffaloes of 2 to 3 years age. The dry matter, crude protein, ether extract and gross energy digestibilities in crossbred cattle remained similar for different dietary treatments differing in energy content (Pachauri and Negi, 1980). Crude protein digestibility of 86 per cent and a significant relation between crude protein digestibility and dry matter intake were observed by Lippke (1980) in yearling steers fed different Sorghum x Sudan hay varieties.

Mohan and Ranjhan (1982) reported a significant increase in the nitrogen retention by increased levels of energy in the diet, while reduction in tissue protein synthesis was reported in sheep fed an additional energy source (Nissen and Ostaszewski, 1985). Rao *et al.* (1985) observed significant difference between the digestibilities of dry matter, ether extract and crude fibre for the complete rations fed to lambs containing different nitrogen sources.

A reduction in fibre digestibility was observed for barley based diets by DePeters and Taylor (1984) when lactating Holstein cows were fed complete ration with corn or barely as cereal component. However, the dry matter and energy digestibilities were similar. A higher crude fibre digestibility was observed by Sangwan *et al.* (1987) in buffaloes (62.9 per cent) than cattle (56.9

per cent) when fed rations containing different fibre and protein sources. But they could not find any difference in the digestibility of nutrients between cattle and buffalo.

Grummer (1988) reported that dry matter and neutral detergent fibre digestibilities were lower in Holstein cows receiving 0.68 kg of prilled fat per day (64.6 and 40.9 per cent, respectively) as against those supplemented with prilled fat at the rate of 0.9 kg per day (66.9 and 44.8 per cent, respectively). A higher dry matter, acid detergent fibre and neutral detergent fibre digestibilities were reported by Bernard and McNeill (1991) in cows fed soyabean hulls as high fibre energy supplement. Fluharty *et al.* (1994) observed that the digestibility coefficients of dry matter and acid detergent fibre were similar in beef steers fed different cereal based diets and protein sources. However, the apparent digestibility of protein was higher in animals fed barley based diets (64.6 per cent) than those fed corn (61.7 per cent) based diets.

A reduction in organic matter digestibility was reported in mid-lactation cows by Ferlay and Dorean (1992) when supplemented with 1 kg of rape seed oil. Sagathevan (1995) observed that the digestibilities of dry matter, crude protein, ether extract, crude fibre, nitrogen free extract and acid detergent fibre were unaffected by the addition of dried spleen as a biostimulator for growth in the diets of crossbred calves. A non significant increase in the digestibilities of dry matter, crude protein and nitrogen free extract was reported for diets incorporating prawn waste at 10 per cent level compared to a standard diet fed to crossbred heifer calves of 11 to 15 months of age (Anon., 1999). Singh and Kumar (1998) reported higher crude protein and ether extract digestibilities in female calves when fed at NRC recommended level than those at a lower plane of nutrition. A higher ether extract digestibility and a lower neutral detergent fibre digestibility were recorded in heifers fed a ration higher in energy than those fed at NRC level (Girdhar and Singh, 2000).

2.5 Rumen fermentation characteristics

Leng and Leonard (1965) measured the rates of the volatile fatty acids (VFA) production in the rumen of sheep and observed an increase in the concentration of volatile fatty acids after feeding while the pH and molar proportions of individual acids remained at a steady level throughout the 24 hr period. A quantitative assessment of the daily VFA production showed that 79 per cent of the apparently digestible energy was accounted by the volatile fatty acids.

Nayeem *et al.* (1973) analysed the strained rumen liquor collected from fistulated steer at two hour intervals after feeding different oil cakes such as groundnut cake and gingelly oil cake. The peak concentrations of total volatile fatty acid (TVFA) was observed at second and fourth hour after feeding of groundnut cake and ginglley oil cake, respectively. The peak ammonia nitrogen production was at 6^{th} hour after feeding of both groundnut cake and gingely oil cake, while the ammonia nitrogen concentration was lower with ginglley oil cake. A significant correlation was established between production rates of TVFA and intake of DE and ME (Chaturvedi *et al.*, 1974) in growing male Hariana cattle and Murrah buffaloes.

Rumen liquor collected from steers fed long, chopped and alkali treated straw diets were analysed by Kannan *et al.* (1975) and they reported that the total volatile fatty acid concentration varied significantly among treatments, but remained similar between days and time. Rhodes *et al.* (1978) observed a significantly lower total volatile fatty acid concentration in cows fed diets supplemented with micro encapsulated tallow.

In vitro studies by Venkatayan *et al.* (1981) in steers fed isonitrogenous rations with and without maize indicated a lower ammonia nitrogen concentration in the rumen liquor collected from animals fed a ration without maize. However an increased TVFA concentration and decreased butryic acid concentration were observed by the same authors in animals fed a ration containing maize. Reddy and Das (1984) measured the TVFA and ammonia nitrogen concentration in rumen liquor collected from cattle and buffaloes and found no significant variation between the species.

Rao *et al.* (1985) reported a significant decrease in the rumen ammonia nitrogen and blood urea nitrogen levels of lambs fed extruded tapioca as an energy supplement compared to unprocessed tapioca. Sampath (1985) recorded a mean total volatile fatty acid concentration of 90.31, 83.63 and 85.38 meq/l of strained rumen liquor from cows fed diets with rumen degradable protein levels of 45.3, 64.7 and 76.9 per cent under similar feeding regimen. The rumen fermentation characteristics of dairy cows fed barley or corn based diets did not show any difference (DePeters and Taylor, 1984).

Rumen fermentation studies in mid lactation dairy cows fed oats or corn as energy supplements did not show any difference in rumen ammonia nitrogen, TVFA and molar percentage of VFA between the treatments (Robinson and Burgess, 1990).

Kalbande (1995) reported that the TVFA concentration increased and ammonia nitrogen concentration decreased in rumen liquor of dairy cattle with increase in dietary protein degradability. Sagathevan (1995) observed that addition of dried spleen as a biostimulator for growth in the diets of heifer calves did not alter any of the rumen fermentation characteristics. He recorded the values for ammonia nitrogen as 88.74, 87.86, 76.32, 77.48 meq/l respectively, for diets with 20 and 16 per cent crude protein level containing spleen at 0 and 0.1 per cent levels.

Oka *et al.* (1999) could establish an increase in the rumen ammonia content and acetate concentration in growing Japanese black steers fed high forage diets. The ruminal pH was similar between low and high roughage diets. A higher ammonia nitrogen level was observed in Deccani sheep fed diets with low energy levels, but the TVFA concentration was high in high energy rations with a corresponding inverse relationship with pH (Sridhar *et al.*, 1999).

2.6 Haematological parameters

A reduction in the blood glucose level (76 mg/dl) was observed in heifers fed a diet containing protected lipid as against those fed a control diet without protected lipid (87.3 mg/ml). However, the levels of triglycerides in the plasma was high in those supplemented with protected lipid when compared to the control diet (Rhodes *et al.*, 1978). Omprakash *et al.* (2000) recorded no significant difference between the blood glucose levels of crossbred heifers which were maintained on a diet incorporating dried poultry excreta at 30 per cent level and a control diet.

Lal *et al.* (1994) compared the mineral status of lactating buffaloes in the two different seasons of rabi and kharif. They reported the serum calcium and phosphorus levels as 11.02 ± 0.5 and 8.45 ± 0.11 mg/dl, respectively, during kharif season. The serum calcium levels of growing buffalo bulls fed urea or lime treated wheat straw based diets were 8.4 to 11.97 mg/dl (Sirohi and Rai, 1997). Rajora and Pachauri (1998) monitored the mineral status of a crossbred herd and they reported that the serum calcium concentration of non pregnant cows were 2.3 ± 0.04, 2.07 ± 0.05 and 2.095 ± 0.39 mmol/l at 90, 180 and 300 days of lactation. Mineral profile of cows and buffaloes in Rewari district of Haryana.was assessed by Yadav *et al.* (1998). They reported the serum calcium levels as 8.92, 8.41 and 9.28 mg/dl, the serum phosphorus contents being 4.03, 4.92 and 3.66 mg/dl, for milch cows, buffaloes and buffaloe heifers, respectively. Varghese (1998) reported that the serum calcium and phosphorus content of lactating dairy cows in the state of Kerala were 7.06 to 10.19 mg/dl and 4.12 to 5.88 mg/dl, respectively. The serum calcium and phosphorus levels remained statistically similar in crossbred calves maintained on dietary treatments with three different protein sources and two methods of processing of maize (Pattanaik *et al.*, 1996).

2.7 Reproductive performance

Wishart *et al.* (1977) in their study to relate the effect of nutrition on fertility using Friesian heifers reported that the number of animals calved is more in the group supplemented with cereals as an additional energy source. Beal *et al.* (1978) reported that in intact heifers and cows, dietary energy restriction influenced the leutinising hormone (LH) release directly at the pituitary or indirectly through the ovarian steroid hormones. The hormonal concentrations observed in the under-nourished animals suggested the influence of energy on fertility by altering the endocrine function. A reduced LH concentration and a delayed puberty were reported by Day *et al.* (1986) in heifers fed restricted energy diets. Harrison and Randel (1986) reported that energy restriction in beef heifers led to a reduction in the weight of corpus luetum and insulin secretion or metabolism without altering the LH or progesterone levels.

Richards *et al.* (1989) stated that severe reduction in body weight caused by restricted feed intake resulted in cessation of oestrous cycle and quiescent ovaries. Houghton *et al.* (1990) observed that calves born to cows receiving a low energy prepartum diet were lighter and the energy levels of prepartum and post partum diets interacted to affect the post partum anoestrum and cyclic activity. Nolan *et al.* (1990) measured various parameters such as body weight, hip height, scrotal circumference and serum LH and GnRH levels to assess the reproductive performance of Brahman bull calves fed different levels of energy. The measurements indicated a positive influence of dietary energy on the onset of puberty most directly at the testicular level. Dunn and Moss (1992) reviewed the effect of nutrient deficiencies and excess on the reproductive performance of livestock and they stated that severe restriction of feed intake delayed the onset of puberty. Singh and Kumar (1998) reported that in comparison with a low energy diet, heifers fed at NRC level reached puberty 92 days earlier.

Gardner *et al.* (1977) reported that Holstein heifers which were allowed an accelerated growth rate by maintaining at a high plane of nutrition were 1.9 months younger at first standing oestrus. But the number of inseminations required per conception for the accelerated group was higher. The weight of heifers at breeding and the weight of calves born were also lower for the accelerated group. Rhodes *et al.* (1978) reported delayed puberty in heifers which received isocaloric diets with 20 per cent protected lipid, without affecting the conception rate.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation was carried out at the University Livestock Farm, under the Kerala Agricultural University located at Mannuthy.

3.1 Animals

Eighteen crossbred heifers born and reared in the farm were selected for the experiment. The animals were housed together at the experimental shed provided with individual mangers 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 age and body weight. The average age and body weights of the animals of the three groups were 439.83 ± 45.5 and 175.16 ± 13.62, 489.66 ± 60.07 and 170.0 ± 11.22 and 464.16 ± 43.63 days and 176.06 ± 18.01 kg respectively. The duration of the experiment was five months (155 days) from September 2000 to January 2001.

3.2 Experimental rations

The heifers of the three experimental groups were randomly allotted to the dietary treatments T1, T2 and T3. All the experimental animals received enough of the routine farm ration comprising compounded concentrate mixture in the pellet form (manufactured by Kerala Feeds Limited, Kallettumkara, Thrissur) and paddy straw as roughage. The animals were fed as per the ICAR recommendations (I.C.A.R., 1985). Animals of the dietary treatments T2 and T3 received 0.5 kg and 1 kg of ground maize grain, respectively, over and above the basal ration. Vitamin AB_2D_3 supplement (Indomix – manufactured by Nicholas Pirmal India Ltd. containing 40,000 IU of Vitamin A, 20 mg of Vitamin B_2 and 5000 IU of Vitamin D_3 per gram) was also included in the diet of all animals.

The three dietary treatments were:

T1 - Concentrate mixture + paddy straw

T2 - Concentrate mixture + paddy straw + 0.5 kg ground maize grain

T3 - Concentrate mixture + paddy straw + 1 kg ground maize grain

Representative samples of the concentrate mixture, maize and paddy straw used for feeding were analysed for their chemical composition.

3.3 Methods

Every day at 8 AM the animals were given the required quantity of the concentrate mixture. Ground maize was fed to those in the dietary treatments T2 and T3. Paddy straw was given to all animals *ad libitum* in two divided lots every day to ensure minimum wastage. The left over concentrate feed, maize and straw were removed and weighed every day. Individual records of daily intake of concentrate, maize and straw were maintained throughout the experiment. Drinking water was made available at all times. Body weights were recorded at fortnightly intervals. The feed offered was revised quantitatively every 15 days to ensure that the animal's requirements of crude protein and TDN were met. From the data on body weight and feed consumed, the average daily gain, feed to gain ratio and protein efficiency were calculated.

3.4 Digestibility coefficients

Towards the end of the feeding experiment a digestion trial was carried out using all the animals of the three groups allowing a collection period of seven days.

Representative samples of concentrate mixture, maize and paddy straw were taken every day during the trial for analysis. The dry matter content of the feed was determined every day. After the collection period, the feed samples collected daily were pooled and sub-samples were taken for analysis. All precautions were taken to ensure the collection of dung quantitatively, uncontaminated by urine or feed residue or dirt. The dung was collected manually as and when voided. At 9 AM every day the dung collected during the previous 24 hours was weighed accurately, mixed thoroughly and representative samples at the rate of one per cent of the total voided quantity were taken in double lined polythene bags and stored in deep freezer till they were analysed. The processes of collection, weighing and sampling of dung were continued till the end of the trial. The dung samples collected each day from each animal were pooled, and mixed thoroughly and sub samples were taken for analysis.

Feed samples (concentrate mixture, maize and straw) and dung were analysed for dry matter, crude protein, ether extract, total ash, acid insoluble ash, acid detergent fibre and acid detergent lignin as per standard procedures (A.O.A.C., 1990). The samples were also analysed for neutral detergent fibre (Vansoest and Wine, 1967).

Data obtained from the digestion trial were used for the calculation of digestibility coefficients of dry matter, crude protein, ether extract, neutral detergent fibre and acid detergent fibre.

3.5 Analysis of rumen liquor

At the beginning and the end of the experiment rumen liquor was collected by using a stomach tube. Approximately 200 ml of the fluid was collected, strained through multiple layers of cheese cloth and the pH was determined immediately using a digital pH meter (M.C. Dalal and Co., Madras). The total volatile fatty acid concentration was estimated as per the method suggested by Barnett and Reid (1957). One drop of concentrated sulphuric acid was added to 5 ml of rumen liquor and was kept frozen for the analysis of ammonia nitrogen (Beecher and Whittew, 1970).

3.6 Haematological studies

Blood samples were collected in the beginning, middle and towards the end of the experiment in sterile tubes containing required quantity of sodium fluoride as anticoagulant and the plasma was separated immediately. The plasma samples were analysed for the levels of calcium (Clark and Collip, 1925) and inorganic phosphorus by modified metol method using kits supplied by Qualigens Diagnostics. The blood samples collected at the end of the experiment were also analysed for the level of glucose (Folin and Wu, 1920).

3.7 Reproductive performance

The animals were carefully observed for the signs of behavioural oestrus and those which showed the signs were inseminated regularly. The conception rate, the number of inseminations required per conception and the average age at conception were noted.

3.8 Economics

The cost of feed for producing one kilogram gain in body weight was calculated using the data on total feed consumed and the total body weight gain during the experimental period. The rate contract fixed by the University for the different feed stuffs was used for the calculations of the cost of feed.

3.9 Statistical analysis

The data obtained were subjected to statistical analysis using the standard statistical procedures of Snedecor and Cochran (1980).

Results

4. RESULTS

The results obtained during the course of the present investigation are detailed under the following topics.

4.1 Chemical composition of the feed and dung

Data on the chemical analysis of the feeds used (the commercial concentrate mixture, ground maize and straw) and the dung collected during the digestibility trial are summarised in Table 1.

4.2 Growth performance

4.2.1 Body weights

The mean values of the fortnightly body weights of animals in the three treatment groups recorded during the experimental period are listed in Table 2 and the data are represented graphically in Fig.1. The final body weights were 258.16 ± 15.56, 263.33 ± 6.82 and 274.0 ± 13.03 kg, respectively, for the animals of groups T1, T2 and T3. Statistical analysis of the data (analysis of covariance) is presented in Table 3.

4.2.2 Average daily gain

The average daily gain in body weight of the animals maintained on the three treatments T1, T2 and T3 were 535.47 ± 35.18, 602.15 ± 41.29 and

631.18 ± 42.9 g, respectively. The data are presented in Table 4 and represented in Fig.2.

4.3.1 Dry matter intake

The total dry matter consumed by animals during the experimental period in the three groups T1, T2 and T3 were 1016.41 ± 35.57, 1092.75 ± 24.30 and 1168.87 ± 44.90 kg, respectively (Table 5 and Fig.3). The dry matter consumption was significantly higher for T3 than T1 and T2 ($P<0.05$).

4.3.2 Feed to gain ratio

Overall feed to gain ratio calculated were 12.49 ± 0.89, 12.09 ± 1.13 and 12.34 ± 1.10, respectively for the animals of the three dietary treatments T1, T2 andT3 and the data are presented in Table 5.

4.3.3 Protein efficiency

Values for protein efficiency were 1.39 ± 0.11, 1.34 ± 0.14 and 1.35 ± 0.14, respectively for the animals of the treatments T1, T2 and T3. Statistical analysis of the data did not reveal any significant difference between the three groups (Table 5).

4.4 Digestibility of nutrients

The data on digestibility coefficients of dry matter, crude protein, ether extract, neutral detergent fibre and acid detergent fibre of the three experimental rations are set out in Table 6 and are represented graphically in Fig.4. The digestibility coefficients for dry matter and crude protein of the rations T2 and T3 were significantly higher ($P<0.05$) when compared to T1.

4.5 Rumen fermentation characteristics

Data on the pH, total volatile fatty acid concentration and ammonia nitrogen concentration of the rumen liquor collected from the experimental animals are set out in Table 7. There was no significant difference ($P>0.05$) between the treatments in any of the said rumen fermentation characteristics.

4.6 Haematological values

Values of plasma calcium and phosphorus levels at the beginning, middle and end of the experiment are set out in Table 8. The values for the three treatments remained statistically non significant ($P>0.05$). The blood glucose level at the end of the experiment for T1, T2 and T3 were 69.77 ± 1.89, 69.70 ± 2.89 and 72.13 ± 2.46 mg/dl, respectively.

4.7 Reproductive performance

The number of animals conceived per group, average age at conception and the number of inseminations required per animal for conception (AI index) of the animals maintained on the three dietary treatments T1, T2 and T3 are shown in Table 9.

4.8 Economics

Data on the cost of feed per unit gain in body weight for the animals maintained on the three dietary treatments are tabulated in Table 10 and represented in Fig.5.

Table 1. Per cent chemical composition of feed and dung samples (on dry matter basis)

Nutrients	Feed			Dung		
	Concentrate	Straw	Maize	T1	T2	T3
Dry matter	89.5 ±0.5	90.97 ±0.04	89.11 ±0.88	20.53 ±0.25	20.85 ±0.67	20.58 ±0.22
Crude protein	17.92 ± 0.07	4.56 ±0.21	7.03 ±0.12	9.63 ±0.29	10.57 ±0.55	10.49 ±0.16
Ether extract	4.45 ±0.35	3.12 ±0.02	3.43 ±0.59	2.84 ±0.37	3.66 ±0.57	3.23 ±0.41
Total ash	13.32 ± 0.15	16.56 ±0.13	2.02 ±0.06	23.84 ±0.30	22.97 ±0.40	22.65 ±0.24
Acid insoluble ash	2.9 ±0.13	12.59 ±0.19	0.39 ±0.01	15.81 ±0.52	14.25 ±0.37	15.35 ±0.29
Neutral detergent fibre	45.73 ±0.26	72.19 ±0.26	31.12 ±0.34	62.43 ±1.28	60.76 ±1.83	60.86 ±1.63
Acid detergent fibre	10.90 ± 0.52	46.9 ±0.28	2.49 ±0.14	38.36 ±1.23	37.74 ±1.29	34.50 ±0.59
Acid detergent lignin	2.79 ±0.10	12.02 ±1.93	0.37 ±0.01	16.76 ±1.7	16.31 ±1.5	14.39 ±1.65

Table 2. Average fortnightly body weights (in kg) of animals of the three experimental groups

Fortnights	T1	T2	T3
0	175.16 ± 13.62	170.0 ± 11.22	176.06 ± 18.11
1	178.5 ± 14.42	175 ± 9.7	184.33 ± 17.73
2	185 ± 14.76	181.66 ± 9.6	192.33 ± 17.66
3	199.16 ± 15.15	192.16 ± 10.14	199.16 ± 17.66
4	201.16 ± 14.71	202.33 ± 8.8	205 ± 16.23
5	207.5 ± 14.64	204.5 ± 8.4	213.5 ± 16.27
6	217.33 ± 13.89	218.16 ± 7.95	225.33 ± 15.36
7	222.5 ± 13.64	229.5 ± 8.81	237.16 ± 14.20
8	237.33 ± 13.68	239.66 ± 8.05	247.83 ± 14.59
9	246.33 ± 15.29	251.16 ± 6.6	259.5 ± 14.49
10	258.16 ± 15.56	263.33 ± 6.82	274.0 ± 13.03

Table 3. Analysis of covariance of body weights of animals of the three experimental groups recorded at fortnightly intervals

Fortnights	Mean sum of squares			Probability
	Treatments	Covariate	Error	
1	37.08	18129.94	28.20	0.2998
2	64.72	18396.21	19.89	0.0691
3	52.78	18863.14	33.38	--
4	51.68	15990.46	52.69	--
5	40.59	15561.09	67.38	--
6	82.09	13811.43	68.29	0.3298
7	323.99	12492.48	105.69	0.0786
8	146.49	12759.28	85.16	0.2148
9	244.984	12411.677	157.285	0.2450
10	345.57	11344.79	172.95	0.1724

Fig.1. Fortnightly body weights of animals on the three dietary treatments

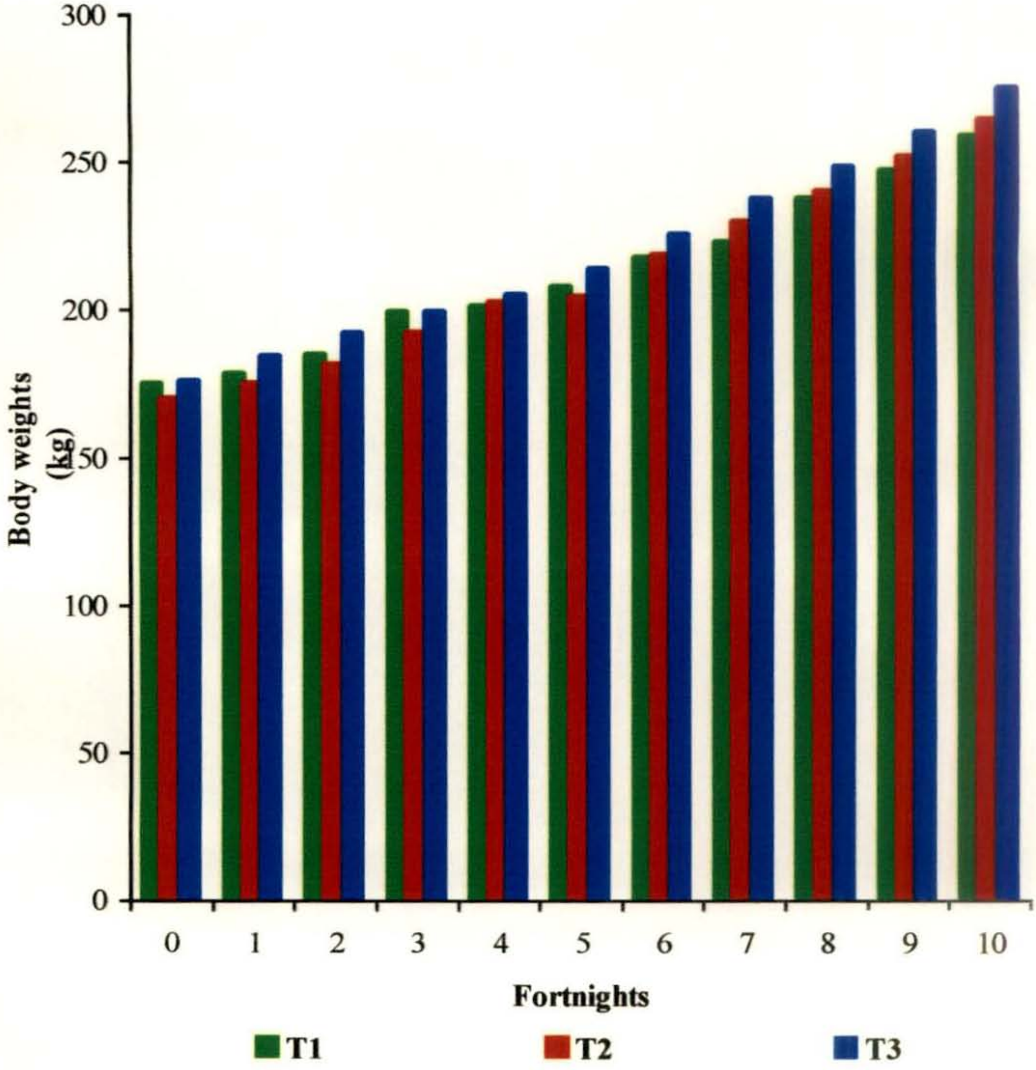


Table 4. Summarised data on body weight, total gain and average daily gain of animals of the three experimental groups

	T1	T2	T3	F value
Initial body weight (kg)	175.16 ±13.62	170.00 ±11.22	176.16 ±18.11	0.05(NS)
Final body weight (kg)	258.16 ±15.56	263.33 ±6.82	274.00 ±13.03	0.42(NS)
Total gain (kg)	83.00 ±5.45	93.33 ±6.4	97.83 ±6.65	1.51(NS)
Average daily gain (g)	535.47 ±35.18	602.15 ±41.29	631.18 ±42.9	1.51(NS)

NS - Non Significant (P>0.05)

Fig.2. Average daily body weight gain of animals on the three dietary treatments

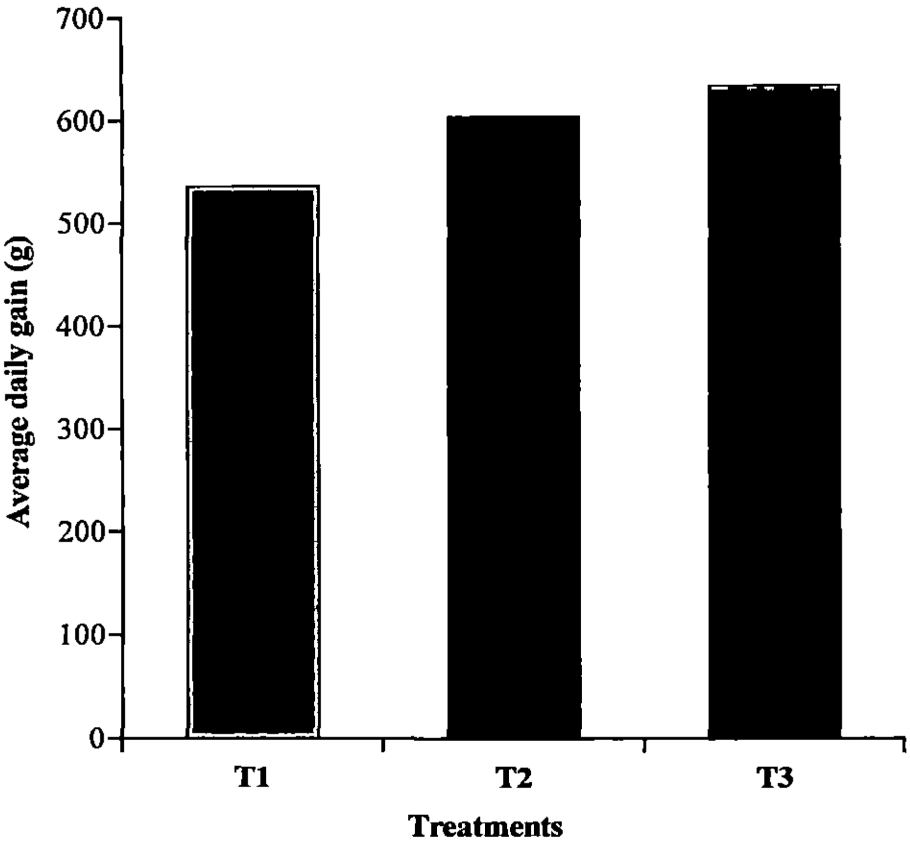


Table 5. Summarised data on dry matter consumption, feed to gain ratio and protein efficiency ratio of animals of the three experimental groups

	T1	T2	T3	F value
Total dry matter consumed (kg/animal)	1016.41[a] ±35.57	1092.75[a] ±24.30	1168.87[b] ±44.90	4.55
Average daily dry matter consumed (kg/animal)	6.56[a] ± 0.23	7.05[a] ± 0.16	7.54[b] ± 0.29	4.55
Dry matter consumed/100 kg body weight (kg)	2.69 ± 0.13	2.89 ± 0.08	2.84 ± 0.09	0.89(NS)
Feed to gain ratio	12.49 ±0.89	12.09 ±1.13	12.34 ±1.10	0.04(NS)
Total protein intake (kg)	113.75 ±5.71	120.99 ±3.79	127.45 ±6.63	1.54(NS)
Protein efficiency	1.39 ±0.11	1.34 ±0.14	1.35 ±0.14	0.05(NS)

a,b – Means within the same row with different superscripts differ (P<0.05)
NS – non significant (P>0.05)

Fig.3. Average daily drymatter consumption of animals on the three dietary treatments

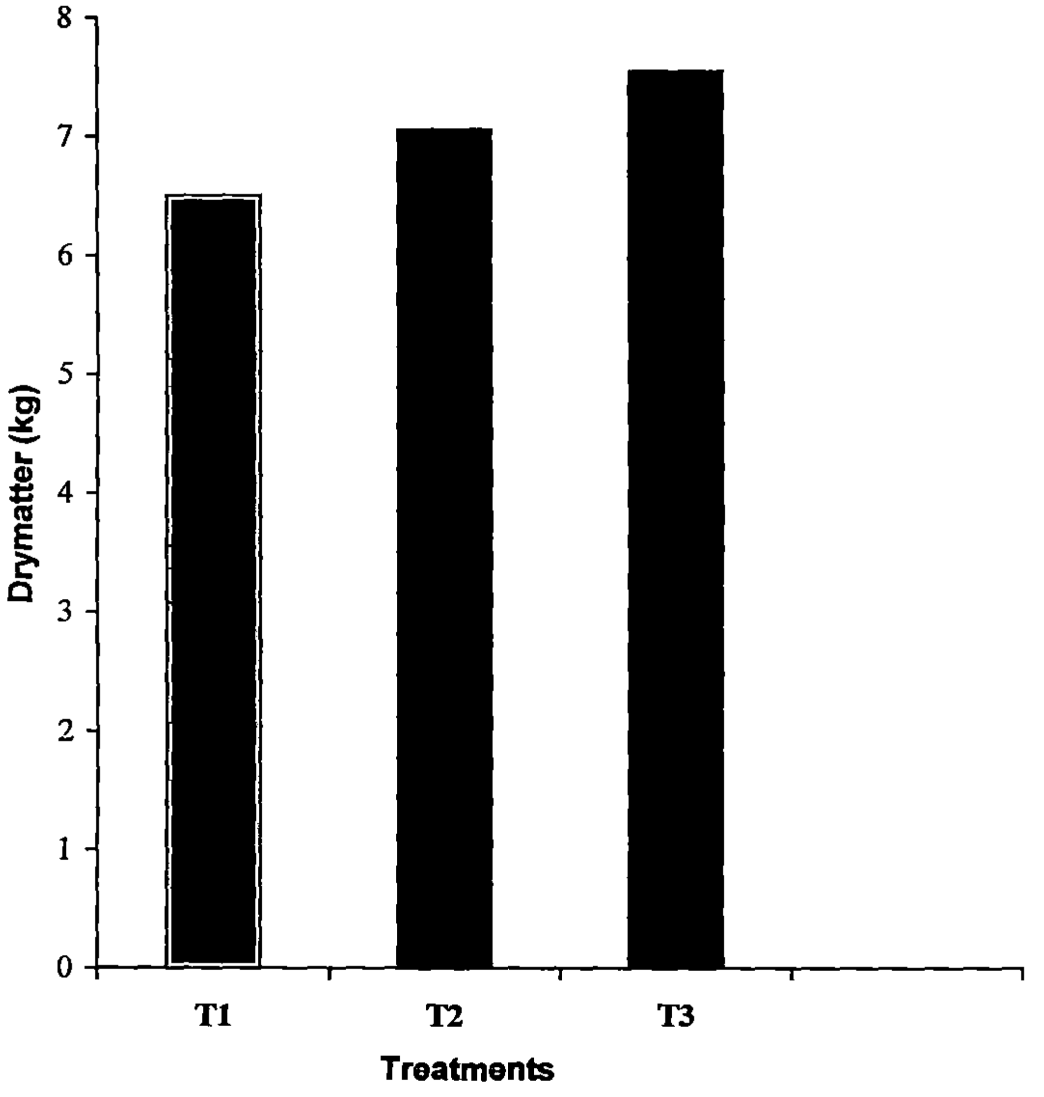


Table 6. Average digestibility coefficients of nutrients of the three rations

Nutrient	Ration I	Ration II	Ration III	F value
Dry matter	56.32 [a] ±1.46	63.01 [b] ±1.75	61.76 [b] ±1.61	4.83 ($P<0.05$)
Crude protein	64.97 [a] ±1.46	73.87 [b] ±1.83	77.89 [b] ±0.96	20.07 ($P<0.01$)
Ether extract	71.63 ±3.43	71.79 ±4.48	75.04 ±3.15	0.27(NS)
Neutral detergent fibre	54.3 ±2.0	61.04 ±2.39	60.60 ±2.37	2.77(NS)
Acid detergent fibre	42.35 ±1.32	46.47 ±2.67	47.17 ±3.23	1.05(NS)

a,b,c – Means within the same row with different superscripts differ

NS – non significant ($P>0.05$)

Fig.4. Digestibility coefficients of nutrients of the three rations

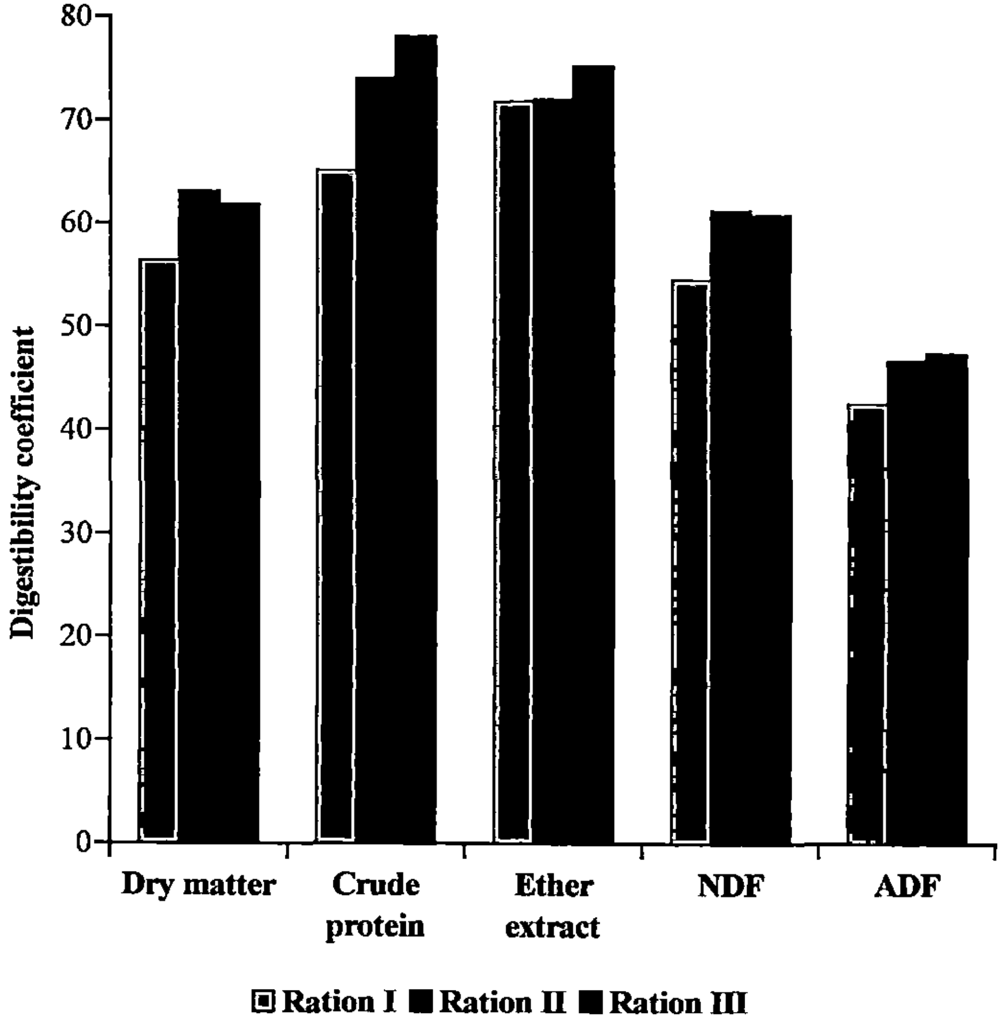


Table 7. Rumen fermentation parameters of animals of the three experimental groups at the beginning and end of the experiment

Rumen fermentation parameters		T1	T2	T3	F value
pH	Beginning	7.04 ±0.18	6.68 ±0.15	6.83 ±0.23	0.09(NS)
	End	8.3 ±0.16	7.73 ±0.18	8.44 ±0.13	3.4(NS)
Total volatile fatty acid (meq/l)	Beginning	73.6 ±6.65	78.83 ±16.42	70.00 ±21.07	0.91(NS)
	End	58.55 ±1.58	53.49 ±3.55	59.44 ±1.07	0.04(NS)
Ammonia nitrogen (µg/ml)	Beginning	307.26 ±53.23	430.97 ±35.58	383.81 ±38.91	1.99(NS)
	End	201.65 ±21.12	229.15 ±24.40	195.6 ±15.5	0.88(NS)

NS – Non significant (P>0.05)

Table 8. Plasma levels of calcium and phosphorus of animals of the three experimental groups at the beginning, middle and end of the experiment

Items		T1	T2	T3	F value
Calcium (mg/dl)	Beginning	8.25 ±0.63	10.0 ±1.47	9.9 ±0.91	0.87(NS)
	Middle	9.3 ±0.44	9.4 ±0.33	9.2 ±0.34	0.19(NS)
	End	10.77 ±1.15	11.5 ±1.47	10.8 ±0.58	0.27(NS)
Phosphorus (mg/dl)	Beginning	8.42 ±0.39	7.99 ±0.49	7.86 ±0.74	0.27(NS)
	Middle	8.48 ±0.79	7.47 ±0.54	7.92 ±0.92	0.45(NS)
	End	6.65 ±0.12	5.71 ±0.46	6.4 ±0.32	1.95(NS)

NS - Non significant (P>0.05)

Table 9. Reproductive performance of animals of the three experimental groups

Reproductive parameters	T1	T2	T3
Number of animals conceived in each group	4	3	5
Average age at conception (in days)	671 ± 43.86	649 ± 31.58	626 ± 48.1
Number of inseminations required per conception (AI Index)	2	2	1.2

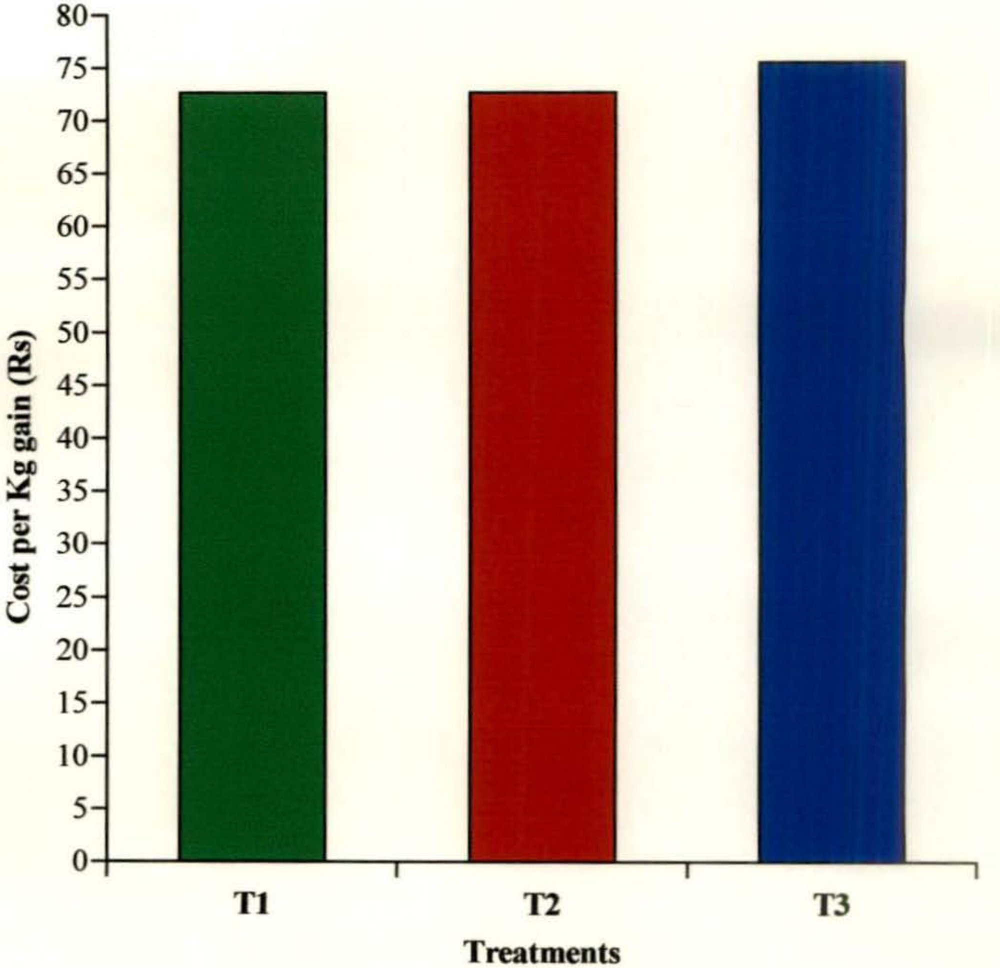
Table 10. Cost of feed per kilogram body weight gain of animals of the three experimental groups

Treatments	Total feed consumed (kg) per animal			Feed cost per animal (Rs.)			Total cost (Rs.)	Total gain in body weight (kg)	Cost per unit gain (Rs.)	F value
	Concentrate	Straw	Maize	Concen-trate	Straw	Maize				
T1	563.7 ± 34.28	562.71 ±5.94		4509.6 ± 274.21	1406.78 ± 14.86		5916.38 ± 287.49	83.0 ±5.45	72.67 ±5.77	
T2	578.63 ±22.36	552.61 ±48.49	74.08 ±0.54	4629.06 ±178.89	1389.53 ±178.89	497.60 ±3.65	6508.20 ±192.38	93.33 ±6.4	72.15 ±7.15	0.053(NS)
T3	588.01 ±38.03	552.39 ±9.57	143.94 ±3.50	4704.13 ±304.26	1380.97 ±23.94	967.29 ±23.55	7052.00 ±342.58	97.83 ±6.65	74.49 ±7.29	

NS – Non significant (P>0.05)

Cost of concentrate mixture – Rs.8.00/kg, straw Rs.2.5/kg and maize Rs.6.72/kg

Fig.5. Cost of feed per kilogram gain of animals on the three dietary treatments



Discussion

5. DISCUSSION

5.1 Growth performance

Data on the fortnightly body weights presented in Table 2 and represented in Fig.1 reveal that the mean final body weights of crossbred heifers maintained on the rations T1 (control concentrate mixture + paddy straw to meet the requirements as per the ICAR standards), T2 (control ration + 0.5 kg ground maize) and T3 (control ration + 1 kg ground maize) were 258.16, 263.33 and 274.0 kg, respectively. The average cumulative gain of animals of the three groups T1, T2 and T3 were 83.00, 93.33 and 97.83 kg, respectively (Table 4 and Fig.2) during the 155 days of experimental period. The data also reveal that the average daily body weight gain was higher for T3 groups (631.18 g) followed by T2 (602.15 g) and T1 (535.47 g), but the differences were not significant. Analysis of covariance of the fortnightly body weights with initial body weight as the covariate also could not establish any significant influence of the dietary treatments on growth performance (Table 3).

The average daily gains observed in the present study were in accordance with the growth rates obtained for one year old crossbred heifers fed at 100, 120 and 140 per cent of NRC recommendations (Malik *et al.*, 1998). Almost similar body weight gains (608 to 660 g/day) were reported by Pirlo *et al.* (1997) in prepubertal heifers fed at NRC level while those fed at

110 per cent NRC showed higher gains of 794 to 848 g/day. Rajagopal *et al.* (1999) also reported similar gain (550 g/day) in 14 to 15 month old crossbred heifer calves fed at 125 per cent NRC level. Oka *et al.* (1999) reported body weight gains of 640 and 600 g, respectively, in fattening steers fed high and low roughage diets. Almost similar gains of 679 and 690 grams/day were reported by Girdhar and Singh (2000) when 8 to 9 month old Frieswal bull calves were fed at 100 and 120 per cent of NRC recommendations.

Higher body weight gains of 0.79 kg/day were reported by Day *et al.* (1986) in prepubertal heifers fed a standard diet. Kertz *et al.* (1987) also reported gains upto 1 kg/day in Holstein calves from 3 to 12 months of age. They further observed that Holstein fattening steers of 8 months of age registered higher body weight gains during early, middle and finishing periods. The average daily gains during the entire period were 1.17 and 1.09 kg, respectively, when fed low and high energy rations.

Lower body weight gain of 386 g/day was reported by Verma and Mudgal (1971) in 1½ to 2 year old Sahiwal male calves fed at NRC level. Similarly Beal *et al.* (1978) obtained a daily body weight gain of 330 g/day in 18 to 20 months old heifers fed a high energy ration. Heifer calves of 3 to 7 months of age registered lower daily gains of 329 to 468 g when fed diets containing energy at 75, 100 and 125 per cent and protein at 75 and 100 per cent of NRC levels according to Mohan and Ranjhan (1982). Crossbred heifers fed a diet containing 10% dried prawn waste also gained at a lower rate (433 g/day) than that of the present study (Anon, 1999).

In the present experiment, the animals of the control group were fed as per ICAR (1985) standards and the heifers grew at the rate of 531.5 g/day which is slightly lower than the recommended growth rate of 550 g/day. When ground maize was supplemented at 0.5 and 1 kg/day, the average daily gain of the animals increased numerically by 13 and 19 per cent, respectively. However, Gardner *et al.* (1977) obtained 38 per cent increase in the growth rate of Holstein heifers by providing a high energy diet.

Lippke (1980) and Mohan and Ranjhan (1982) have concluded from their studies that the growth rate is positively correlated to the energy levels, whereas Fluharty and Loerch (1996) could not find any influence of energy level on the average daily gain of feedlot calves. Miyakoshi *et al.* (1999) on the other hand reported a lower gain in Holstein steers fed a high energy diet (77% TDN) than those fed a low energy diet (73% TDN) in early fattening period.

The differences in the average daily gain reported by the different workers may be due to the difference in the type of animal, whether beef or dairy breed, whether large sized or small sized, age, type of feed used, climate and other managemental factors. From the perusal of the above reports it could be concluded that the growth rates obtained for crossbred heifers in the present study are optimum for their age. The animals given extra energy did not show any significant improvement in the growth rate, which shows that ICAR recommended levels are optimum.

5.2.1 Dry matter consumption

The average daily dry matter consumption of heifers supplemented with ground maize at 0, 0.5 and 1 kg, respectively, were 6.56, 7.05 and 7.54 kg (Table 5 and Fig.3). The dry matter consumption per 100 kg body weight was 2.69, 2.89 and 2.84 kg, respectively, for heifers under the three dietary treatments. The total dry matter consumption increased ($P<0.05$) when ground maize was fed at 1 kg/day when compared to those fed at 0 and 0.5 kg levels. Verma and Mudgal (1971) also observed higher dry matter intake in male Sahiwal calves when the energy content of the diet was increased to 100 and 120 per cent of Morrison's standard when compared to those fed at 80 per cent of Morrison standard. Similarly, Quigley *et al.* (1986) and Malik *et al.* (1998) also reported increased dry matter intake in heifers when the energy content of the ration was increased. Singh and Kumar (1998) observed a reduced dry matter intake in crossbred heifers when fed diets containing lesser energy than that of NRC standards. However, Fluharty *et al.* (1994) observed a reduced dry matter intake when the energy content of the diet was increased.

Low dry matter intake was reported in cattle by several workers under different dietary treatments. Padgett *et al.* (1978) reported lower dry matter consumption per day (4.30 kg/day) in one year old steers when fed isocaloric diets in which whole cattle blood protein was substituted for peanut meal at different levels. Rhodes *et al.* (1978) also observed reduced dry matter intake in prepubertal beef heifers fed diets containing protected lipids. Dry matter consumption reported by Pachauri and Negi (1980) in non producing cattle was also lower than those observed in the present study.

Lubis *et al.* (1990) observed a reduced dry matter intake when calcium tallowate was incorporated at 8 per cent level in the rations of lactating dairy cows. They also observed that the dry matter intake was increased when the protein content of the ration was raised from 14 to 18 per cent. Sagathevan (1995) observed lower values for dry matter consumption in 6 to 9 month old calves maintained on different dietary treatments. However, Subramanian (1995) reported a dry matter intake of 3.3 kg/100 kg body weight in crossbred calves of 5 to 7 months of age when fed rations with and without fish meal, the values being higher than those observed in the present study.

Lippke (1980) correlated the body weight gain and dry matter intake in Hereford steers fed diets containing seven varieties of sorghum and Sudan hay. He attributed the rate of passage of undigested fibre residues from the reticulo-rumen and rate of fibre digestion to be the principle factors affecting dry matter intake.

5.2.2 Feed to gain ratio

The feed to gain ratios observed in the present investigation were 12.49, 12.09 and 12.34, respectively, (Table 5) when crossbred heifers were supplemented with ground maize at 0, 0.5 and 1 kg per day respectively. There was no significant difference between the three groups.

Better feed to gain ratio (7.09 and 6.12) was reported in prepubertal beef steers fed protein protected lipids by Rhodes *et al.* (1978) which may be due to the difference in the genetic potential of the animals. Fluharty *et al.* (1994) observed a better energetic efficiency in feedlot calves fed a high energy ration. Sagathevan (1995) also reported better feed to gain ratios ranging from 8.09 to 8.74 in 6 to 9 month old calves maintained on diets containing 20 and 16 per cent protein with and without supplementation of dried spleen as biostimulator. Similarly Subramanian (1995) observed feed to gain ratio ranging from 6.28 to 6.96 in 5 to 7 month old crossbred calves fed ration with or without fish meal. Malik *et al.* (1998) also observed slightly better feed to gain ratios than those recorded in the present study, the values being 10.37, 10.49 and 10.65 in crossbred heifers fed at 100, 120 and 140 per cent of NRC recommendations. They observed that the feed to gain ratio was not affected by the energy level of the diets.

The lower feed to gain ratio observed in the present investigation may be due to the difference in age of the heifers, the higher dry matter consumption of the animals fed ground maize and the non significant increase in body weight gain.

5.2.3 Protein efficiency

Protein efficiency of animals supplemented with ground maize at 0, 0.5 and 1 kg per day were 1.39, 1.34 and 1.35, respectively (Table 5). Statistical analysis of the data did not reveal any significant difference among the treatment groups.

Very few reports are available in literature regarding the protein efficiency of crossbred heifers. Sagathevan (1995) observed similar protein efficiency in 6 to 9 months old calves while Subramanian (1995) observed better protein efficiency (0.69 to 0.85) in 5 to 7 month old crossbred calves when compared to the results of the present study. Lower protein efficiency was reported by Malik *et al.* (1998) in crossbred heifers fed diets containing different energy levels.

5.3 Digestibility of nutrients

The digestibility coefficients of nutrients of the three rations are given in Table 6 and depicted in Fig. 4.

5.3.1 Dry matter

The dry matter digestibility of the three rations supplemented with 0, 0.5 and 1 kg maize were 56.32, 63.01 and 61.76 per cent, respectively. There was a significant increase in the dry matter digestibility of the rations supplemented with ground maize at 0.5 and 1 kg levels compared to that of the control ration. While the dry matter digestibility increased by 11.8 and 9.7 per cent, respectively, in the rations supplemented with 0.5 and 1 kg ground maize, Fluharty *et al.* (1994) reported a 5 per cent increase in dry matter digestibility in feedlot calves with an increase in the energy density of the ration. Almost similar digestibilities were reported by Verma and Mudgal (1971) in Sahiwal male calves fed at 80, 100 and 120 per cent of Morrison's standards. Similar digestibility was also reported in Murrah buffaloes (Jayaraman *et al.*, 1979) and in crossbred heifers (Singh and Kumar, 1998) fed different rations.

Higher digestibility coefficients of dry matter were reported in crossbred calves (Sagathevan, 1995) and in heifers (Girdhar and Singh, 2000) for diets supplemented with and without dried spleen and diets high in energy, respectively. Fluharty *et al.* (1994) also observed slightly higher dry matter digestibility in feedlot calves when compared to that obtained in present study. Higher dry matter digestibilities were reported in latacting dairy cows fed diets incorporating corn or barley (DePeters and Taylor, 1984), fat supplements (Grummer, 1988) and soyabean hulls (Bernard and McNeill, 1991).

5.3.2 Crude protein

The crude protein digestibility of the three rations were 64.97, 73.87 and 77.89 per cent respectively (Table 6). The values were significantly compared to that of the control. Venkatayen *et al.* (1981) obtained better crude protein utilisation in the diets incorporating maize. Mohan and Ranjhan (1982) observed better nitrogen retention on a high energy ration. Singh and Kumar (1998) also recorded high crude protein digestibility when the energy content was increased. In contrary to the above, Verma and Mudgal (1971) recorded a low crude protein digestibility when the energy content was increased, while Girdhar and Singh (2000) could not establish any significant effect of energy content of the ration on protein digestibility. Lippke (1980) correlated crude protein digestibility to the dry matter intake.

Padgett *et al.* (1978) obtained crude protein digestibility of 69.4 per cent in steers fed diets containing whole cattle blood at varying levels. Crude protein digestibilities similar to the present study were also reported by Sangwan *et al.* (1987) in cattle and Sagathevan(1995) in crossbred calves of 6 to 9 months of age.

Lower crude protein digestibilities than those obtained in the present study were reported by DePeters and Taylor (1984), Grummer (1988) in lactating cows, Singh and Kumar (1998) in female calves and Girdhar and Singh (2000) in heifers fed different diets. Very low values (27 to 35%) were reported by Pachauri and Negi (1980) in bullocks and non producing cows maintained on different dietary treatments.

5.3.3 Ether extract

The digestibility coefficients obtained for ether extract were 71.63, 71.79 and 75.04 which were similar in the three rations. An increase in the ether extract digestibility with increased energy content in the ration was reported by Girdhar and Singh (2000). They obtained values of 75.98, 65.05 and 51.49 per cent, respectively, for diets fed as per 120 per cent NRC, NRC and military farm ration which was lower in energy. Significant reduction in the ether extract digestibility with reduction in energy was also obtained by Singh and Kumar (1998). However, Verma and Mudgal (1971) reported a reduced digestibility of ether extract with an increase in the energy content over Morrison standards, but lowering the energy content had no effect.

Concordant values with those of the present study for ether extract digestibility were obtained by Padgett *et al.* (1978) in steers, Sangwan *et al.* (1987) in cattle and Sagathevan (1995) in six to nine month old crossbred calves.

5.3.4 Neutral detergent fibre

The digestibility coefficients of neutral detergent fibre (NDF) were similar for the three rations, the values being 54.3, 61.04 and 60.6, respectively. Lippke (1980) observed similar NDF digestibility ranging from 53 to 66 per cent for rations containing different varieties of hay. Similar values were also reported by Bernard and McNeill (1991) in cows fed soybean hulls and Sagathevan (1995) in crossbred calves fed diets with or without dried spleen as a biostimulator. The NDF digestibility values obtained by DePeters and Taylor (1984) for corn supplemented diets were higher when compared to barley supplemented ones which was attributed to the higher cell wall content of barley. Lower NDF digestibility was observed by Grummer (1988) in lactating dairy cows fed prilled fat supplement and Girdhar and Singh (2000) in crossbred heifers fed at NRC, 120 per cent NRC and military farm ration.

5.3.5 Acid detergent fibre

The acid detergent fibre (ADF) digestibilities obtained in the present investigation were 42.35, 46.47 and 47.17 per cent, respectively, for the three rations. Though a numerical increase was obtained for the rations T2 and T3 supplemented with maize at 0.5 and 1 kg level, the difference was not significant. DePeters and Taylor (1984) obtained similar ADF digestibilities of 44.3 and 34.5 for diets containing corn or barley as the cereal part. The small particle size of barely was attributed as the cause of reduced fibre digestibility for barley based diets. Higher values than those observed in the present study were obtained by Bernard and McNeill (1991) for diets supplemented with soyabean hulls as energy supplement. They obtained ADF digestibility of 53.3, 61.8, 45.4 and 52.0 per cent, for the different dietary treatments. Sagathevan (1995) also recorded higher values for diets incorporating dried spleen at 0 and 0.1 per cent levels. The digestibility coefficients of ADF reported by Girdhar and Singh (2000) were 57.4, 56.1 and 60.6 respectively, for diets fed at NRC and 120 per cent NRC levels and for military farm ration in crossbred heifers. These values remained unaffected by varying levels of energy in the ration.

5.4 Rumen fermentation characteristics

Rumen fermentation characteristics as measured from the strained rumen liquor, collected using a stomach tube, did not show any significant difference between the three treatment groups (Table 7). The rumen pH tended to be slightly higher for the samples collected towards the end of the experiment. The ammonia nitrogen concentration, the total volatile fatty acid (TVFA) concentration and the pH remained within the normal range. The dietary treatments failed to exert any significant effect on the fermentation characteristics.

The total volatile fatty acid concentration in the rumen liquor collected towards the end of the experiment from the animals maintained on the three dietary treatments T1, T2 and T3 were 58.55, 53.49 and 59.44 meq/l, respectively. Though Chaturvedi *et al.* (1974) established a positive correlation between the available metabolisable energy intake and the rate of production of volatile fatty acids in growing cattle and buffaloes, the TVFA production in the present study remained unaffected by the extra energy supplemented. The TVFA concentration observed in the present study is in agreement with the values obtained by Kannan *et al.* (1975) in two year old steers fed long, chopped or alkali treated straw as roughage and Reddy and Das (1984) in cattle and buffaloes fed different varieties of rice straw.

Higher ruminal TVFA concentration was obtained by Sridhar *et al.* (1999) in Deccani sheep, fed high and medium energy rations compared to one with a low energy. They attributed the increase in the ruminal volatile fatty acid concentration to the increased carbohydrate content of the high energy diet. The ruminal pH remained inversely related to the TVFA concentration. In contradiction, Oka *et al.* (1999) could not establish any statistically significant difference in the rumen TVFA concentration or pH between the different dietary treatments varying in energy levels.

Higher values for TVFA concentration viz., 134, 113, 121 and 144 mmol/l were recorded by Leng and Leonard (1965) in sheep, infused with acetate, butyrate, sodium bicarbonate and the control without any infusion. They found that the TVFA concentration increased after feeding while the proportion of the individual acids remained constant. Venkatayan *et al.* (1981) obtained TVFA concentration of 94 and 90 mmol/l in steers fed diets with and without maize. DePeters and Taylor (1984) reported concentration of TVFA ranging from 101 to 130.1 mmol/l in lactating Holstein cows fed diets containing corn or barley as energy supplement. But they could not establish any effect of the dietary treatments on the TVFA concentration. Sampath (1985) and Robinson and Burgess (1990) also reported slightly higher TVFA concentration in lactating cows fed diets varying in rumen degradable protein levels and diets containing corn, oats or tallow, respectively.

Kalbande (1995) established a positive relationship between the production of volatile fatty acids and protein degradability in dairy cows. He also reported higher TVFA concentration than those obtained in the present study. However, TVFA concentration reported by Rhodes *et al.* (1978) in heifers fed protected lipid as energy supplement was lower than the values recorded in the present study.

The ammonia nitrogen concentration in the rumen liquor collected at the end of the experiment from the animals maintained on the three dietary treatments T1, T2 and T3 were 201.65, 229.15 and 195.6 μg/ml, respectively.

Kalbande (1995) observed a decrease in ammonia nitrogen content of the rumen liquor with an increase in the protein degradability of the diet in mid lactation cows. The ammonia nitrogen content measured by Sagathevan (1995) varied from 76.32 to 88.74 meq/l when spleen was included at 0 and 0.1 per cent levels in the diet of 6 to 9 month old heifer calves. Rumen ammonia nitrogen content of 56.7 and 46.55 mg/100 ml were obtained in lambs fed unprocessed and processed tapioca in studies carried out by Rao *et al.* (1985). These values were higher than those of the present study. Comparable values were reported by Robinson and Burgess (1990) in dairy cows supplemented with corn, barley or tallow as energy supplement.

Rams fed groundnut cake or gingelly oil cake had rumen ammonia content of 119 mg/l and 180.8 mg/l at the 4[th] and 6[th] hour post feeding, respectively (Nayeem *et al.,* 1973). These values were less than that obtained in the present investigation. Venkatayan *et al.* (1981) also reported lower values of 123.5 and 136 mg/l for rumen ammonia nitrogen content in steers fed rations with or without maize.

5.5 Haematological parameters

The plasma calcium level of the animals of the three groups remained similar in all the treatments throughout the course of the experiment (Table 7). The values obtained in the present study are concordant with the values obtained by Lal *et al.* (1994) in lactating buffaloes. The serum calcium concentration of 8.4 to 11.97 mg/dl for buffalo bulls reported by Sirohi and Rai (1997) also agrees with the values obtained in the present study. Results of assessment of the serum calcium concentration of cows of Rewari district of Haryana (Yadav *et al.*, 1998) and lactating dairy cows of Kerala (Varghese, 1998) coincide well with the values of the present study.

The plasma concentration of phosphorus in the experimental animals varied from 5.71 to 8.48 mg/dl. The dietary treatments had no effect on the plasma phosphorus concentration throughout the study. The serum phosphorus levels of 8.45 mg/dl in lactating buffaloes (Lal *et al.*, 1994), 3.66 to 4.92 in cows and buffaloes of Rewari district of Haryana (Yadav *et al.*, 1998) and 4.12 to 5.88 mg/dl in lactating dairy cows of Kerala (Varghese,

1998) are in accordance with the present study. Thus it can be concluded that supplementation of an energy source to crossbred heifers has no significant effect on the plasma concentration of calcium and phosphorus.

5.6 Reproductive performance

Perusal of the data on the reproductive performance of animals maintained on the three experimental rations (Table 9) reveal a better performance of the heifers maintained on diets containing 1 kg ground maize over and above the control ration. The heifers maintained on the third dietary treatment were 45 days younger at conception than the animals on the control ration. The animals of the third group required only 1.2 services per conception while those on the other two dietary treatments required two services per conception. The relationship of dietary energy intake with reproductive performance was reviewed by Dunn and Moss (1992) and they suggested that the negative energy balance due to a restricted intake can lead to weight loss which can result in cessation of oestrus cycle and development of quiescent ovaries. Houghton *et al.* (1990) also attributed the better conception rates in postpartum cows to the body condition.

Conception rates of 67.2 and 52.8 per cent respectively were obtained by Wishart *et al.* (1977) in heifers fed diets supplemented with cereals and a control diet. The animals supplemented with 1 kg of ground maize showed higher conception rate than those of control in the present study, which could be attributed to the better utilisation of nutrients and the improved body condition. However, a low conception rate of 30 per cent was observed by Rhodes *et al.* (1978) in prepubertal yearling heifers fed on diets containing protein protected lipid.

Day *et al.* (1986) reported the average age at puberty as 423 ± 13 days in heifers fed a standard diet while puberty was delayed beyond 474 days in those fed energy restricted diets. The delay was attributed to the reduction in leutinizing hormone (LH) concentration when dietary energy was limited. However, Harrison and Randel (1986) could not establish any change in the LH concentration in animals fed energy restricted diets but the size of the corpus luteum as well as the body metabolism were affected. Beal *et al.* (1978) suggested an increased LH response to GnRH release directly at the pituitary in spayed cows fed an energy restricted diet and the serum progesterone level of intact heifers tended to decrease with a decrease in the dietary energy intake. The crossbred female calves fed at NRC level reached puberty at 551.6 days while those fed an energy deficient diet attained puberty at 644.7 days of age (Singh and Kumar, 1998). Nolan *et al.* (1990) also established a significant influence of dietary energy on the reproductive performance of Brahman bull calves. These findings are in agreement with the results of the present study since the animals fed 1 kg of ground maize were 45 days younger at conception than those of the control.

Gardner *et al.* (1977) accelerated the growth rates of Holstein heifers to 1.1 kg/day. Though the accelerated group reached puberty earlier and conceived at 319 kg body weight at the age of 9.6 months, more number of services were required for the accelerated group. These observations partly agree with that of the present study where the animals of the third dietary treatment conceived earlier but the services required per conception were less.

5.7 Economics

Economics of the dietary treatments assessed as cost per kilogram gain in body weight remained almost similar for the three diets. Though the cost per unit gain was slightly higher for the diets supplemented with maize, the increase was not significant.

Thus a critical assessment of the overall results obtained during the course of the present study did not reveal any significant effect of energy supplementation on the growth, feed efficiency, rumen fermentation characteristics and the plasma levels of calcium and phosphorus. However, energy supplementation improved the dry matter and crude protein digestibilities. The reproductive performance of the animals was also better in the high energy supplemented group.

Summary

6. SUMMARY

An investigation was carried out to assess the effect of energy supplementation on growth of crossbred heifers. Eighteen crossbred heifers of average age of 15 months distributed into three groups as uniformly as possible with regard to age and body weight were randomly allotted to three dietary treatments. The three dietary treatments were:

T1 - control diet consisting of concentrate and paddy straw fed to meet the requirements as per ICAR standards

T2 - control diet + 0.5 kg ground maize

T3 - control diet + 1 kg ground maize

The experiment was carried out for a period of 155 days under similar managemental conditions. Individual records of daily intake of concentrate, maize and straw and fortnightly data on body weights were maintained throughout the experiment. Rumen liquor collected from the animals at the beginning and towards the end of the experiment was analysed for pH, total volatile fatty acid concentration and ammonia nitrogen content. The plasma calcium and phosphorus levels were assessed at the beginning, middle and at the end of the experimental period. Towards the end of the experiment a digestion trial was also carried out using all the experimental animals to arrive at the digestibility coefficients of nutrients. The animals were carefully observed for the signs of behavioural oestrus and those which showed the

signs were inseminated regularly. The conception rates, the average age at conception and the number of inseminations required for conception were noted.

The animals maintained on diets T1, T2 and T3 showed average daily weight gains of 535, 602 and 631 g, respectively, during the experimental period. There was no significant difference between the animals of the three treatments.

The average daily dry matter intakes were 6.57, 7.03 and 7.54 kg, respectively, for animals in the three groups. Animals maintained on T3 showed a significantly higher ($P<0.05$) dry matter consumption. However, the dry matter consumed per 100 kg body weight remained similar and were 2.69, 2.89 and 2.84 kg, respectively, by the heifers fed the rations T1, T2 and T3.

The cumulative feed to gain ratios observed were 12.49, 12.09 and 12.34, respectively, for animals of T1, T2 and T3 groups which remained unaffected by the dietary treatments.

The protein efficiency ratios remained similar in the three treatment groups, T1, T2 and T3, the values being 1.39, 1.34 and 1.35, respectively.

The energy supplementation had no influence on any of the rumen fermentation characteristics studied such as pH, total volatile fatty acid concentration and ammonia nitrogen concentration of the rumen liquor.

The plasma calcium and phosphorus levels remained unaltered between the treatment groups. The concentration of plasma calcium varied from 8.25 to 11.5 mg/dl while the plasma phosphorus levels were between 5.71 and 8.48 mg/dl for the different treatment groups.

The digestibility coefficients of dry matter was higher ($P<0.05$) in rations T2 and T3 compared to T1. The crude protein digestibility values were significantly higher ($P<0.01$) for T2 and T3 diets as against the control diet (T1). However, no significant difference was obtained between the different groups fed the various rations with regard to the digestibility coefficients of ether extract, neutral detergent fibre and acid detergent fibre.

The reproductive performance was better as assessed by conception rate, the average age at conception and number of services required per conception for animals maintained on the dietary treatment T3.

The cost of feed per kilogram gain were Rs.72.67, 72.15 and 74.49, respectively, for T1, T2 and T3, the difference between the various groups being non significant in this regard.

From an overall evaluation of the results obtained during the course of the present study it can be inferred that supplementation of energy to a standard diet of crossbred heifers did not influence their weight gain, feed efficiency, protein efficiency, rumen fermentation and plasma calcium and phosphorus levels, though a higher dry matter intake along with an increased digestibility for dry matter and crude protein could be established. The reproductive performance of the animals also improved with supplementation of energy.

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EFFECT OF ENERGY SUPPLEMENTATION ON GROWTH OF CROSSBRED HEIFERS

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ABSTRACT OF A THESIS

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ABSTRACT

An investigation was carried out to assess the effect of energy supplementation on growth of crossbred heifers. Eighteen crossbred heifers with an average age of 15 months and were distributed into three groups as uniformly as possible with regard to age and body weight. The dietary treatments T1, T2, and T3 were randomly allotted to each group. The three dietary treatments were T1 – control diet (concentrate mixture + straw) as per ICAR recommendations, T2 – control diet supplemented with 0.5 kg ground maize and T3 – control diet supplemented with 1 kg ground maize.

The animals maintained on the three dietary treatments T1, T2 and T3 showed an average daily body weight gain of 535.47, 602.15 and 631.18 g respectively during the experimental period of 155 days. Statistical analysis of the body weight gain showed no significant difference between the three dietary treatment groups.

The average daily dry matter intake was significantly higher ($P<0.05$) in the animals maintained on T3 ration compared to T1 and T2. However the dry matter intake as percentage of body weight remained similar in the heifers fed the three experimental diets. The energy supplementation did not seem to have any effect on the feed to gain and protein efficiency ratios of the crossbred heifers.

Energy supplementation to the crossbred heifers had no effect on any of the rumen fermentation characteristics as pH, total volatile fatty acid concentration and ammonia nitrogen concentration of the rumen liquor.

The plasma levels of calcium and phosphorus also remained similar for the animals maintained on the three dietary treatments. A significant increase in the digestibilities of dry matter ($P<0.05$) and crude protein ($P<0.01$) were observed in the animals supplemented with maize at 0.5 (T2) and 1 kg (T3) levels as an energy source compared to the control (T1). However the digestibilities of ether extract, neutral detergent fibre and acid detergent fibre remained unaffected by the extra energy supplementation.

An improved reproductive performance was exhibited by the animals maintained on T3 ration.

The cost of feed for producing unit gain was almost similar for the three dietary treatments.

Thus a critical assessment of the overall results obtained during the course of the present study did not reveal any significant effect of energy supplementation on the growth, feed efficiency, rumen fermentation characteristics and the plasma levels of calcium and phosphorus. However, energy supplementation improved the dry matter and crude protein digestibilities. The reproductive performance of the animals was also better in the high energy supplemented group.