EFFECT OF REPLACING DRIED FISH WITH LYSINE AND METHIONINE IN THE CALF STARTER ON THE GROWTH PERFORMANCE OF CROSSBRED CALVES

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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 REPLACING DRIED FISH WITH LYSINE AND METHIONINE IN THE CALF STARTER ON THE GROWTH PERFORMANCE OF CROSS BRED CALVES" 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.

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Certified that the thesis entitled **"EFFECT OF REPLACING DRIED FISH WITH LYSINE AND METHIONINE IN THE CALF STARTER ON THE GROWTH PERFORMANCE OF CROSS BRED CALVES"** is a record of research work done independently by **JITH JOHN MATHEW,** 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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Introduction

1. INTRODUCTION

India is predominantly an agricultural country with about 70 per cent of population dependant on income from agriculture. Animal husbandry is an adjunct to crop agriculture. Dairy cattle population forms an integral part of Indian animal wealth. Dairy calf losses are of most concern to dairyman. The success of any cattle-breeding programme depends upon the rate of survival of calf crop produced.

The calf nutrition is one aspect in which much development has occurred and there is a drive to find economical, healthy and hygienic alternative to milk for calves. Dairy industry in India cannot afford to feed calves solely on milk till they start ruminating as this could reduce the financial returns to the farmer from selling milk. Intake of colostrum by neonatal calves and early transitions to calf starter are two important factors in a successful calf-rearing programme (Franklin *et al.*, 2003).

Increased interest in rearing calves on proteins less expensive than milk protein, has resulted in formulation of calf starters with animal and plant protein sources. Calves fed with such calf starters begin to ruminate early in life (Luchini *et al.*, 1993). Manipulations in protein nutrition done in adult cattle by feeding non protein nitrogenous sources have not been successful in pre-ruminant calves. Pre-ruminant calf should be considered essentially as a monogastric animal and should be fed with diets containing protein of high biological value for growth.

Fish protein is an important animal protein source incorporated in calf starter. In India fish protein is available as unsalted dried fish which has a lower crude protein (34 to 62 per cent) compared to the international standard set, for crude protein content in fish meal (65 per cent) and the inferiority in quality arises by processing at sea shore where contamination by sand particles cannot be avoided. Hot and humid climate in tropical and sub tropical regions can result in putrefaction of fish before processing, during transport and in storage. The high ratio of less digestible stroma protein such as scales, viscera, cartilage, and bone and non protein nitrogenous substances such as peptides, free amino acids, amines, betaines, and trimethylamine oxide to desirable myofibrillar and sarcoplasmic proteins makes the Indian fish protein markedly inferior (Zombade *et al.,* 1980). Unsalted dry fish is prone to autolytic, lipolytic and microbial spoilage (Hussein and Jordan, 1991) and may lodge harmful pathogens dangerous for the newborn calf. The calf mortality decreases with age and more than half of all calf deaths occur with in first month of birth and digestive disorders accounted for the largest proportion of such deaths (Khera, 1981; Jain and Sharma, 1982). In such a scenario, replacement of fish protein with alternative sources of protein in the diet of pre-ruminant calves achieve considerable practical importance.

Substitution with a plant protein source for fishmeal is limited by the deficiencies of indispensable amino acids (Mambrini *et al.,* 1999). Plant protein sources are commonly deficient in lysine and sulfur containing amino acids such as methionine and cystine. Lysine is often found limiting in diets high in corn protein. Soyabean meal is deficient in methionine. Methionine is the first limiting and lysine the second limiting amino acid in a corn and soyabean meal based diet for calves weaned at less than three months of age (Abe *et al.,* 1998). This study was under taken to assess the effect of replacing unsalted dry fish in the calf starter by a cent per cent vegetable protein source equated with regard to energy, protein and amino acids lysine and methionine plus cystine, on growth performance of crossbred calves.

Review of Literature

2. REVIEW OF LITERATURE

Pre-ruminant calves are unique in their anatomical and physiological functions and differ from their mature counterpart in not possessing a developed and functional rumen. The nutrition of pre-ruminant calf could therefore be considered similar to a simple stomached animal.

2.1 DIETARY FACTORS INFLUENCING RUMEN DEVELOPMENT

A solid diet is known to induce rumen development. Preston *et al.* (1957) opined that calf acquires ability to ruminate and digest roughage gradually and adult type rumen function is attained when calf is six months of age. Weaning the new born calf on solid food resulted in faster development of reticulo-rumen and reduced rumen ammonia production from casein hydrolysis in calves fed solely on milk (Godfrey, 1961). Singh *et al.* (1973) demonstrated faster structural development of rumen in calves weaned on dry food from six weeks of age than those fed on milk till 15 weeks of age. Bacteria start to appear in stomach of pre-ruminant calves at second week and protozoa at first month respectively and their population and digestion capacity increases upto six months of age (Singh *et al.,* 1983). In contrast to above line of thinking Orskov and Ryle (1990) opined that rumen development occurred from the stimulation by volatile fatty acids formed from fermentation of ingested carbohydrates. More the consumption of rapidly fermentable carbohydrates more is the development of rumen. However Luchini *et al.* (1993) opined that consumption of dry feed from first week of age is important to promote rumen development and to maintain acceptable growth rates in calves weaned at an early age. Intake of colostrum by neonatal calves and early transitions to calf starter are two important factors in successful calf rearing programme. A calf consuming both calf starter and water at an early age develops rumen faster than those fed only on milk. (Franklin *et al.,* 2003).

2.2 PROTEIN FOR GROWTH IN PRE-RUMINANT CALVES

Pre-ruminant calves require diets with high crude protein (CP) and total digestible nutrients (TDN) to meet their very demanding growth requirements. Stobo *et al.* (1967a) opined that *ad libitum* intake of concentrates having a high crude protein content (19.2 per cent) was essential for faster weight gains by calves from birth to 12 weeks of age. Bureau of Indian Standards (BIS, 1983) for calf starter meal specify a crude protein requirement of 23-26 per cent for optimum growth of calves. Calves responded to increased protein intake by increasing their protein and fat deposition and extra protein free energy intake resulted mainly in extra fat deposition but it also increased protein deposition at low protein intake levels (Gerrits *et al.*, 1996). Ludden and Kerley (1998) opined that while formulating a diet for growing steers, partitioning of protein and energy between requirements for maintenance and for deposition of protein and fat is of major importance and amino acid makeup of the protein fed is very important in this regard. Singh *et al.* (2000) found that crude protein levels affected the per cent nitrogen retention significantly and faster growth was obtained when cross bred calves were fed diets having 25 per cent more crude protein than ICAR standards (505g/day) compared to those fed diets having crude protein as per ICAR standards (450g/day).

2.2.1 Vegetable Protein Sources

Proteins of vegetable origin possess a poorly balanced amino acid constitution, and they are deficient in one or more essential amino acids. Khorasani *et al.* (1990) reported that soyabean meal protein has a high nutritional value for young growing calves but is deficient in methionine. Lysine was often limiting in diets high in corn protein (Ladely *et al.*, 1995; Piepenbrink and Schingoethe, 1998). Abe *et al.* (1998) found that methionine was the first limiting and lysine the second limiting amino acid for growth in calves, aged eleven weeks fed with corn and soyabean based diet. In calves above three months of age, Abe *et al.* (1999) observed that neither lysine nor methionine to be limiting amino acid in a corn and soybean meal diet for an average daily gain between 0.4 to 1.3 kg.

Preston *et al.* (1964) observed that when groundnut meal was equated in lysine and methionine with fish meal, the lower nitrogen retention and body weight gain in calves of seventy days age was suggested to occur from deamination of highly soluble supplementary amino acids in developing rumen. Griffin *et al.* (1993) opined that direct measurement of animal growth would be the most biologically relevant method for determining the effects of protein quality and it would also reflect the increased flow of feed amino acids to the intestine and the amount of amino acid absorbed and utilized by the animal body.

Rao *et al.* (1966) and Mukherjee *et al.* (1966) opined that the efficiency of all vegetable protein diets is primarily dependent upon an adequacy of both lysine and methionine. The apparent digestibility of total nitrogen and ileal digestibility of most amino acids were significantly lower with pea and soyabean based diets than with milk based control diets (Nunesdoprado *et al.*, 1989). Lalles *et al.* (1996) analyzed the antinutritional factors in soyabean products and documented the presence of aggregated protein, antitryptic activity and immuno reactive proteins like glycinin, alpha-conglycinin, and beta-conglycinin. Replacement of fishmeal with plant protein source is limited due to deficiencies of indispensable amino acids, the poor digestibility of carbohydrates and the presence of antinutritional factors (Mambrini *et al.*, 1999).

2.2.2 Animal Protein Sources

Animal protein sources are often used to make good the deficiencies of amino acids when simple stomached animals are fed with all vegetable diets. Orskov and Ryle (1990) opined that fish protein hydrolysate with a digestibility of 92 per cent is the most successful substitute for casein (casein digestibility is 95 per cent). Mabjeesh *et al.* (1996) opined that animal protein sources are superior to plant protein sources for amino acid absorption.

Solubility of fish meal is the most reliable guide of nutritive value in ruminants (Whitelaw *et al.*, 1964). Kay *et al.* (1966) observed better live weight gain in calves fed fish meal compared to those fed soyabean meal, groundnut meal, or distillers grains and the better growth was attributed to the better protein quality of fish meal. Zombade *et al.* (1980) observed that dried fish of Indian origin has a lower crude protein (34-62per cent) than the international standard for fish meal crude protein (65per cent) and such an inferiority, in quality, is multi-factorial in origin. Processing at sea shore makes contamination by sand particles inevitable. Hot and humid climate in tropical and sub tropical regions result in putrefaction of fish before processing, in transport and in storage. All this along with the higher ratio of low digested stroma protein (scales, viscera, cartilage, and bone) and non protein nitrogenous substances (peptides, free amino acids, amines, betaines, and trimethylamine oxide) to desirable myofibrillar and sarcoplasmic proteins makes the Indian dried fish inferior to the international heat rendered product.

Zerbini *et al.* (1988) observed an increase in the proportion of lysine and methionine in the total amino acids flowing to the duodenum, when fishmeal supplied more than four per cent of dry matter compared to soybean meal. Hussein and Jordan (1991) opined that though fish meal is rich in essential amino acids especially lysine and sulfur containing amino acids methionine and cystine, the quality obtained is often inferior which might be due to its production from fish of quality unacceptable for human consumption and waste materials from filleting, canning, and fish processing industries making them prone to autolytic, lipolytic and microbial spoilage. When fish meal was substituted for soyabean meal on an isonitrogenous basis as 0, 25, 50, and 100 per cent of the supplemental protein in the concentrate mixture for growing calves, dry matter intake did not differ significantly among the treatments. (Abu-Ghazaleh *et al.*, 2001)

Bender *et al.* (1997) opined that dairy producers have to consider contamination of animal byproducts to prevent and control infections by

Salmonella. Quigley (2002) opined that biological availability and safety of animal byproducts used in feed needs increased scrutiny. Animal byproducts must be collected, handled, processed, stored and fed in a way that minimizes the risk of transmission of pathogens, unwanted biologically active peptides, and antinutritional factors.

2.3 NON PROTEIN NITROGEN (NPN) SOURCES FOR GROWTH

2.3.1 Urea

Pre-ruminant calves cannot utilize nonprotein nitrogenous sources. Kay *et al.* (1967) observed a reduction in growth rate, feed conversion efficiency, dry matter digestibility and dry matter intake from 2.02 to 1.80 kg/day when fish meal nitrogen was partially replaced by urea or ammonium acetate or totally replaced by urea in calves weaned at 28 days of age. It was observed that new born calves receiving urea supplemented diets had an average daily gain of 0.48 kg/day, which was lower than those fed soyabean meal supplemented diets, with an average daily gain of 0.55 kg/day (Miron *et al.,* 1967). Stobo *et al.* (1967b) also reported better weight gain and apparent digestibilities of nutrients in calves fed 20 per cent CP diets than those fed 18 per cent CP diets with 33 per cent in form of urea. In contrast to this finding Sharma *et al.* (1983) reported that urea had no adverse effect on weight gain after third month when ten per cent of equivalent protein in groundnut cake was replaced with urea. However, daily weight gain and dry matter intake was reported to decrease in calves fed maize meal diet containing urea from 7 to 98 days of age (Gonzalez and Elias, 1984).

2.3.2 Amino Acid Supplementation

Pre-ruminant calves require all essential amino acids except arginine (Church, 1980). Schwab *et al.* (1992) suggested that the strategies to meet animal requirements for specific amino acids included stimulation of microbial protein synthesis and feeding proteins or amino acids that have been treated to prevent degradation. To reduce the environmental nitrogen pollution a combination of dietary protein sources and synthetic amino acids that will minimize nitrogen content in the excrement might hold good value (Mahan and Shields, 1998).

Methionine and cystine requirements are considered together while calculating the requirements of sulfur containing amino acids of the animal. Williams and Hewitt (1979) suggested that methionine requirement was difficult to be defined in absolute terms as it could be used to satisfy cystine requirements. Summing up of cystine and methionine quantity is required while considering sulfur amino acid requirement and metabolism in pre-ruminant calves (Gerrits *et al.,* 1997a; Gerrits *et al.,* 1997b). Vernon-Young (2001) opined that requirement for methionine and cystine could be met from methionine alone, though it is more usually achieved through a combination of methionine and cystine in diets.

2.4 EFFECT OF REPLACEMENT OF FISH MEAL BY AMINO ACID SUPPLEMENTATION IN PRE-RUMINANT CALVES ON

2.4.1 Dry Matter Intake

Muller and Rodriguez (1975) found that average daily dry matter intake (DMI) reduced from 2.49 to 1.98 kg/day in calves between 4-12 weeks of age, when isonitrogenous diets with 13.5per cent crude protein was supplemented with 0.50per cent methionine hydroxy analog compared to the animals fed control diets with out supplementation. Dry matter intake did not differ among growing calves fed corn silage supplemented with ground soyabean and fish meal or ground soyabean supplemented with rumen-protected lysine (Davenport *et al.,* 1990). Veira *et al.* (1991) also observed that supplementation with rumen-protected lysine and methionine had no influence on DMI of growing cattle fed grass silage. Abe *et al.* (2000) reported that graded increase in methionine as DL-methionine from 6 g/day to 24 g/day, reduced DMI from 1.59 kg/day to 1.21 kg/day in calves of seven weeks age. They further observed that when graded increase in supplemental methionine was made from 8g/day to 32 g/day at a constant level of supplemental lysine (16 g/day) the DMI reduced from 2.56 kg/day to 1.63 kg/day.

Dry matter intake as per cent of body weight in steers remained constant (2.1per cent) among those fed corn gluten meal supplemented with graded increasing amounts of rumen-protected lysine from 0 to 10 g/day (Klemeserud *et al.,* 2000). Abe *et al.* (2001) observed that in calves of five weeks of age, graded increase in lysine as L- lysine HCl from 16 to 64 g/day, resulted in a DMI reduction from concentrate (3.17 to 2.84 kg/day) and rice straw (0.50 to 0.35 kg/day). On the contrary Mandal *et al.* (2002) observed that DMI and total digestible nutrients (TDN) during the feeding trial was significantly higher in buffalo calves of six months of age supplemented with lysine (20g/day/head) and methionine (10 g/day/head) than the nonsupplemented diet. They also observed an improvement in the intake of nitrogen per unit metabolic size. When early weaned cross bred calves were fed cottonseed meal based diets having 24.35 per cent CP no difference in average daily feed intake was observed between groups supplemented with lysine (0.67 per cent of the diet) and methionine (0.07 per cent of the diet) than the non-supplemented groups (Khan *et al.,* 2002).

2.4.2 Nutrient Digestibility

Preston *et al.* (1964) observed in calves of two months of age, that there was no significant difference in apparent nitrogen and dry matter digestibility between the groups fed fish meal based diet (75.2 per cent and 76.6 per cent) and those fed groundnut meal diet supplemented with Lysine and Methionine (74.1 per cent and 78.5 per cent). In contrast to the above finding, Kay *et al.* (1966) observed that in calves fed with isonitrogenous and isocaloric diets formulated with four different nitrogen sources dry matter digestibility were significantly different among those fed diets having soyabean meal (77.3 per cent) and those fed diets having groundnut meal (76.3 per cent), fish meal (75.6 per cent) or distillers dry grains (75.2 per cent).

Williams and Hewitt (1979) observed that when calves were supplemented with different levels of lysine, the group fed with 7.5 g/day of lysine supplementation had maximum apparent digestibility of nitrogen compared to those supplemented with 4.5 g/day and 12 g/day. Wessels and Titgemeyer (1997) observed that digestibility of nitrogen and dry matter in steers fed three levels of crude protein in diets, decreased when such diets were supplemented with rumen protected lysine (2 g/day) and methionine (0.75 g/day). However, Kanjanapruthipong (1998) observed better ileal digestibility for dry matter and nitrogen (82.2, 68.4 per cent, respectively), in calves fed milk replacers supplemented with lysine, methionine, and threonine compared to those fed milk replacers without amino acid supplementation (80.9, 66.7 per cent, respectively). Abe *et al.* (1999) reported that the absorption and retention of nitrogen were similar in calves fed diets supplemented with lysine and methionine and those fed on L-glutamine supplemented diet. Mandal *et al.* (2002) opined that supplementation of lysine and methionine did not affect digestibility of dry matter, crude protein, ether extract and nitrogen free extract, but had a stimulatory effect on fibre digestibility especially the neutral detergent fraction in calves which was attributed to increased bacterial growth in supplemental diet and the subsequent increase in cellulolytic activity. Khan *et al.* (2002) performed a digestibility trial at fifth and ninth week in pre-ruminant calves and observed similar dry matter and crude protein digestibility in those fed lysine and methionine supplemented cotton seed meal based diet and an isonitrogenous non supplemented cotton seed meal based diet.

2.4.3 Growth And Average Daily Gains

There are many reports about the value of fish meal based diets on the growth of pre-ruminant calves. Preston *et al.* (1964) observed that the daily live weight gain was significantly higher in calves fed fish meal based diet (600 g/day), than those fed on groundnut meal based diet supplemented with lysine and methionine (492 g/day). In a similar experiment it was found that in calves fed four different isonitrogenous, isocaloric diets each having a different protein source the daily gains were higher with fish meal based diet (890 g/day) than with soyabean meal (850 g /day), groundnut meal (810 g/day) or distillers dry grains (810 g/day) based diets (Kay *et al.*, 1966). Davenport *et al.* (1990) reported a significantly better average daily gain (1.01 kg) in growing calves fed corn silage supplemented with ground soyabean and fish meal when compared to those fed ground soyabean supplemented with rumen protected lysine (0.87kg). Hussein and Jordan (1991) concluded that a diet supplemented with fish meal was the most effective feed for young lambs and calves during the rapid phase of growth that occur immediately after weaning.

Viera *et al.* (1991) observed that average daily gains increased significantly by 16.3 per cent from 0.92 kg to 1.07 kg in growing cattle receiving supplemental rumen protected lysine and methionine compared to those receiving unsupplemented diets. Kanjanapruthipong (1998) observed that average daily gains were higher in calves fed soya protein based milk replacer with supplemented amino acids lysine, methionine and threonine (308.5 g) compared to those fed on soya protein based milk replacer without supplementation (244.3 g). Klemeserud *et al.* (2000) observed in steers fed corn gluten meal based diets that average daily gains were higher with 0.9 g/day of lysine supplementation (0.56 kg/day) than those on diets without supplementation (0.46 kg/day). In calves of five weeks age, average daily gains were not affected by a graded increase in lysine as L-lysine HCl from 16 to 64 g/day (Abe *et al.*, 2001). However Mandal *et al.* (2002) observed a higher average daily gain (0.523 kg/day) in buffalo calves fed lysine (20 g/day/head) and methionine (10g/day/head) supplemented diet compared to those fed non-supplemented diet (0.370 kg/day). Khan *et al.* (2002) reported a significantly higher average daily gain of 0.64 kg/day in pre-ruminant calves fed 24.35 per cent CP diets supplemented with lysine (0.67 per cent) and methionine (0.07 per cent) compared to the average daily gain of 0.57 kg in the non supplemented group.

Muller and Rodriguez (1975) observed that average daily gain reduced from 0.88 to 0.56 kg/day in 4 to 12 weeks old calves fed 13.5 per cent CP diets when such diets were supplemented with 0.50 per cent methionine hydroxy analog. Williams and Hewitt (1979) reported that in pre-ruminant calves the weekly live weight gains were 2.2 kg, 0.8 kg and 2 kg respectively when they were fed synthetic diets supplemented with 9 g, 4.5 g and 12 g lysine daily. Abe *et al.* (2000) observed that a graded increase in methionine as DL-methionine from 6 to 24 g/day reduced average daily gains from 400 to –129 g/day in calves seven weeks of age. They also observed that in calves of twelve weeks age, a graded increase in supplemental methionine from 8 g/day to 32 g/day at a constant level of supplemental lysine (16 g/day) reduced the average daily gains from 536 to - 429 g/day.

2.4.4 Feed Efficiency

Kay *et al.* (1967) found that when fish meal nitrogen in control diet was fully replaced by urea, feed efficiency reduced from 2.89 kg feed/kg gain to 3.98 kg feed/kg gain. In growing calves fed corn silage, supplementation with ground soyabean and fish meal resulted in a feed efficiency significantly higher than those fed ground soyabean and rumen protected lysine (Davenport *et al.*, 1990).

Muller and Rodriguez (1975) observed that feed efficiency reduced from 2.85 kg to 3.54 kg of DM/kg gain with a 0.5 per cent supplementation of methionine hydroxy analog in calves 4 to 12 weeks of age fed with 13.5 per cent CP diets. In growing cattle, feed efficiency significantly improved when rumen protected lysine and methionine were supplemented to silage compared to non-supplemented control (Veira *et al.*, 1991). Abe *et al.* (2000) reported a reduction in feed efficiency in calves when the level of supplemented methionine increased from 6 to 24 g/day. They also reported that a graded increase in supplemental methionine from 8 to 32 g/day at a constant level of supplemental lysine (16g/day) reduced feed efficiency. Abe *et al.* (2001) observed that there was no significant difference in gain/feed intake, when level of supplemental lysine increased from 16 to 64 g/day in calves of five weeks age. Calves on lysine and methionine supplemented diet required less amount of crude protein per unit gain than the group on diet without supplementation, but both the groups utilized dry matter and energy with a similar efficiency (Mandal *et al.*, 2002). However, Khan *et al.* (2002) observed a better feed efficiency in weaned calves fed lysine and methionine supplemented cottonseed meal based calf starter (2.65kg feed/kg gain) than those fed non supplemented cottonseed meal based calf starter (2.98 kg feed/kg gain).

2.5 HAEMATOLOGICAL PARAMETERS

Wharton (1966) observed that average haemoglobin content in zebu cross bred calves was 12.4 gram per cent and opined further that there was no influence of growth rate on haemoglobin levels. Kay *et al.* (1976) studied the various blood parameters of calves at 11 th ,12 th and 13 th week after birth, weaned on a 18 per cent CP diet and reported mean values to range between 11.7 to 12.1 g/100ml for haemoglobin, 72.8 to 73.1 mg/100ml for glucose, 11.5 to 13.3 mg/100ml for blood urea nitrogen (BUN), 10.04 to 10.09 mg/100ml for inorganic phosphate and a constant value of 10.3 mg/100ml for calcium. Rowlands (1980) observed a direct correlation between blood glucose levels and growth rate in calves aged between 6 to 13 weeks of age and opined that the calves that maintain high blood glucose concentration grow faster. In calves aged between 9 to 19 weeks, values for plasma inorganic phosphorus ranged between 6.08 to 9.05mg/100ml and plasma calcium ranged between 10.37 to 10.71 mg/100ml. (Jackson *et al.*, 1988). Weil *et al.* (1988) reported plasma calcium to range between 4.9 to 5.5 meq/litre in calves aged between 3 to 10 weeks. In calves between 2 to 16 weeks of age mean value of total protein ranged between 5.6 to 6.4 g/dl and heamoglobin ranged between 6.4 to 10.2 g/dl (Wilson *et al.*, 1994). Terosky *et al.* (1997) evaluated and reported values of blood parameters in calves reared from 36 hours of birth to 8 weeks of age, to range between 10.7 to 12.5 mg/dl for haemoglobin, 4.7 to 4.9 g/dl for total protein, 7 to 8 mg/dl for BUN and 106.8 to 112.9 mg/dl for glucose. Blood parameters in calves fed milk replacer and *ad libitum* calf starter from birth to 6th week of age, ranged between 33.6 to 36.5 per cent for haematocrit, 96 to 104mg/dl for plasma glucose, 4.99 to 5.29 g/dl for serum total protein, and 8.52 to 9.96 mg/dl for serum urea nitrogen (Lammers *et al.*, 1998). In day old calves Davenport *et al.* (2000) observed that haematocrit ranged between 27.3 to 28.9 per cent, serum total protein between 4.11 to 4.88 g/dl and BUN between 4.59 to 7.97 mM/l.

Kay *et al.* (1967) observed that when fish meal in diets of pre-ruminant calves was fully replaced with urea the blood urea increased from 20 mg/100ml to 32 mg/100ml. Williams and Smith (1975) observed that when a synthetic diet simulating milk but deficient in methionine was fed instead of cows milk, plasma urea concentration increased from 3784 ± 500 to 5747 ±214 micro mol/litre, and supplementation of such deficient diets with methionine led to a fall in plasma urea concentration in pre-ruminant calves. Williams and Hewitt (1979) opined that amino acid balance could be improved by supplementation of the limiting amino acid, which increases protein synthesis and reduction in catabolism of the non-limiting amino acids, both together resulting in a decrease in amount of urea in plasma, the primary end product of amino acid catabolism and further reported that in pre-ruminant calves fed synthetic diets increasing levels of dietary lysine from 4.5g/day to 12 g/day decreased plasma urea concentration from 6850 micromol/litre to 2410 micro mol/litre. But Abe *et al.* (2001) observed that plasma urea nitrogen (mg/dl) was not affected by a graded increase in supplemented lysine from 16g/day (20.6 mg/dl) to 64 g/day (20.7 mg/dl). However blood urea concentration in crossbred calves from birth to third week of age, and at five and ten months of age was higher compared to blood urea concentration at 28th day of birth which was opined to be due to the lower availability of nitrogen to the liver as a result of multiplication and propagation of microflora in developing rumen and initiation of synthesis of microbial protein (Kumar *et al.*, 2002).

Materials and Methods

3. MATERIALS AND METHODS

The feeding experiment was conducted in the University Livestock Farm and Fodder Research and Development Scheme (ULF&FRDS), College of Veterinary and Animal Sciences, Mannuthy, using pre-ruminant calves. The research project was undertaken following the stipulations laid down under prevention of cruelty to animals act.

3.1 EXPERIMENTAL ANIMALS

Fourteen crossbred calves below one month of age, belonging to ULF & FRDS were selected for the experiment after colostrum feeding and they were grouped into two as uniformly as possible with regard to the breed, age, sex, and body weight. The animals of each group were housed in individual pens, fed individually and were maintained under identical feeding and managemental conditions. Animals were dewormed at the beginning of feeding trial followed by once in every month during the duration of the study.

3.2 EXPERIMENTAL DIETS

The experimental diets consisted of two isonitrogenous and isocaloric concentrate mixtures, the control and treatment formulated as per Bureau of Indian Standards (BIS, 1983). The ingredient composition of both the concentrate mixtures are given in Table1. Both the concentrate mixtures had 23 per cent crude protein (CP) and 72 per cent total digestible nutrients (TDN). The control diet had unsalted dry fish as the source of animal protein while the treatment diet did not contain any animal protein source. The lysine and methionine plus cystine content of the treatment diet were equated with that of control diet by supplementing it with synthetic lysine and methionine. The calculated CP, TDN, lysine and methionine plus cystine content of the two diets are given in Table 2.

Calves of the two groups were randomly allotted to the two dietary treatments, control and treatment.

3.3 FEEDING TRIAL

During the first month, the calves of both groups were fed milk at the rate of $1/10^{th}$ of their body weight, the total quantity fed in two equal parts, once in the morning and afternoon. There after the quantity of milk fed daily was changed to $1/12^{th}$ and $1/15^{th}$ of body weight in the second and third month respectively. For the initial two weeks, the calf starter was fed mixed with milk, thereafter it was fed separately once daily during the first month. Milk feeding was stopped once the calves were above three months of age. Feeding frequency of the calf starter was increased to twice daily, from second month onwards. The quantity of calf starter fed to animals of each group was fixed as per standards (NRC, 1989).

The daily dry matter (DM) given to each animal was revised every fortnight according to the body weight and intake. Green grass was provided *ad libitum* to meet the dry matter requirement. Clean drinking water was provided round the clock all through the trial period of 145 days. Daily records of intake of dry matter from concentrate, green grass, and milk were maintained.

3.4 DIGESTIBILITY TRIAL

A digestibility trial was conducted at the end of experiment with a five-day collection period. Dung samples were collected manually taking all precautions to collect it quantitatively free from feed, urine and dirt. Dung samples so collected each day were weighed and samples at the rate of five per cent of total weight were collected in double lined polythene bags after mixing thoroughly. The samples collected each day were kept in freezer. After the end of trial, samples collected from each animal for the five days were pooled, mixed together and sub samples were taken for analysis. During the collection period feed samples (calf starter and green grass) were collected daily from individual animal and at the end of trial, feed samples so collected from each animal were pooled and sub samples were taken for analysis.

3.5 ANALYSIS OF FEED AND DUNG

Proximate analysis of the experimental calf starters, dung, green grass, and milk were carried out as per standard procedure (AOAC, 1990). Crude protein in dung was estimated using fresh samples, rest of the analysis was done with dry samples. The acid detergent fiber (ADF) was estimated by the method suggested by Van Soest (1963) and neutral detergent fiber (NDF) by the method suggested by Van Soest and Whine, (1967). The calcium content in feed and dung was found out by Atomic Absorption Spectrophotometer using hollow calcium cathode tubes. Phosphorus content in the feed and dung was determined by Vanado-Molybdate method (AOAC, 1990).

3.6 HAEMATOLOGICAL PARAMETERS

Blood samples from experimental animals were collected at the first, third and fifth month of the feeding trial. Blood samples were used to determine Haemoglobin (cyanmethaemoglobin method), plasma glucose (GOD-PAP method), serum inorganic phosphorus (phosphomolybdate method), serum total protein (direct biuret method) using the kits supplied by Agappe diagnostics. Serum urea nitrogen was estimated by DAM method using kit supplied by Qualigens diagnostics and serum calcium by Atomic Absorption Spectrophotometer using hollow calcium cathode tubes.

3.7 STATISTICAL ANALYSIS

The data on fortnightly body weight were analysed using covariance analysis and all other means were compared using students 't' test (Snedecor and Cochran, 1985).

Table1. Ingredient composition of the two concentrate mixtures given to the experiment animals, kg

Ingredient	Control	Treatment
Maize	33.0	31.5
Wheat bran	22.5	22.0
Soya bean meal	34.0	44.0
Unsalted dry fish	8.5	Nil
Shell grit	1.5	2.0
Salt	0.5	0.5
L-Lysine	Nil	0.23
DL-Methionine	Nil	0.12

To every 100 kg calf starter, 100 grams of Ultra-TM* and 8 grams of Indomix-AB_2D_3K** was added.

* Trace mineral mixture supplied by Neospark Drugs and Chemicals Pvt Ltd., Unit-2, 64-B, I.D.A, Jeedimetla, Hyderabad-500055, having in every 5 kg, Manganese-270 g, Zinc-260 g, Iron-100 g, Iodine-10 g, Copper-10 g, Cobalt -5 g.

** Vitamin premix supplied by Nicholas Piramal India Ltd, 100, Centrepoint, Dr Ambedkar road, Parel, Mumbai-400012, having in every gram, Vitamin A-82500 I.U, Vitamin D_3-12000 I.U, Vitamin B_2-50 mg, Vitamin K-10 mg.

Table 2. Calculated crude protein, total digestible nutrients, lysine and methionine plus cystine content of the two experimental concentrate mixtures after supplementation

Nutrient	Control	Treatment
CP per cent	23.42	23.64
TDN per cent	72.65	72.83
Lysine (g /kg feed)	1.88	1.88
Methionine plus Cystine (g /kg feed)	0.96	0.96

Results

4. RESULTS

The results obtained in the present study are documented under the following headings.

4.1 PROXIMATE COMPOSITION

The per cent chemical composition of both the calf starters and green grass are presented in the Table 3.

4.2 BODY WEIGHT

The body weight of experimental calves receiving either of the two dietary treatments, recorded at fortnightly intervals are documented in Table 4 and represented in Fig.1. Data were analysed using covariance and are given in Table 5.

4.3 AVERAGE DAILY GAIN

Average daily gain was 325 g in the control group and 348g in the treatment group. Summarized data on initial body weight, final body weight, total weight gain and average daily gain obtained for the calves maintained on the two dietary treatments are listed in Table 6. Fortnightly cumulative average daily gain made by calves is presented in Fig.2.

4.4 DRY MATTER INTAKE

Average dry matter intake (kg /day) was 1.29 in the control group and 1.34 in the treatment group. The weekly average daily dry matter intake (DMI) of the calves in the two groups is documented in Table 7 and the fortnightly average DMI is presented in Fig. 3.

4.5 FEED CONVERSION EFFICIENCY

The mean feed conversion efficiency (kg feed / kg gain) was 3.85 for the control and 3.81 for the treatment group, as presented in Table 8. Fortnightly cumulative feed conversion efficiency of the calves is represented in Fig. 4.

4.6 DIGESTIBILITY COEFFICIENT

Data on the proximate composition of the dung collected in the digestibility trial from both the dietary treatments are presented in Table 9. The digestibility coefficient of nutrients observed is represented in Table 10. Digestibility coefficient were 66.37 and 65.84 for dry matter, and it was 72.21 and 72.36 for crude protein, 64.28 and 61.85 for ether extract, 62.34 and 60.71 for neutral detergent fibre and 51.95 and 52.25 for acid detergent fibre for the control and treatment diets respectively and the same data is represented in Fig.5.

4.7 HAEMATOLOGICAL PARAMETERS

Haematological parameters of calves like haemoglobin, total serum protein, serum calcium, serum phosphorus, plasma glucose and blood urea nitrogen (BUN) recorded at first, third and the fifth month of the experiment are listed in Table 11.

4.8 COST PER KILOGRAM WEIGHT GAIN

The feed cost per kg weight gain for the control group was Rs. 71.40 and for the treatment group it was Rs. 69.63. The economics is depicted in Table 12.

Table 3. Chemical composition of calf starters and grass fed to experimental animals, %*

Parameter	Control	Treatment	Grass
Dry matter	91.10 ± 0.01	91.04 ± 0.02	22.06± 2.149
Crude protein	24.64 ± 0.15	24.55 ± 0.27	6.55 ± 0.39
Ether extract	1.96 ± 0.06	1.80 ± 0.04	0.53 ± 0.03
Crude fibre	7.87 ± 0.21	7.97 ± 0.19	30.14 ± 0.78
Total ash	10.45 ± 0.08	9.65 ± 0.07	13.34 ± 0.22
Nitrogen free extract	55.08 ± 0.34	56.03 ± 0.49	49.44 ± 0.20
Acid insoluble ash	4.18 ± 0.60	3.55 ± 0.01	7.46 ± 0.68
Neutral detergent fibre	46.93 ± 0.68	45.53 ± 0.23	73.57 ± 0.21
Acid detergent fibre	21.54 ± 0.17	15.25 ± 0.15	40.40 ± 0.04
Acid detergent lignin	5.44 ± 0.07	4.29 ± 0.15	7.54 ± 0.01
Calcium	0.90 ± .002	0.82 ± 0.002	0.38± .0005
Phosphorus	0.42 ± 0.06	0.40 ± 0.05	0.28 ± 0.01

* Average of six values on DM basis

Table 4. Fortnightly average body weight of calves maintained on the two experimental rations, kg*

Fortnight	Control	Treatment
0	25.66 ± 1.54	25.81 ± 1.51
1	28.43 ± 1.71	29.86 ± 1.97
2	31.99 ± 1.97	32.86 ± 2.16
3	35.00 ± 2.25	36.50 ± 2.00
4	39.14 ± 1.99	41.71 ± 2.37
5	42.86 ± 1.74	45.71 ± 2.13
6	48.43 ± 2.15	52.29 ± 2.75
7	53.93 ± 2.39	58.07 ± 2.90
8	60.57 ± 2.49	64.50 ± 2.62
9	66.43 ± 2.94	70.00 ± 2.78
10	71.21 ± 2.70	74.57 ± 2.96

* Average of seven values

Table 5. Analysis of covariance of body weight of calves maintained on the two experimental rations recorded at fortnightly intervals

Fortnights	Mean sum of squares			Probability
	Groups	Covariate	Error	
1	5.471	250.996	3.189	0.2169
2	1.661	263.119	8.677	---
3	6.251	211.154	15.395	---
4	20.223	221.293	16.499	0.2919
5	25.971	139.117	16.197	0.2316
6	47.976	187.734	29.446	0.2281
7	55.849	171.955	38.316	0.2526
8	50.007	173.082	34.057	0.2510
9	40.568	218.551	42.606	---
10	35.977	178.937	44.973	---

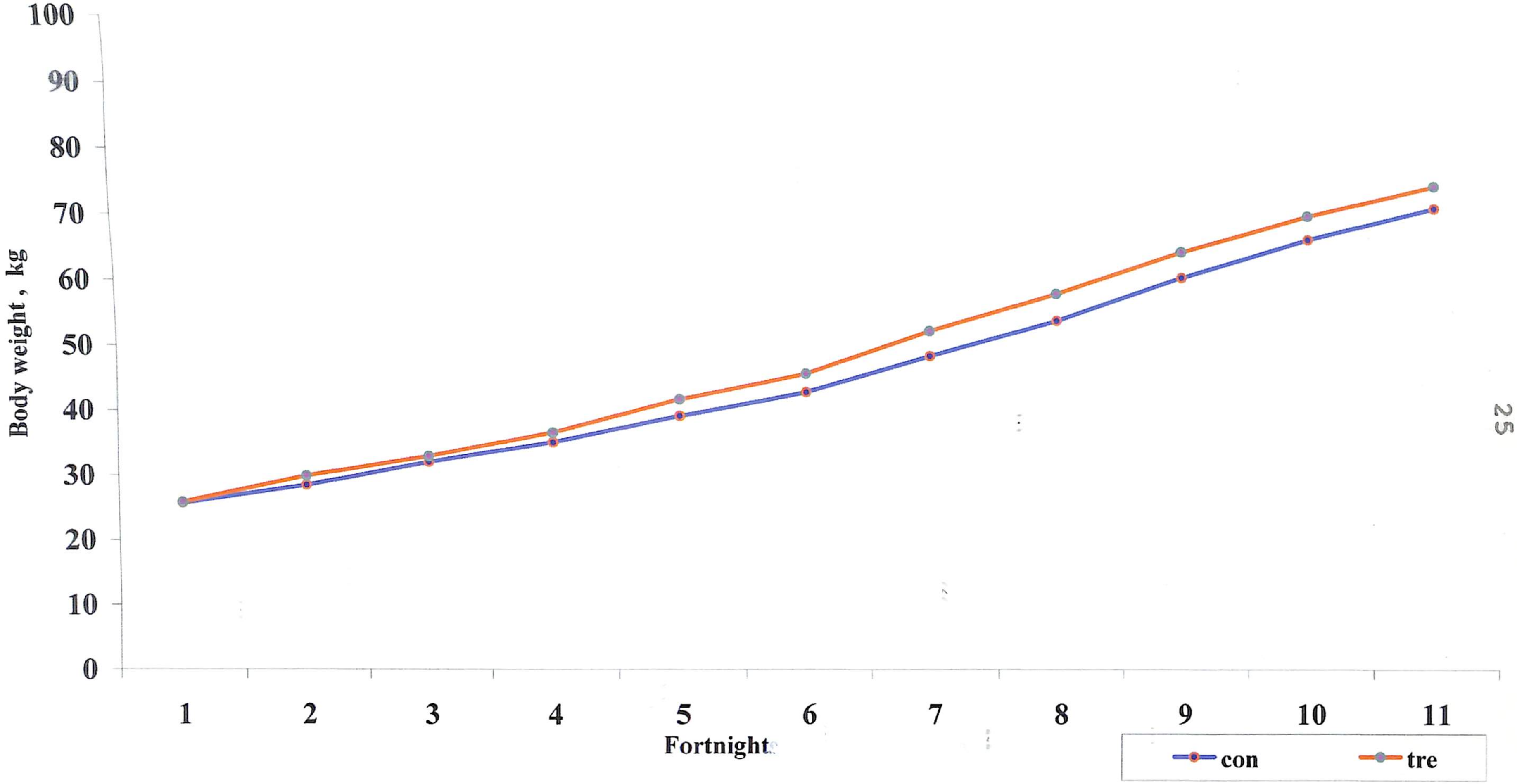

Fig. 1 Fortnightly body weight of calves maintained on two experimental rations

Table 6. Average daily gain of calves maintained on experimental ration*

Parameter	Control	Treatment
Initial body weight, kg	25.66 ± 1.54	25.81 ± 1.51
Final body weight , kg	71.21 ± 2.70	74.57 ± 2.96
Total gain, kg	45.55 ± 2.14	48.76 ± 2.69
Average daily gain, g	325 ± 30	348 ± 27

* Average of seven values

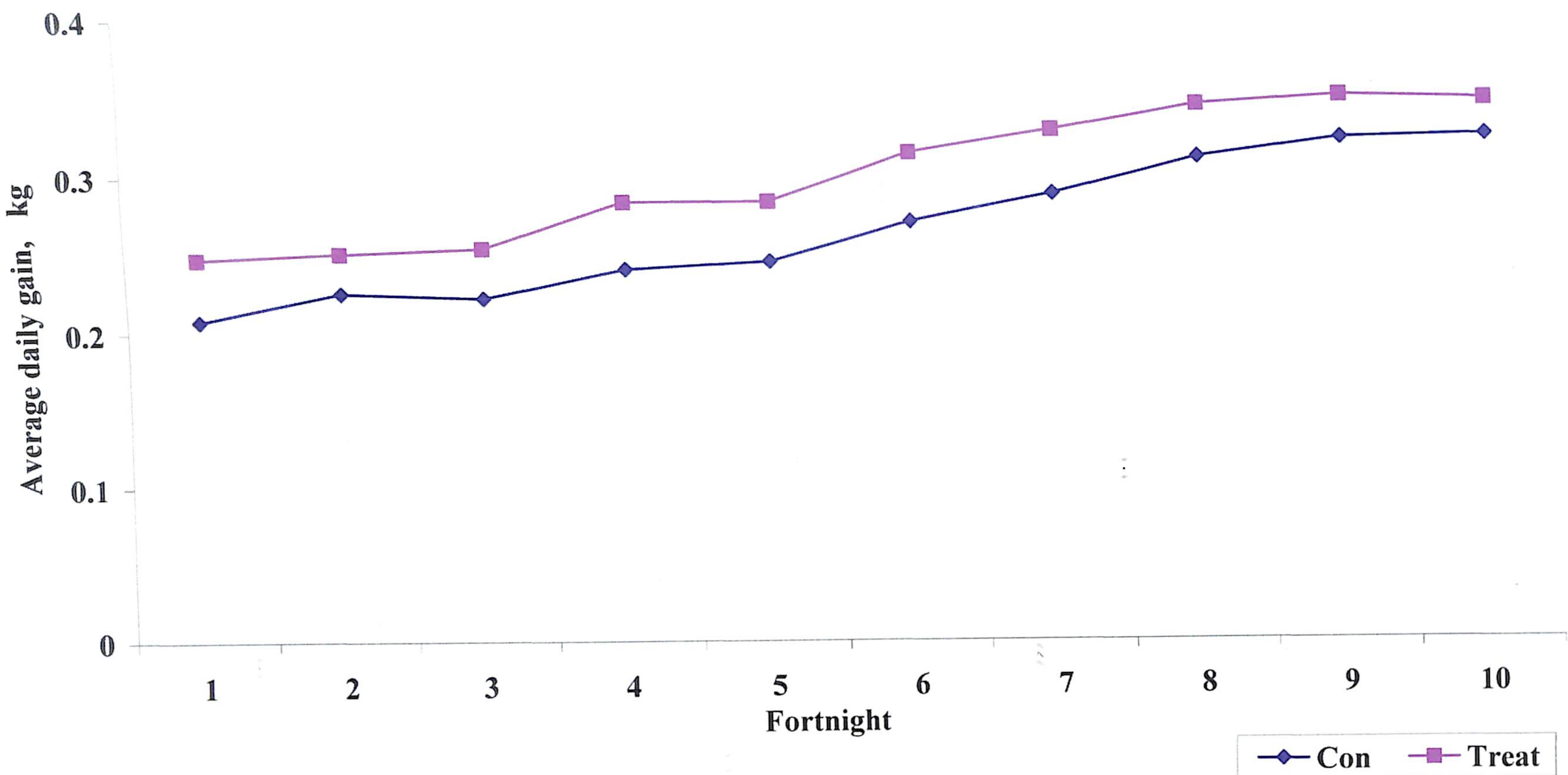

Fig.2 Fortnightly cumulative average daily gain of calves maintained on the two experimental rations

Table 7. Weekly average daily dry matter intake of calves maintained on two experimental rations, kg*

Week	Control	Treatment	P value
1	0.35 ± 0.009	0.35 ± .009	0.8338
2	0.42 ± 0.034	0.42 ± .027	0.9499
3	0.54 ± 0.047	0.55 ± 0.041	0.9111
4	0.65 ± 0.074	0.68 ± 0.063	0.7875
5	0.72 ± 0.095	0.77 ± 0.080	0.7054
6	0.82 ± 0.095	0.85 ± 0.073	0.8610
7	0.88 ± 0.103	0.95 ± 0.850	0.5802
8	1.07 ± 0.097	1.14 ± 0.077	0.5758
9	1.21 ± 0.074	1.29 ± 0.068	0.5006
10	1.28 ± 0.074	1.34 ± 0.056	0.4894
11	1.34 ± 0.057	1.39 ± 0.051	0.7814
12	1.42 ± 0.059	1.49 ± 0.048	0.3428
13	1.55 ± 0.050	1.58 ± 0.053	0.6060
14	1.63 ± 0.069	1.63 ± 0.072	1.00
15	1.67 ± 0.086	1.73 ± 0.069	0.6146
16	1.71 ± 0.089	1.81 ± 0.075	0.3865
17	2.00 ± 0.050	2.08 ± 0.068	0.4134
18	2.15 ± 0.074	2.21 ± 0.077	0.5924
19	2.28 ± 0.066	2.32 ± 0.076	0.7502
20	2.28 ± 0.065	2.34 ± 0.057	0.4820

* Average of seven values

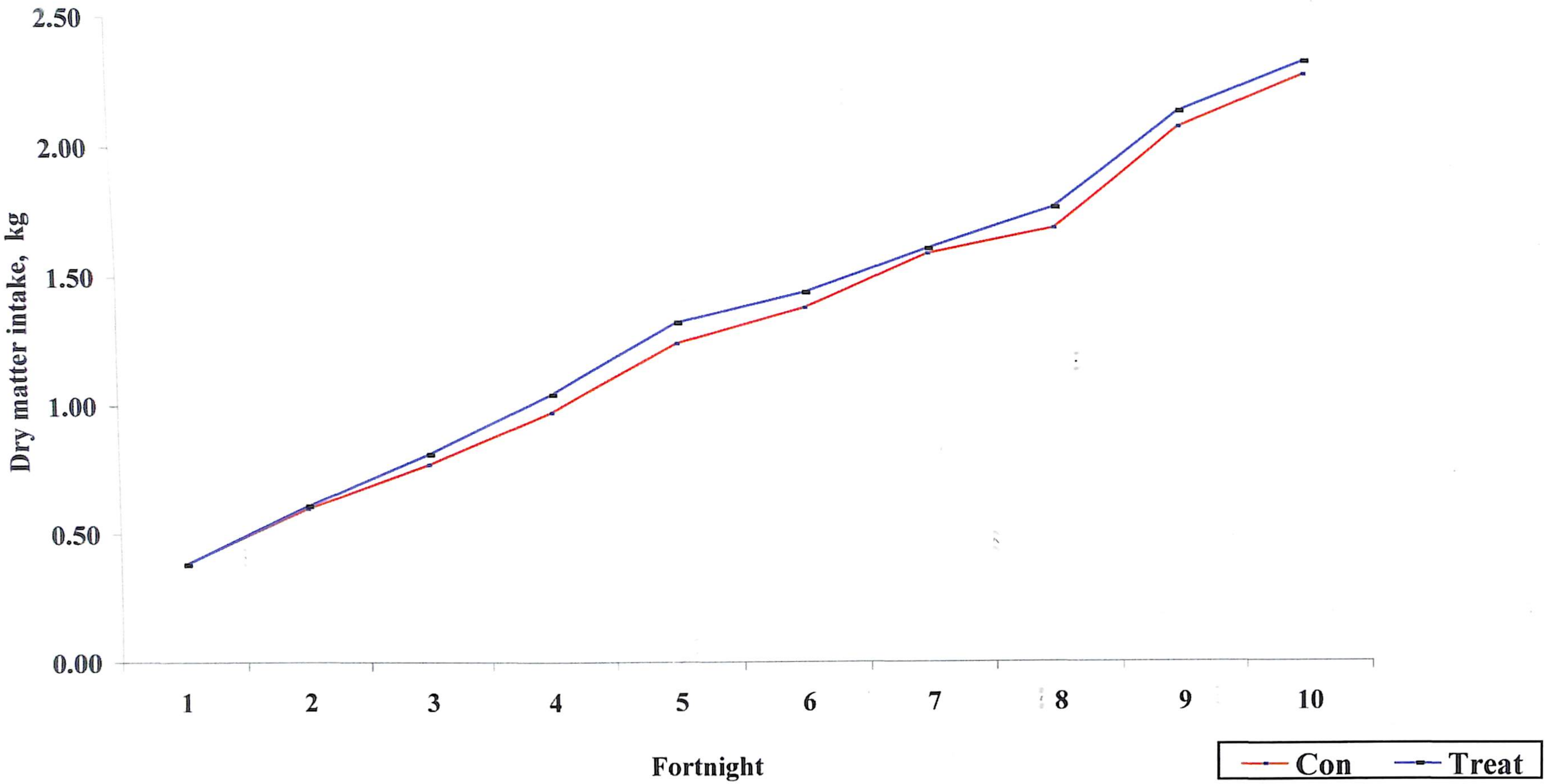

Fig. 3 Average fortnightly dry matter intake of calves maintained on two experimental rations

Table 8. Performance of calves fed experimental ration*

Parameter	Control	Treatment
Total dry matter intake in 140 days (kg/calf)	181.65 ± 9.36	188.20 ± 7.53
Average dry matter intake (kg/day)	1.29 ± 0.07	1.34 ± 0.05
Dry matter intake per 100 kg body weight (kg)	3.06 ± 0 .07	3.14 ± 0.11
Total body weight gain (kg)	45.55 ± 2.14	48.76 ± 2.69
Feed efficiency (kg feed/ kg gain)	3.85 ± 0.43	3.81 ± 0.51

* Average of seven values

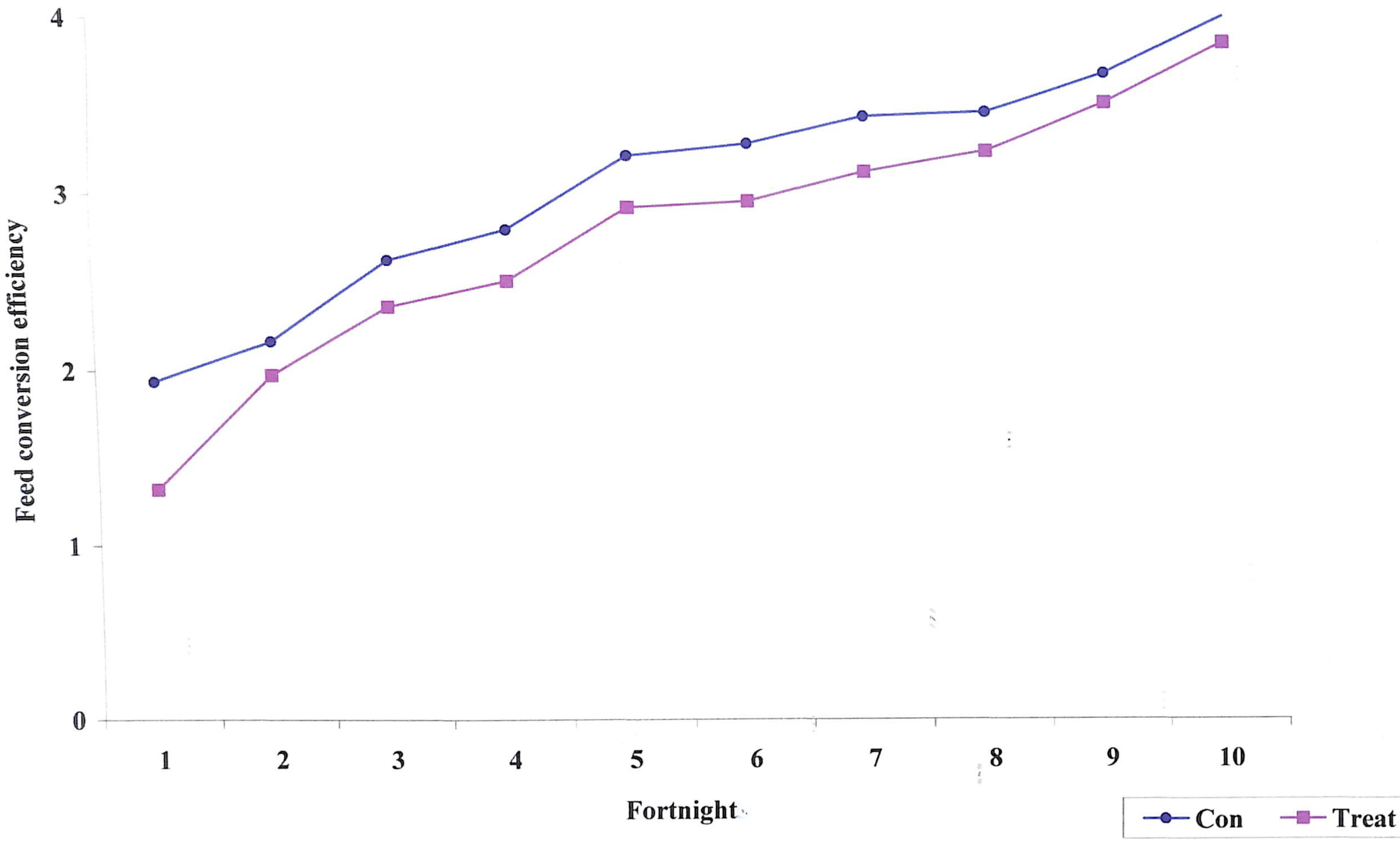

Fig. 4 Fortnightly cumulative feed conversion efficiency of calves maintained on the two experimental rations

Table 9. Chemical composition of dung of calves maintained on the two experimental rations, %*

Parameter	Control	Treatment
Dry matter	23.30 ± 0.26	22.61 ± 0.24
Crude protein	14.72 ± 0.19	14.27 ± 0.22
Ether extract	1.51 ± 0.05	1.47 ± 0.04
Crude fibre	17.40 ± 0.09	21.10 ± 0.29
Total ash	20.74 ± 0.16	18.85 ± 0.21
Nitrogen free extract	45.63 ± 0.28	44.31 ± 0.24
Neutral detergent fibre	63.80 ± 0.58	64.71 ± 0.25
Acid detergent fibre	40.35 ± 0.68	34.75 ± 0.75

* Average of seven values

Table 10. Digestibility coefficient of nutrients of experimental rations*

Nutrients	Control	Treatment	P value
Dry matter	66.37 ± 0.59	65.84 ± 0.65	0.5574
Crude protein	72.21 ± 0.59	72.36 ± 0.59	0.8972
Ether extract	64.28 ± 1.64	61.85 ± 1.46	0.2903
Nitrogen free extract	63.84 ± 0.80	64.68 ± 0.74	0.4583
Neutral detergent fibre	62.34 ± 0.80	60.71 ± 0.74	0.1599
Acid detergent fibre	51.95 ± 1.27	52.25 ± 1.79	0.8916

*Average of seven values

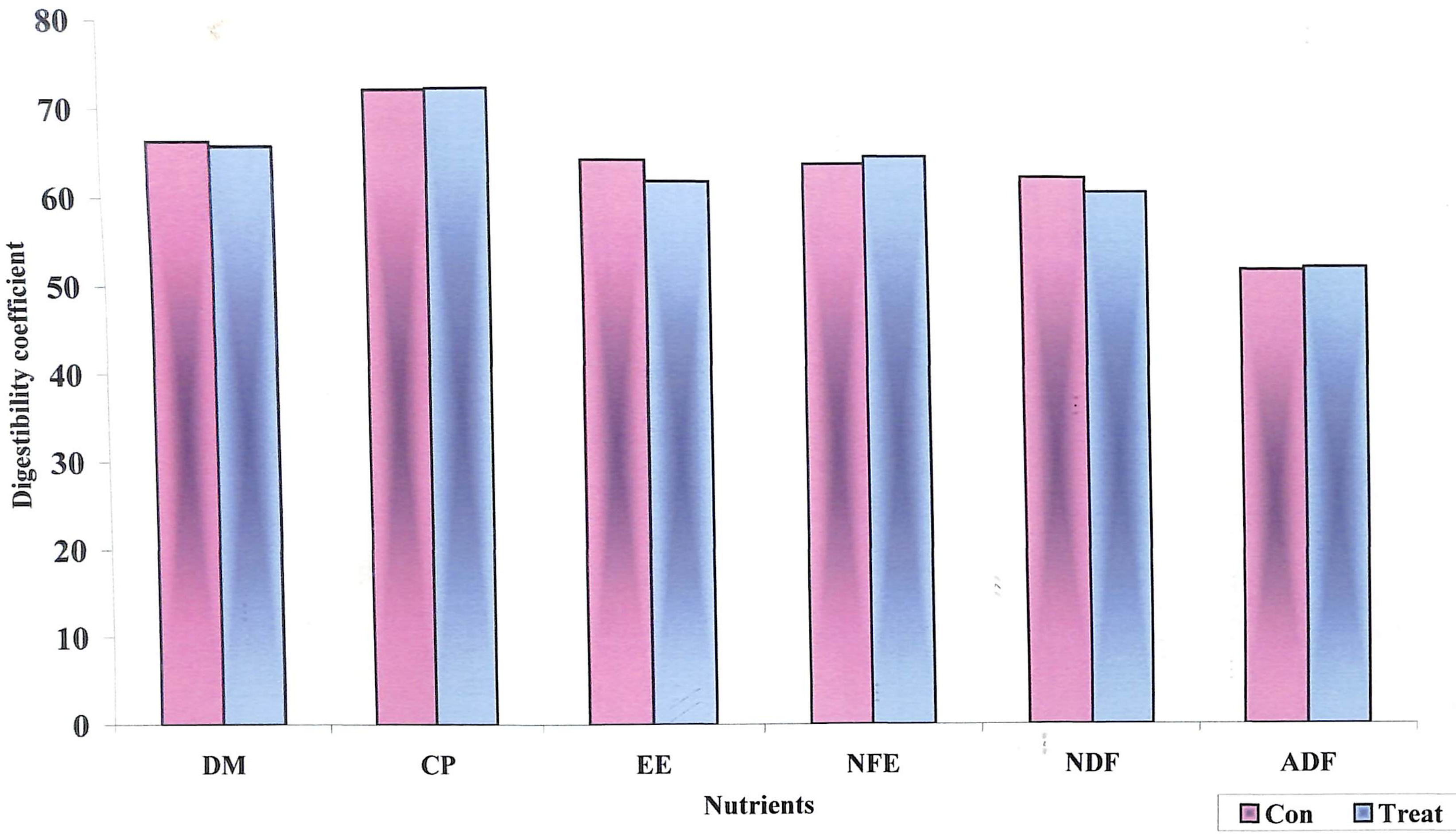

Fig.5 Digestibility coefficient of nutrients of experimental rations.

Table 11. Haematological parameters of calves maintained on the two experimental rations*

Parameter	Diets	Month		
		First	Third	Fifth
Blood haemoglobin, g/dl	Control	13.45 ± 0.93	12.58 ± 0.92	12.21 ± 0.59
	Treatment	13.35 ± 0.83	12.00 ± 0.93	12.12 ± 0.42
Serum calcium, mg per cent	Control	10.11 ± 0.61	11.88 ± 0.68	11.47 ± 0.50
	Treatment	11.04 ± 0.70	10.76 ± 0.77	12.19 ± 0.55
Serum phosphorus, mg per cent	Control	6.76 ± 0.29	6.98 ± 0.19	6.94 ± 0.21
	Treatment	7.09 ± 0.12	6.86 ± 0.21	7.05 ± 0.14
Plasma glucose, mg/dl	Control	97.74 ± 12.79	71.35 ± 3.00	59.12 ± 1.23
	Treatment	91.30 ± 5.67	71.15 ± 3.91	62.22 ± 2.48
Serum total protein, g/dl	Control	6.09 ± 0.17	5.67 ± 0.19	5.73 ± 0.08
	Treatment	6.10 ± 0.23	5.70 ± 0.13	5.71 ± 0.09
Blood urea nitrogen, mg per cent	Control	9.84 ± 0.44	11.36 ± 0.24	12.58 ± 0.24
	Treatment	10.21 ± 0.53	11.86 ± 0.26	13.22 ± 0.09

* Average of seven values

Table 12. Cost per kilogram gain in calves maintained on the two experimental rations*

Parameter	Control	Treatment
Total milk intake (kg/calf)	170.64	170.64
Total grass intake (kg/calf)	361.01	394.22
Total calf starter intake (kg/calf)	104.77	104.34
Total cost of feed (Rs/calf)	3252.97	3395.16
Total weight gain (kg/calf)	45.56	48.76
Cost/ kg gain (Rs)	71.40	69.63

* Average of seven values

Discussion

5. DISCUSSION

5.1 BODY WEIGHT GAIN

Body weight of the calves recorded at fortnightly interval is presented in Table 4 and its covariance analysis in Table 5. It could be observed from the table that there was no significant difference between the body weight of the calves maintained on two dietary treatments. The animals receiving the treatment diet presented a numerical superiority in body weight gain over the animals receiving control diet through out the trial. From the data on weight gain by the experimental animals presented in Table 6 it could be observed that the total weight gain by the calves is 45.55 kg and 48.76 kg for the control and treatment groups respectively. From the same table, it could also be observed that the average daily gain (g/day) of calves was 325g for the control and 348g for the treatment. There was no significant difference in total gain or the average daily gain (ADG) between the two groups of calves.

Preston *et al.* (1964) in a similar experiment with pre-ruminant calves equated the lysine and methionine plus cystine content of a ground nut meal based diet to that of fish meal based diet and found that average daily gains were significantly lower in the ground nut meal based diet (492 g/day) when compared to the diet having fish meal (600 g/day). Methionine was the first limiting and lysine the second limiting amino acid in corn and soyabean meal based diet for growing calves (Abe *et al.*, 1998). The supplementation of lysine and methionine to a calf starter with cent per cent vegetable protein resulted in significantly better average daily gain in calves (Kanjanapruthipong, 1998; Khan *et al.*, 2002; Mandal *et al.*, 2002). Both the starter diets in the present study had corn and soyabean as its main ingredients. Control diet had fish meal and treatment diet was supplemented with lysine and methionine. Zombade *et al.* (1980) reviewed the inferior nature of fish protein available locally for animal consumption. They threw light on the protein constitution of such fish protein and demonstrated that it was constituted of less digestible stroma protein and had a higher amount of acid insoluble ash. The similar growth performance of calves obtained in both the dietary treatments may be due to the inferior nature of fish protein available.

5.2 DRY MATTER INTAKE

The weekly average daily dry matter intake (DMI), by the animals of both the groups is presented in Table 7 and the summarized data of total dry matter intake and average daily dry matter intake in Table 8. The average daily DMI observed from Table 8 was 1.29 kg in the control group and 1.34 kg in the treatment group. Total dry matter consumed by the animals in the trial was 181.65 kg and 188.20 kg in the control and treatment group respectively. Dry matter consumption /100 kg body weight (Table 8) was 3.06 kg and 3.14 kg for the calves in the control and treatment diets respectively. The dry matter intake was similar between the two dietary treatments and presented no significant difference when analyzed statistically.

A lower dry matter intake (2.33 kg/ 100 kg body weight) by crossbred calves than that was obtained in the present study were reported by Gnanasekar and Balaraman (2001) and (2.86 kg per 100 kg body weight) by Ahuja *et al.* (2001) in buffalo calves. Bhagavat and Srivastava (1991) reported a DMI of 3.14 kg per 100 kg body weight by crossbred calves fed on concentrate mixtures with 24.7 per cent crude protein (CP).

Kay *et al.* (1966) reported that dry matter intake in calves was not affected by the protein source and was similar among those fed soyabean meal or fish meal as their main protein source. Similar lack of influence of the source of protein in the diet on DMI was also reported by Abu-Ghazaleh *et al.* (2001). Davenport *et al.* (1990) observed that there was no difference in the DMI of calves fed on soyabean meal plus fish meal to that of those fed on soyabean meal plus supplemented amino acids.

Mandal *et al.* (2002) reported an increased DMI in calves fed vegetable protein diet supplemented with lysine and methionine. However supplementation of lysine and methionine in excess resulted in reduced DMI in pre-ruminant calves (Abe *et al.*, 2000; Abe *et al.*, 2001).

5.3 FEED EFFICIENCY

Feed efficiency (kg dry matter intake/ kg gain) observed in the present study was 3.85 in the control group and 3.81 in the treatment group, as depicted in Table 8. No significant difference in feed efficiency was observed between the experimental diets when analyzed statistically. This finding was in agreement with Mandal *et al.* (2002) who reported similar feed efficiency among calves in the group supplemented with lysine and methionine (6.97) and the group receiving diets without supplementation (8.09). Davenport *et al.* (1990), in their study with beef calves reported a feed per gain ratio of 6.06 in the group fed ground soybean meal (GSB) plus fish meal (FM) plus lysine, 6.13 in GSB plus FM group, 7.01 in GSB plus lysine group and 7.39 in GSB group. Khan *et al.* (2002) also reported that feed efficiency significantly improved (2.65 compared to 2.98) when calves fed cotton seed meal were supplemented with lysine and methionine. Muller and Rodriguez (1975) reported a reduction in feed efficiency from 2.85 to 3.54 when a supplementation with 0.50 per cent methionine hydroxy analogue was made in the diets of pre-ruminant calves. Abe *et al.* (2000) and Abe *et al.* (2001) demonstrated the toxicity of excess amino acid supplementation in pre-ruminant calves and the adverse effect of such indiscriminate supplementation on feed efficiency.

5.4 DIGESTIBILITY COEFFICIENT OF NUTRIENTS

The data on the digestibility coefficient of nutrients of both the experimental diets are presented in Table 10.

Digestibility coefficient for dry matter observed in the present study was 66.37 per cent and 65.84 per cent for the control and treatment diets respectively. Pandey and Agrawal (2001) reported a dry matter digestibility of 65.10 per cent in calves fed 22.5 per cent CP diets. Bhagavat and Srivastava (1991) and Asitha (2002) reported a dry matter digestibility of 71 per cent in crossbred calves below six months of age. Ahuja *et al.* (2001) observed a lower dry matter digestibility of 62 per cent in buffalo calves fed calf starter containing 20 per cent CP.

Eventhough the dry matter digestibility was numerically higher for control diets, the difference was not statistically significant. Preston *et al.* (1964) reported a similar dry matter digestibility in their experiments with pre- ruminant calves fed diets with fish meal (76.6 per cent) and groundnut meal supplemented with lysine and methionine (78.5 per cent). Mandal *et al.* (2002) and Khan *et al.* (2002) also reported similar dry matter digestibility in calves fed on lysine and methionine supplemented diet and those on diets without supplementation. Wessels and Titgemeyer (1997) reported a reduction in dry matter digestibility from 73.9 per cent to 70.9 percent when growing steers were fed on rolled corn supplemented with lysine and methionine. Kanjanapruthipong (1998) reported an improvement in ileal digestibility of dry matter in pre-ruminant calves from 80.9 per cent to 82.2 per cent when diets were supplemented with amino acids.

Digestibility coefficient of crude protein, as presented in Table 10, was 72.21 per cent and 72.36 per cent for the control and treatment diets respectively. A lower CP digestibility of 62 to 64 per cent were reported by Ahuja *et al.* (2001) and Bhagavat and Srivastava (1991) with 20 to 24 percent CP diets while Gnanasekar and Balaraman (2001) observed a CP digestibility of 72.7 per cent in buffalo calves fed with 20 per cent CP diets. In the present trial no significant difference was observed between the two dietary treatments for crude protein digestibility. No significant difference in crude protein digestibility between diets supplemented with lysine and methionine and diets without amino acid supplementation in calves were also reported by Preston *et al.* (1964); Khan *et al.*

(2002); Mandal *et al.* (2002). Kanjanapruthipong (1998) reported a significant improvement in ileal nitrogen digestibility in calves fed soy protein based milk replacer, from 66.7 to 68.4 per cent when it was supplemented with amino acids lysine, methionine and threonine. Wessels and Titgemeyer (1997) observed a drastic reduction in crude protein digestibility from 73.9 to 70.9 per cent when rolled corn diets fed to growing steers were supplemented with lysine and methionine.

Digestibility coefficient for ether extract observed in the trial was 64.28 in the control diet and 61.85 for the treatment diet. Singh *et al.* (2000) had reported similar values of ether extract digestibility in his study with calves. Ahuja *et al.* (2001) reported a higher value of 72.5 per cent for ether extract digestibility in buffalo calves fed with 20 per cent CP concentrate mixtures while Bhagavat and Srivastava (1991) reported a value of 62.1 for concentrate mixtures with 24.7 per cent CP in crossbred calves. Although the digestibility of ether extract was numerically higher in control diets it was not statistically significant. There was no difference between digestibility of ether extract in calves fed with diets supplemented with lysine and methionine and those which were not supplemented (Mandal *et al.*, 2002).

Digestibility coefficient for neutral detergent fibre (NDF) observed in the present study was 62.34 for control and 60.71 in the treatment. The value obtained in the present study is higher than the value of 42.55 per cent reported by Gnanasekar and Balaraman (2001) in calves fed on 20 percent CP diets and a value of 53.07 reported by Pandey and Agrawal (2001). A higher value for NDF digestibility, 71.7 per cent was reported by Bhagavat and Srivastava (1991) for diets containing 24.7 per cent CP. Asitha (2002) reported a NDF digestibility of 65.01 per cent in pre-ruminant calves fed 26 per cent CP diets, when reared on similar conditions.

Digestibility coefficient for acid detergent fibre (ADF) observed in the present study were 51.95 in the control diet and 52.25 for the treatment diet. The data presented no significant difference between the treatments. The result was in agreement to Mandal *et al.* (2002) who reported similar digestibility coefficients for ADF in calves fed lysine and methionine supplemented diets and those on diets without supplementation. Bhagavat and Srivastava (1991) and Asitha (2002) also reported similar ADF digestibility of 51.95 and 55.64 per cent respectively. But Gnanasekar and Balaraman (2001) reported an ADF digestibility of 38.6 per cent and Pandey and Agrawal (2001) reported ADF digestibility of 46.1 per cent in cross bred calves fed with 20 per cent CP diets.

5.5 HAEMATOLOGICAL PARAMETERS

The haematological parameters estimated at first, third and the fifth month in the present study are given in Table 11. There was no statistical difference between the two groups regarding the various parameters estimated in any collection.

Blood haemoglobin values recorded were 13.45, 12.58 and12.21 g/dl in control group and 13.35, 12.00 and 12.12 g/dl in treatment group for the three collections respectively. Wharton (1966) and Kay *et al.* (1976) reported haemoglobin values to range between 11.7 to 12.4 g/dl in calves.

Serum calcium levels obtained in the trial for the three collections were 10.11, 11.88, and 11.47, mg per cent for control and 11.04, 10.76 and 12.19, mg per cent for the treatment group respectively. There was no difference statistically between the two dietary treatments. The values obtained for serum calcium falls in the range of 9.00 to 12.34 mg per cent that were reported by Kay *et al.* (1976); Jackson *et al.* (1988) and Asitha (2002) in calves of similar age.

Serum phosphorus values were 6.76, 6.98, and 6.94, mg per cent in control and 7.09, 6.86 and 7.05, mg per cent in treatment group for the three collections.

The values obtained were within the range 5.05 to 9.05 mg per cent, that were reported by Jackson *et al.* (1988) and Asitha (2002).

Plasma glucose values were 97.74 mg/dl in the first month, which reduced to 71.35 and 59.12 mg/dl in the third and fifth month respectively for the control group. In the treatment group, blood glucose was 91.30 mg/dl in the first month which reduced to 71.15 and 62.22 mg/dl in the third and fifth month respectively. The statistical analysis revealed no significant difference between the two treatments for plasma glucose. The values obtained were in the range 60.56 to 102.67 mg / 100 ml (Kay *et al.*, 1976; Terosky *et al.*, 1997; Asitha, 2002).

Serum total protein values recorded in the trial for the three collections were 6.09, 5.67, and 5.73 g/dl in control and 6.10, 5.70, and 5.71 g/dl in treatment diets respectively. The values obtained were with in the range (4.11 to 6.4 g/dl) reported by Lammers *et al.* (1998) and Wilson *et al.* (1994).

Blood Urea Nitrogen (BUN) values recorded in the first, third and fifth month of the trial were 9.84, 11.36 and 12.58 mg per cent for control and 10.21, 11.86 and 13.22 mg per cent for the treatment diets respectively. The data presented no significant difference between the treatments when analyzed statistically. The BUN values were in the range of 8.52 to 13.3 mg per cent reported earlier by Lammers *et al.* (1998) and Kay *et al.* (1976).

5.6 COST PER KILOGRAM GAIN

The feed cost per kilogram gain for the control and treatment groups were Rs 71.40 and Rs 69.63 respectively as depicted in Table 12. In agreement to the present study, Mandal *et al.* (2002) reported that there was no difference in cost per kilogram gain among calves older than six months, fed lysine and methionine supplemented diets (Rs 43.14) and those on diets without supplementation (Rs 43.55). Khan *et al.* (2002) also observed that cost of feed to produce one kilogram live body weight gain in calves reared without milk exclusively on a calf starter were similar in groups fed diets with lysine and methionine supplementation (Rs 17.92) and those without supplementation (Rs 19.19).

Identical performance was obtained for all the parameters recorded. It could be inferred that unsalted dried fish in calf starter could be fully replaced with a vegetable protein source made good of its deficiencies in lysine and methionine plus cystine to obtain similar growth and performance.

Summary

6. SUMMARY

A growth trial was conducted in crossbred calves to assess the effect of complete replacement of unsalted dried fish in a calf starter by a vegetable protein source, equated with regard to lysine and methionine plus cystine by supplementation on the growth performance. Fourteen calves of below one month of age were selected and divided into two groups as uniformly as possible with regard to age, sex and body weight. They were randomly allotted to two dietary treatments. The control group was fed with calf starter having unsalted dried fish. The treatment group was fed an iso caloric and iso nitrogenous calf starter without animal protein source equated with the control calf starter for lysine and methionine plus cystine.

Calves on both dietary treatments received milk, till they were three months of age. The quantity of calf starter fed to animals of each group was fixed as per standards (NRC, 1989). Grass was provided *ad libitum* to meet the dry matter requirement. Animals were provided with clean water round the clock through out the trial duration of 145 days and were maintained under identical managemental conditions. Individual records of daily intake from calf starter, milk, and green grass and also the fortnightly gain in body weight were maintained through out the trial. Haematological parameters such as haemoglobin, plasma glucose, serum calcium, serum phosphorus, total protein and blood urea nitrogen were recorded at the first, third and the last month of the trial. A digestibility trial was conducted towards the end of the study with a collection period of five days to arrive at the digestibility coefficient of nutrients.

Animals maintained on control diet gained 45.55 kg during the trial period with an average daily gain of 325 grams and the animals on the treatment diet gained 48.76 kg with an average daily gain of 348 grams. Statistical analysis of the data

showed that there was no significant difference in any of the parameters recorded during the study. The average daily dry matter intake was 1.29 kg for calves on control diet and the same in treatment was 1.34 kg. The mean feed conversion efficiency (kg feed/kg gain) was 3.85 for the control and 3.81 for the treatment group.

The digestibility coefficients of nutrients observed were 66.37 and 65.84 for dry matter, and it was 72.21 and 72.36 for crude protein, 64.28 and 61.85 for ether extract, 62.34 and 60.71 for neutral detergent fibre and 51.95 and 52.25 for acid detergent fibre for the control and treatment diets respectively. Cost/ kg gain was Rs.71.40 in the control group and Rs. 69.63 in the treatment group.

It could be inferred from the study that unsalted dried fish in a calf starter can be fully replaced by plant protein sources supplemented for existing deficiencies in lysine and methionine plus cystine to obtain similar growth and performance in cross bred pre-ruminant calves.

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EFFECT OF REPLACING DRIED FISH WITH LYSINE AND METHIONINE IN THE CALF STARTER ON THE GROWTH PERFORMANCE OF CROSSBRED CALVES

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ABSTRACT

A growth trial was conducted with fourteen crossbred calves below one month of age for 145 days to study the effect of replacement of unsalted dried fish in the calf starter with a total vegetable protein source supplemented with lysine and methionine. Calves were divided into two groups as uniformly as possible and allotted randomly to two dietary treatments. The control group was fed with a calf starter containing unsalted dried fish. The treatment group was fed a calf starter with only vegetable protein sources formulated to be isonitrogenous and isocaloric with control calf starter and equated by supplementation, with the same as regard to amino acids lysine and methionine plus cystine. Statistical analysis of the data showed that there was no significant difference in any of the parameters recorded during the study. An average daily gain of 325 grams and 348 grams were obtained in calves fed with the control and treatment diets respectively. Feed to gain ratio for the control and treatment groups were 3.85 and 3.81 respectively. Dry matter intake and haematological parameters such as haemoglobin, serum phosphorus, serum calcium, plasma glucose, serum total protein and blood urea nitrogen were similar in calves receiving the two dietary treatments. The digestibility coefficients of nutrients observed were 66.37 and 65.84 for dry matter, 72.21 and 72.36 for crude protein, 64.28 and 61.85 for ether extract, 62.34 and 60.71 for neutral detergent fibre and 51.95 and 52.25 for acid detergent fibre for the control and treatment diets respectively. Identical performance was obtained in all the parameters recorded. Cost per kilogram body weight gain was Rs 71.40 for the control group and Rs 69.63 in the treatment group. It could be inferred from the study that unsalted fish in a calf starter can be fully replaced by plant protein sources supplemented for existing deficiencies in lysine and methionine plus cystine to obtain similar growth performance of cross bred pre-ruminant calves.