UTILIZATION OF UREA AT DIFFERENT STAGES OF DEVELOPMENT OF RUMEN IN WEANED CALVES

RAJA, D.

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Department of Animal Nutrition
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
MANNUTHY, THRISSUR-680651
KERALA, INDIA

DECLARATION

I hereby declare that this thesis, entitled **"UTILIZATION OF UREA AT DIFFERENT STAGES OF DEVELOPMENT OF RUMEN IN WEANED 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.

Mannuthy
12-08-05

RAJA, D.

CERTIFICATE

Certified that this thesis, entitled **"UTILIZATION OF UREA AT DIFFERENT STAGES OF DEVELOPMENT OF RUMEN IN WEANED CALVES"** is a record of research work done independently by **Shri. Raja, D.,** under my guidance and supervision and it has not previously formed the basis for the award to me of any degree, diploma, fellowship or associateship to him.

Dr. T.V. Viswanathan
Major Advisor
Associate Professor and Head
Department of Animal Nutrition
College of Veterinary and Animal Sciences
Mannuthy

Mannuthy
12.08.05

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Shri. Raja, D.,** a candidate for the degree of Master of Veterinary Science in Animal Nutrition, agree that this thesis entitled **"UTILIZATION OF UREA AT DIFFERENT STAGES OF DEVELOPMENT OF RUMEN IN WEANED CALVES"** may be submitted by Shri. Raja, D., in partial fulfilment of the requirement for the degree.

Dr. T.V. Viswanathan,
(Chairman, Advisory Committee)
Associate Professor and Head
Department of Animal Nutrition
College of Veterinary and Animal sciences
Mannuthy.

Dr. P. Gangadevi,
Associate Professor and Head
University Livestock Farm and
Fodder Research and Development Scheme
College of Veterinary and
Animal Sciences, Mannuthy.
(Member)

Dr. Syam Mohan, K.M.,
Assistant Professor
Department of Animal Nutrition
College of Veterinary and
Animal Sciences, Mannuthy.
(Member)

Dr. S. Ajitkumar,
Assistant Professor
Department of Clinical Medicine
College of Veterinary and Animal Sciences
Mannuthy.
(Member)

12.9.05
External Examiner

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Raja, D.

Dedicated to

my

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Introduction

1. INTRODUCTION

Rural economy of India is closely tied up with agricultural and livestock farming. India is first among the world's livestock population. But the performances of our animals are less when compared to other countries. The main handicap in the promotion of livestock is the acute qualitative and quantitative shortage of livestock feeds in the country. Indian Council of Agricultural Research (ICAR) has reported that there was a shortage of 25 to 30 per cent roughage and 45 per cent concentrates. Particularly, protein is relatively scarce and generally quite expensive. As a gift of nature, ruminants have the capacity to utilize urea. So urea, a non-protein nitrogenous substance has been extensively used in the ration of ruminants to substitute partly the conventional proteins for a long time. Many reports are available showing that non-protein nitrogen (NPN) sources such as urea can be successfully and economically incorporated in rations of growing ruminants. The feeding of non-protein nitrogen supplements to ruminant is based on the fact that ammonia is the major end product of degradation of proteins and NPN in the rumen. There is a belief which has been generally accepted that most of the nitrogen utilized by rumen microbes comes from ammonia pool in the rumen, which implies that NPN compounds are utilized by ruminants by virtue of symbiotic microbial population in the rumen. Therefore, quality as well as quantity of the ruminal microorganisms is bound to influence this utilization. In the case of non-ruminant animals, there is conflicting evidence concerning utilization of urea. Some claims that non-ruminants are unable to utilize urea (Jones and Combs, 1953), while others suggest that urea may replace some of the non-essential amino acids in the diet (Webhrein *et al.*, 1970).

Generally pre-ruminant calves are like monogastric animals and they should be fed with feeds having high biological value for growth. In the early calfhood stage, digestion and metabolism are in a transition state from a monogastric to that of

a ruminant. Characterizing the transition is a rapid increase in the size and capacity of the fore stomach (rumen, reticulum and omasum) relative to the other organs of the digestive tract. This increase in size and capacity will get stabilized as that of adult only at four months of age. But the total VFA content of the rumen fluid at 20 weeks was essentially the same as at 14 weeks indicating that rumen absorptive capacity may have stabilized by this period (Winter, 1985). Likewise, the development of rumen from the second to eight weeks after weaning are reflected by the increase in rumen pH, rumen volume and decrease in rumen NH_3-N concentration, possibly indicating increased N utilization by the rumen microorganisms (Vazquez-Anon *et al.*, 1993).

It is observed that majority of farmers in Kerala feed the calves with the same compounded feed that they feed the adult stock. The compounded cattle feed containing NPN may not be utilized or may adversely affect the growth of calves in early stage. Non-availability of calf starter and lack of knowledge about adverse effect of NPN substances to pre-ruminant calves leads to this system of feeding of calves by the farmers. Not much work has been done in India to find out the age at which calves tolerate urea-containing feed. Hence, the objective of this study is to assess the optimum age for the utilization of urea in calves.

Review of Literature

2. REVIEW OF LITERATURE

2.1 DEVELOPMENT OF FUNCTIONAL RUMEN

In recent years, considerable emphasis has been given to the importance of stimulating early development of the rumen in calves, to enable them to utilize dry feeds at a very young age. The rumen development depends more upon the chemical nature of the products of fermentation in the rumen than upon the physical texture of its contents, when calves were fed on certain solid, but low fibre diets (Browlee, 1956). McCarthy *et al.* (1956) stated that rumen volatile fatty acid (VFA) peaked at seven weeks and then plateaued, by this he opined that although the rumen continues to increase in size, rumen function in the calf could be considered qualitatively similar to the adult by six weeks of age. Godfrey (1961) stated that development of mature ruminal function has been defined traditionally by physical development of the organ. The rapid development of the reticulo-rumen was accompanied by changes in the eating habits of the young calves. Restricting the calves to an all milk diet obviously prevented the development of mature levels of rumen acids until such time as pasture or roughage became available. Qualitative development of rumen function in calves with free access to roughage is complete by at least second month of age and also reported that the rumen ammonia nitrogen (NH_3-N) level was higher during first two weeks of age and thereafter gradually decrease and the level was almost stabilized earlier by sixth week of age may be due to utilization of ammonia by rumen microorganisms for microbial protein synthesis.

Young *et al.* (1965) demonstrated that non-ruminating calves as young as three weeks could utilize VFA. Agabawi *et al.* (1968) reported that total ruminal VFA reach adult concentration by six to eight weeks of age if calves are offered dry feed from about first week of age. Huber (1969) observed that growth and elongation of rumen papillae have been associated with the functional development of the rumen.

Williams and Dinusson (1973) observed that total volatile fatty acid (TVFA) approached that of mature ruminant as early as third week of age, when calves were consuming a high roughage pelleted starter ration at 1.5 per cent of body weight. In contrast, Winter (1985) reported that total VFA content of the rumen fluid at 20 weeks was essentially the same as at 14 weeks indicating that rumen absorptive capacity might have stabilized by 14 weeks of age.

Quigley *et al.* (1985) reported that young calves possess mature ruminal function within one week of weaning as determined by both ruminal concentration of total VFA and contribution of bacterial N to total N in abomasal contents which were similar to that of adult ruminant by fifth and seventh weeks of age for calves weaned at fourth and sixth week of age, respectively. They also opined that the mature ruminal function tends to be reached at an earlier age in calves weaned at fourth week than those weaned at eighth or twelfth weeks. Anderson *et al.* (1987) opined that acceleration of weaning age of calves appeared to increase their ruminal activity.

Vazquez-Anon *et al.* (1993) reported that the development of rumen from the second to eight weeks after weaning was reflected by increase in rumen pH, rumen volume and decrease in rumen NH_3-N concentration, possibly indicating increased N utilization by the rumen microorganisms. 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 CALF STARTER

2.2.1 Protein

The requirement of protein has been shown to depend on the source of protein, being 19 per cent for groundnut meal (Whitelaw *et al.*, 1961) and 17 per cent for fish meal (Preston *et al.*, 1965). Gardner (1967) showed that maximum weight gains of calves weaned from milk at six weeks of age could be achieved with diets

containing 12 per cent crude protein (CP), while Stobo *et al.* (1967) reported that the protein requirements of calves weaned at three to six weeks of age to be 16 to 19 per cent. Daniels and Flynn (1971) reported that Jersey calves fed a starter containing 12.5 per cent CP grew slower than calves fed starter containing 14.9 or 17.9 per cent CP, whereas Holstein calves grew faster when fed 14.9 per cent CP than fed 12.5 or 17.9 per cent CP. Leibholz (1972) showed that the growth of calves given a diet containing 13.7 per cent CP was 12 per cent lower than that of calves given a diet containing 19.4 per cent CP. Morrill and Melton (1973) reported that 13 per cent protein in calf starter was as good as 16.2 per cent protein starter. The NRC (1989) lists 18 per cent CP (as fed basis; 20 per cent DM basis) as the requirement for calf starter based on dry matter intake (DMI) of about 2.6 per cent of body weight (BW). Field reports have suggested to have higher protein than NRC recommendations. Akayezu *et al.* (1994) opined that calf starters containing higher amounts of protein offer no additional advantage, even when weaning occurs as early as four weeks of age. Starters containing protein concentration lower than NRC (1989) recommended level if DMI is adequate, could achieve satisfactory growth of young calves from birth to second month of age. Drackley *et al.* (2003) observed that calves fed starters containing 22 percent CP were more efficient than calves fed starters with 18 per cent CP.

2.2.2 Urea Supplementation

There are only few experimental evidence to suggest that the calf could utilize urea-N at less than four months of age. Loosli *et al.* (1943), who reported that those calves given a concentrate containing 16.2 per cent protein of which 73 per cent of the nitrogen was in the form of urea nitrogen, gained weight at 0.46 kg per day between second and fourth months of age, compared with 0.61 kg per day in calves given a normal diet having the same protein content. Brown *et al.* (1956) opined that calves could utilize appreciable quantities of urea from sixth weeks of

age. He has observed a significant increase in live weight gain when urea was added to the concentrate mixture to increase its protein content from 6.7 to 15.1 per cent.

Kay *et al.* (1967) reported that the growth of young calves was reduced significantly with the partial replacement of supplementary protein with urea or ammonium acetate in a diet containing 19 per cent of crude protein when fed from four weeks of age. Stobo *et al.* (1967) observed that calves given the concentrate containing 20 per cent crude protein gained weight significantly faster from three to twelve weeks than those given concentrates containing either 12 or 18 per cent CP of which 33 per cent was in the form of urea.

Leibholz and Naylor (1971) showed that the replacement of 40 per cent of the dietary nitrogen with non-protein nitrogen (NPN) did not impair the growth of calves between fifth and eleventh weeks of age. Leibholz and Kang (1973) reported that diets containing 15 per cent CP appeared to meet the protein requirement of the calf irrespective of whether the nitrogen supplement to the basal 12 per cent CP diets was meat meal, soyabean meal or urea. Sharma *et al.* (1983) reported that there was no significant difference in growth rate when ten per cent of equivalent protein in groundnut cake was replaced with urea after third month. Daniel *et al.* (1986) observed significant reduction in body weight of calves fed with urea molasses liquid diet than groundnut cake fed group.

2.3 EFFECT OF UREA SUPPLEMENTATION

2.3.1 Average Daily Gain

2.3.1.1 Calves

Nelson *et al.* (1966) stated that young calves did not perform so well on a urea-supplemented starter compared to those fed a soyabean meal (SBM) supplemented starter. The growth of young calves was reduced by 20 to 30 per cent

when 33 per cent of dietary protein was replaced by urea in their diet (Stobo *et al.*, 1967). Miron *et al.* (1968) opined that even though the urea in calf starter supported a satisfactory rate of gain, it was significantly less than that obtained from those fed soyabean supplemented starter. So, the use of urea in calf starters may be desirable under conditions where maximum gains are not necessary. Winter (1976) reported that calves at five to six weeks of age fed the SBM supplemented starter tended to give better performance in terms of weight gains and feed consumption than calves fed urea supplemented starter. Saha and Gupta (1988) reported that calves fed urea treated paddy straw would exhibit lower growth rate as compared to untreated group and also high DM requirement for growth on urea containing diets.

Maynard *et al.* (1979) stated that urea could be utilized by calves, as a part of protein needs for growth. Sharma *et al.* (1983) stated that urea feeding seemed to have no significant effect on the rate of growth due to sex, but females of urea group did perform better than the control (GNC fed) group.

2.3.1.2 Lambs

Clifford and Tillman (1968) reported that growth performance of lambs fed diet-containing urea as the sole source of nitrogen was approximately 70 per cent of that obtained with soyabean protein supplemented diet. When insoluble proteins such as corn gluten meal (CGM) are used as the supplementary nitrogen source, as much as 25 per cent of the supplementary nitrogen may be furnished by urea without adversely affecting performance of lambs (Amos *et al.*, 1970). Bhattacharya and Pervez (1973) observed that there were no significant differences in feed intake, average daily gain and carcass quality in wether lambs supplemented with 1.5 per cent urea as compared to soyabean meal. Singh and Patnayak (1980) reported that there was a trend for a reduction in the daily gain of those lambs fed diet supplemented with urea over control ration without urea.

2.3.1.3 Kids

Anaokar *et al.* (1974) reported that cobalt supplementation @ 2.0 mg per day along with 15 per cent digestible crude protein (DCP) replaced by urea in the diet was more beneficial for growth of growing kids. Singhal and Mudgal (1981) reported that 50 per cent DCP of GNC can be replaced either by urea or biuret without any adverse effect on growth and nutrient utilization in Beetal kids.

Anandan *et al.* (1996) observed that urea treated neem seed kernel meal can be substituted for deoiled ground nut cake with out any deleterious effect on the performance of growing kids.

2.3.1.4 Horses and Rabbits

Slade *et al.* (1970) reported that protein requirement for maintenance could be met through NPN in mature horses. Godbee and Slade (1981) opined that the lack of a positive response by the weanlings horse fed urea might be due to greater demand for higher quality protein during early growth. Binh *et al.* (2005) reported that performance of growing rabbits given blocks with different levels of urea (two and four per cent), a concentrate supplement and grass *ad libitum* was more economical and also there were no indication of toxicity on any level of treatments.

2.3.2. Dry Matter Intake

Brown *et al.* (1956) stated that there was no significant difference in either gain or starter consumption detected between the urea and the conventional protein group (linseed meal) in calves. Lassiter *et al.* (1958) reported that as the level of urea in the ration increased, the consumption of roughage (corn cobs) decreased in growing dairy heifers. The intake of the diets containing urea was less than that of iso-nitrogenous diets containing true protein (Kay *et al.*, 1967; Stobo *et al.*, 1967; Miron *et al.*, 1968). Jordan and Hanke (1970) observed that there was a tendency for

a reduced feed intake in lambs fed rations containing urea compared to those fed diet containing soyabean meal and also further reported that this reduction was more apparent in meal type rations than in pelleted rations.

Leibholz and Kang (1973) reported that supplementation with sulphur of the diets containing urea resulted in a significant increase in feed intake and weight gain. Pande and Shukla (1979) reported that DM intake was not significantly affected by the different treatments, viz., 100 per cent DCP requirements recommended by Sen and Ray (1971), 80 per cent DCP requirements, 100 per cent but 20 per cent DCP requirements replaced by urea in male surti buffalo calves.

Winter (1976) observed that consumption of starter rations tended to increase with the increasing protein (urea) level, calves on the starters containing 17.5 per cent CP (1.5 per cent urea), 21.6 per cent CP (2.7 per cent urea supplemented) and 17.9 per cent CP (SBM) consumed 31, 35, and 46 per cent, respectively more feed than those on low protein starter (16 per cent CP). Morrill and Dayton (1978) reported that calves consumed less starter containing urea than SBM. Gupta and Walli (1987) reported that daily DMI reduced from 598.4 g to 482.1 g per day in kids between four to five months of age when 53.6 per cent of formaldehyde treated groundnut cake was replaced with urea.

2.3.3. Digestibility Coefficient of Nutrients

2.3.3.1 Calves

Leibholz and Kang (1973) observed that the digestibility of nitrogen and dry matter increased with increasing the CP content of the diets and was greater for the diets supplemented with urea than for those supplemented with meat meal or soyabean meal. Pande and Shukla (1979) reported that there was no significant difference between control and 20 per cent DCP replaced by urea group in digestibility of CP, EE, CF, NFE and organic matter in male surti buffalo calves.

Sinha and Nath (1982) reported that urea supplementation to deoiled salseed meal in crossbred female calves made it palatable and enhanced digestibility of nutrients, especially that of crude protein and crude fibre. Khan *et al.* (1999) stated that urease from soyabean meal seed rapidly hydrolyzed the urea benefiting microbial multiplication. Ultimately the host animals got more available amino acid for body growth compared to animals fed only urea treated straw.

Urea feeding improved the digestibility of cellulose (Chalupa *et al.*, 1963). Cellulase activity in the rumen of urea-fed animals was higher than in those fed on urea-free diet or diets containing urea-formaldehyde complexes. The increases in cellulase activity on urea feeding could be due to the increase in the number of cellulolytic bacteria (Makkar *et al.*, 1983). A depression in crude fibre digestibility on liquid urea molasses diet feeding was reported by Pathak and Ranjan (1976). Jacobs and Leibholz (1978) reported that there was a significant reduction in dry matter and nitrogen digestibility in calves fed with 30 per cent poultry litter than those fed diet without poultry litter. Sahoo *et al.* (1992) observed significant increase in dry matter digestibility in urea molasses liquid diet fed groups than control (deoiled rice bran and wheat bhoosa alone) fed group.

2.3.3.2 Lambs

McLaren *et al.* (1959) reported that when methionine was added to a ration containing urea there was increased retention of absorbed N in lambs. Arora *et al.* (1975) reported an increase in the digestibility of dry matter and NFE due to addition of ammonium sulphate or urea in the diet of sheep. Singh and Patnayak (1980) reported that there was no deleterious effect of urea supplementation even to the extent of 2.6 per cent in concentrate supplement on nutrient digestibility in weaner lambs. Bhattacharya and Pervez (1973) found that no significant difference in the digestibility of various nutrients were observed in the urea or soyabean supplemented

rations, but CF, energy and EE digestibility tended to increase upon urea supplementation.

2.3.4. Feed Efficiency Ratio

Kay *et al.* (1967) reported that there was no difference in growth rate and feed conversion efficiency between the groups fed fish meal and urea supplemented feed in calves over the live weight of 50 to 60 kg. Reason being the early development of the rumen and its microbial population on weaning at an early age. Growth and feed conversion ratio of the calves were similar with those fed meat meal, soyabean meal and urea as the source of crude protein added to the basal 12 per cent crude protein diet (Leibholz and Kang, 1973). Jacobs and Leibholz (1978) reported that broiler house litter containing 3.9 to 5.3 per cent nitrogen, of which up to 60 per cent can be in the form of NPN showed poor performances in calves due to lower digestibility of energy and nitrogen of these diet. Fiems *et al.* (1987) reported that replacing soyabean meal with urea (half of the protein in the diets) resulted poor feed efficiency in calves. Saha and Gupta (1988) also reported significantly poorer feed efficiency when 60 per cent of dietary protein replaced with urea treated rice straw.

2.3.5 Metabolic Profile Test

2.3.5.1 Blood Biochemical Parameters

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 to 32 mg per 100 ml. Leibholz and Kang (1973) observed that the concentration of urea in the blood plasma increased with increased dietary CP content, and was higher in calves given urea.

McCandless and Dye (1950) have shown that a decline in blood glucose was characteristic of young ruminants and suggested that this represented the change

from primary dependence on abomasal digestion to dependence on ruminal digestion for energy. Blood glucose did not show any change due to urea supplementation in wether lamb (Bhattacharya and Pervez, 1973). Rowlands (1980) observed a direct correlation between blood glucose levels and growth rate in calves aged between six to thirteen weeks of age and opined that the calves that maintain high blood glucose concentration grow faster.

Jagos *et al.* (1986) reported that there was a trend for a higher plasma urea in experimental group (with urea) than that of control group (without urea). However no differences were observed in the content of vitamin A, level of total protein, glucose, bilirubin, activities of aspartate aminotransferase, gamma glutamyltransferase and lactate dehydrogenase. Bhakt *et al.* (1997) observed that the average values for SGOT, SGPT, TSP and WBC of calves fed different diets containing different levels of urea treated deoiled salseed meal (DSSM)) were within normal range but BUN was higher in calves fed with urea treated DSSM. However blood urea concentration in crossbred calves from birth to third week, and fifth and tenth months of age was higher compared to blood urea concentration at 28th day of birth which was assumed to be due to the lower availability of nitrogen to the liver as a result of multiplication and propagation of micro flora in developing rumen and initiation of synthesis of microbial protein (Kumar *et al.*, 2002). Eryavuz *et al.* (2003) in lambs observed glucose level significantly higher in urea fed lambs than those fed plant protein diet.

2.3.5.2 Urinary Parameters

De Groot and Aafjes (1960) reported that an increase in body weight would usually cause an increase in creatinine excretion in dairy cows. Albin and Clanton (1966) found that protein content of the ration did not affect total creatinine excretion in urine of cattle but creatinine concentration in urine was affected (Kertz *et al.*, 1970). Chetal *et al.* (1975) reported that the protein level of the diet did not affect

the creatinine coefficient. So, it was concluded that in ruminant in general and in growing buffalo calves in particular, creatinine concentration and total creatinine in urine cannot be used as an index to evaluate ruminant nutrition. Pande and Shukla (1982) also reported that creatinine excretion, total nitrogen in urine and creatinine coefficient (mg per kg body weight) was not significantly affected by protein level, urea or castration, but significant daily variation occurred in these values.

Kay *et al.* (1967) observed that urinary nitrogen excretion was highest in the calves receiving the diet in which fish meal nitrogen was completely replaced by urea nitrogen. Jagos *et al.* (1986) also reported that urinary urea was higher in urea fed calves from 17 to 66 days of age.

2.3.5.3 Rumen Liquor Parameters

Christiansen *et al.* (1965) have observed that faunated lambs had higher levels of ruminal ammonia and volatile fatty acids (VFA) but lower rumen pH than ciliate protozoa-free lambs. Anderson *et al.* (1987) observed that the increase in rumen pH with advancing age from birth to 17 weeks of age.

Kay *et al.* (1967) observed that rumen NH_3 concentration increased as the fish meal in the diet was replaced by urea. The same appeared to be the case for blood urea, although the differences were not statistically significant. Bhattacharya and Pervez (1973) reported that ruminal ammonia concentration increased linearly with increase in the level of urea in the ration, while rumen pH decreased upon urea supplementation.

Chalupa *et al.* (1964) reported greater microbial activity when urea was the source of dietary nitrogen. Nour *et al.* (1979) reported that there was a significant negative correlation between total protozoal counts and NH_3-N concentration and also he observed that the increased supplemental N from urea increased protozoal

generation time three to five fold. However, no statistical differences in generation time were attributable to urea nitrogen in the diet. Singh *et al.* (1983) reported that the bacteria and protozoa made their first appearance in rumen contents of buffalo calves at two weeks and one month of age respectively, but protozoal number increased continuously up to fourth month of age and thereafter the values seemed to be stabilized in all animals and also he inferred that TVFA concentration in rumen liquor increased up to 12 weeks and in blood, increased up to 14 weeks of age, which became similar to adult values thereafter.

Elias (1988) observed that rumen environment in animals of urea fed group supported more bacterial growth than the animals fed fish meal diet. It could be due to the insolubility of protein from fish meal resulting in low ammonia production in the rumen. This could have prevented the growth of some of NH_3 requiring bacteria. Viswanathan (1995) observed highest rumen NH_3-N values for wether lambs fed with urea supplemented diet than those fed with diets supplemented with plant or animal protein.

Materials and Methods

3. MATERIALS AND METHODS

3.1 EXPERIMENTAL ANIMALS

Eighteen healthy female crossbred calves of below one week of age belonging to University Livestock Farm and Fodder Research and Development Scheme (ULF & FRDS) Mannuthy were selected for the experiment. After three days of suckling of colostrum, calves were weaned and housed in individual calf pens with separate feeding and watering facility. The calves were grouped into three groups as uniformly as possible with regard to age, weight and breed and were allotted randomly to three treatments T_1, T_2 and T_3. Calves were dewormed at second week of the trial followed by once in every month during the duration of the study. All the calves were maintained under identical feeding and management conditions.

3.2 EXPERIMENTAL RATION

Two diets were formulated:

Diet 1 - calf starter prepared as per BIS (IS: 5560:1970).

Diet 2 - calf starter containing two per cent urea.

Both the diets were made iso-nitrogenous and iso-caloric. Feeds were routinely screened for aflatoxin. The ingredient composition of both the concentrate mixtures are given in Table 1. The concentrate mixtures had 23 per cent crude protein (CP) and 72 per cent total digestible nutrients (TDN).

3.3 FEEDING TRIAL

During the first month, all the calves were fed milk at the rate of $1/10^{th}$ of their body weight. The total quantity was divided into two equal portion and fed in the morning and in the evening. In the second and third month, quantity

of milk fed daily was reduced to $1/15^{th}$ and $1/25^{th}$ of the body weight, respectively. Milk feeding was stopped completely when the calves attained three months of age. Calf starter was slowly fed individually from tenth day onwards in the morning and in the evening just prior to milk feeding. Calves were fed as per the recommendation of NRC (1989). Calves of T_1 were fed with diet 1 from two weeks to five months (control). Calves of T_2 were fed with diet 1 from two to twelve weeks, later on with diet 2 till five months. Calves of T_3 were fed with diet 1 from two to eight weeks, later on with diet 2 till five months.

Green grass and paddy straw were provided *ad libitum* to meet the dry matter requirement. Individual records of daily intake of calf starter, milk, green grass and paddy straw were maintained throughout the experimental period. The left over portion of calf starter, grass and paddy straw were weighed daily and their moisture contents were analyzed. Body weight was recorded at fortnightly intervals. The daily dry matter (DM) given to each animal was revised fortnightly according to the body weight and intake. Clean drinking water was provided round the clock throughout the trial period.

3.4 DIGESTION TRIAL

A digestion trial (total collection method) was conducted at the end of the experiment for a period of 5d. Daily feed intake and dung voided were recorded individually. The total quantity of dung voided was weighed and recorded for each animal daily. Representative sample of dung (five per cent) from each animal was collected daily in a double lined polythene bags. During digestion trial representative feed samples (calf starter, green grass and paddy straw) were collected from each treatment group daily and stored in freezer. At the end of the 5d trial, dung samples collected from each animal for the 5d were pooled, mixed together and sub samples were taken for analyses. Samples of

feed collected from each treatment group were pooled and sub samples were taken for analyses.

3.5 ANALYTICAL METHODS

3.5.1 Feed and Dung

Proximate principles of calf starter, green grass, paddy straw and dung were determined as per standard procedure (AOAC, 1990). Crude protein in dung was estimated using fresh samples. The acid detergent fibre (ADF) was estimated by the method suggested by Van Soest (1963) and neutral detergent fibre (NDF) by the method suggested by Van Soest and Whine (1967). The calcium content in feed and dung was estimated using Atomic Absorption Spectrometer (PERKIN ELMER 3110, U.S. instrument division, Norwalk, U.S.A.). Phosphorus content in the feed and dung was determined by Vanado-Molybdate method (AOAC, 1990).

3.5.2 Blood

Blood samples were collected from jugular vein with sodium fluoride as anticoagulant at fortnightly interval from fifteenth day till the end of the experiment. Blood samples were centrifuged at 3000 rpm for 15 min and plasma was separated. The Autoanalyzer (Mispa Plus by SEAC Radim group, Model-SLIM) was used to determine blood glucose (GOD-PAP Method), AST (IFCC Method), blood urea nitrogen (Modified Berthelot method), creatinine (Modified Jaffe's method), total protein (Biuret method), albumin (Bromo cresol Green method), bilirubin (Modified DMSO method) using the kits supplied by Agappe diagnostics, Maharashtra, India. It was assumed that the difference between total protein and albumin was the globulin concentration. The albumin to globulin ratio (A:G) was calculated.

3.5.3 Urine

Urine samples were collected in the early morning before concentrate feeding at fortnightly interval from second week of age till the end of the experiment. Urinary urea was determined by Modified Berthelot method and creatinine by Modified Jaffe's method using spectrophotometer (Genesys 10 UV, Thermo Spectronic,.Rochester, NY, U.S.A).

3.5.4 Rumen Liquor

Rumen liquor samples were collected by using stomach tube connected to a vacuum pump from calves at second month of age and thereafter once in every month till the end of the trial, 2 hours after the morning feeding. Rumen liquor was strained through eight layers of cheese cloth and the pH of the fluid was measured immediately after the collection by using pH meter (Cyberscan 2500, Singapore). The fluid was examined for the presence of protozoa and was graded accordingly. Bacterial count was done by using Methylene Blue Reduction Test (MBRT) proposed by Rosenberger (1979). Total volatile fatty acid in the rumen liquor was determined by the method prescribed by Barnett and Reid (1957) and rumen ammonia nitrogen was estimated using Spectronic 1001 plus (Milton Roy Company, U.S) by the method of Beecher and Whitten (1970).

3.6 STATISTICAL ANALYSIS

The data on fortnightly body weight were analysed using Covariance analysis and means of all other parameter were compared using ANOVA single factor (Snedecor and Cochran, 1985).

Table1. Ingredient composition of the experimental calf starters, %

Ingredient	Diet 1	Diet 2
Yellow maize	41.0	48.5
Wheat bran	10.0	18.0
Soya bean meal	31.5	16.5
Gingelly oil cake	15.0	12.5
Mineral mixture*	2.0	2.0
Urea	0.0	2.0
Salt	0.5	0.5
L-Lysine**	0.227	0.227
DL-Methionine**	0.122	0.122

*Mineral mixture without salt (Pristine Nutrition Pvt. Ltd., Bangalore) containing Calcium – 23%, Phosphorus – 12%, Magnesium – 6.5%, Sulphur – 0.5%, Iron – 0.5%, Zinc – 0.38%, Manganese – 0.12%, Copper – 0.07%, Iodine – 0.03%, Cobalt – 0.01%, Fluorine (max) – 0.07%, Acid insoluble ash (max) – 2.5% and moisture (max) – 5%.

To every 100 kg calf starter, 10 grams of Indomix-AB_2D_3K (Nicholas Piramal India Ltd., 100, Centrepoint, Dr. Ambedkar road, Parel, Mumbai – 400 012). Composition per gram: Vitamin A – 82500 I.U, Vitamin D_3 – 12000 IU, Vitamin B_2 – 50 mg, Vitamin K – 10 mg

** Ajinomoto Co., (Thailand) Ltd., 487/1 Si Ayutthaya road, Khwaeng Thanon Phaya Thai, Khet Ratchathewi, Bangkok, Thailand- 10400.

Results

4. RESULTS

The results obtained in the present study are as follows

4.1 PROXIMATE COMPOSITION

The proximate composition of calf starter, green grass and paddy straw are presented in Table 2.

4.2 BODY WEIGHT

The mean fortnightly body weight of experimental calves for the three treatments T_1, T_2, and T_3 recorded are presented in Table 3 and graphically represented in Fig. 1. Data were analyzed statistically by Covariance analysis and are presented in Table 4. The mean final body weight of experimental calves for the three treatments T_1, T_2, and T_3 were 70.15, 68.22 and 74.12 kg, respectively.

4.3 AVERAGE DAILY GAIN

Fortnightly cumulative average daily gain of experimental calves are presented in Table 5 and graphically represented in Fig. 2. Average daily gain for the three treatments T_1, T_2, and T_3 were 305, 299 and 321g, respectively. Total body weight gains of the experimental calves were 45.82, 44.89 and 48.28 kg, respectively for the treatments T_1, T_2, and T_3 and graphically represented in Fig. 3.

4.4 DRY MATTER INTAKE

Average dry matter intake (kg per day) was 1.39, 1.43 and 1.53, respectively for the treatments T_1, T_2, and T_3. Fortnightly average daily dry matter intake (DMI) of experimental calves for the three treatments T_1, T_2, and T_3 are documented in Table 6 and fortnightly cumulative average daily DMI of experimental calves are presented in Table 7 and graphically in Fig. 4

4.5 FEED CONVERSION EFFICIENCY

Fortnightly cumulative mean feed conversion efficiency (kg feed per kg gain) was 4.61, 4.85 and 4.83, respectively for the treatments T_1, T_2 and T_3, and are presented in Table 8 and graphically in Fig. 5. Summarized data on performance of experimental calves are listed in Table 9.

4.6 DIGESTIBILITY COEFFICIENT

Data on the proximate composition of the dung collected during the digestibility trial of the calves of the three treatments are presented in Table 10. Digestibility coefficients of nutrients are presented in Table 11 and graphically in Fig. 6.

4.7 BLOOD BIOCHEMICAL PARAMETERS

Haematological parameters of experimental calves maintained on three treatments such as blood glucose, plasma AST, total bilirubin, blood urea nitrogen, creatinine, total protein, albumin, globulin, and A:G ratio recorded at fortnightly interval are listed in Table 12, 13, 14, 15, 16, 17, 18, 19, and 20, and graphically in Fig. 7, 8, 9, 10, 11, 12, 13, 14 and 15, respectively.

4.8 URINARY PARAMETERS

Urinary parameter of calves maintained on three treatments such as urea and creatinine recorded at fortnightly interval are listed in Table 21 and 22, and graphically in Fig. 16 and 17, respectively.

4.9 RUMEN LIQUOR PARAMETERS

Rumen liquor parameter such as pH, Methylene Blue Reduction Test (MBRT), NH_3-N, and total volatile fatty acid (TVFA) of experimental calves are

presented in Table 23 and graphically in Fig. 18, 19, 20, 21, respectively and also protozoal activity is documented in Table 24 for the 2^{nd}, 3^{rd}, 4^{th} and 5^{th} month.

4.10 ECONOMICS OF PRODUCTION

The feed cost per kg weight gain of experimental calves for the three treatments T_1, T_2, and T_3 were Rs.73.45, 73.13 and 70.67, respectively. The data on economics of production is depicted in Table 25.

Table 2. Chemical composition of calf starters, grass and paddy straw fed to experimental calves, %

Item	Diet 1	Diet 2	Grass	Paddy straw
Dry matter	87.18	87.36	24.56	88.35
Crude protein	24.46	24.33	10.44	5.27
Ether extract	3.42	3.45	1.41	1.47
Crude fibre	6.97	7.35	37.78	34.75
Total ash	7.33	8.05	11.63	16.71
NFE	57.82	56.82	38.74	41.80
Acid insoluble ash	2.14	1.73	5.20	14.34
NDF	20.07	24.72	75.36	70.03
ADF	9.35	10.77	45.13	47.63
Calcium	0.88	0.81	0.30	0.26
Phosphorus	0.67	0.65	0.46	0.09

Table 3. Fortnightly average body weight of experimental calves, kg*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
0	24.33 ± 1.50	23.33 ± 0.49	25.83 ± 1.66	0.42
1	27.47 ± 1.53	26.20 ± 0.90	29.92 ± 1.98	0.25
2	29.88 ± 1.70	29.25 ± 1.15	32.75 ± 1.94	0.29
3	32.62 ± 2.49	32.28 ± 1.47	35.82 ± 2.34	0.45
4	36.63 ± 2.92	36.63 ± 1.91	40.52 ± 2.34	0.44
5	41.37 ± 3.58	41.97 ± 1.91	45.60 ± 2.15	0.49
6	47.33 ± 4.00	47.18 ± 2.30	51.05 ± 2.13	0.58
7	53.55 ± 3.82	53.50 ± 2.14	58.03 ± 2.12	0.44
8	57.68 ± 3.74	56.65 ± 2.37	62.37 ± 2.57	0.37
9	63.93 ± 4.26	62.40 ± 2.96	68.65 ± 3.04	0.43
10	70.15 ± 4.91	68.22 ± 3.60	74.12 ± 3.49	0.60

* Average of six values with SE

Table 4. Analysis of Covariance of fortnightly body weight of experimental calves maintained on three treatments

Fortnight	Mean sum of squares			Probability
	Treatments	Covariate	Error	
1	0.501	164.971	0.895	-
2	0.600	186.252	2.795	-
3	3.386	296.207	8.176	-
4	4.612	334.334	13.915	-
5	8.197	334.779	21.281	-
6	6.007	364.473	29.713	-
7	3.923	321.550	28.053	-
8	0.808	305.815	34.953	-
9	0.296	293.803	58.433	-
10	10.068	354.664	88.078	-

- Non-significant (P>0.05)

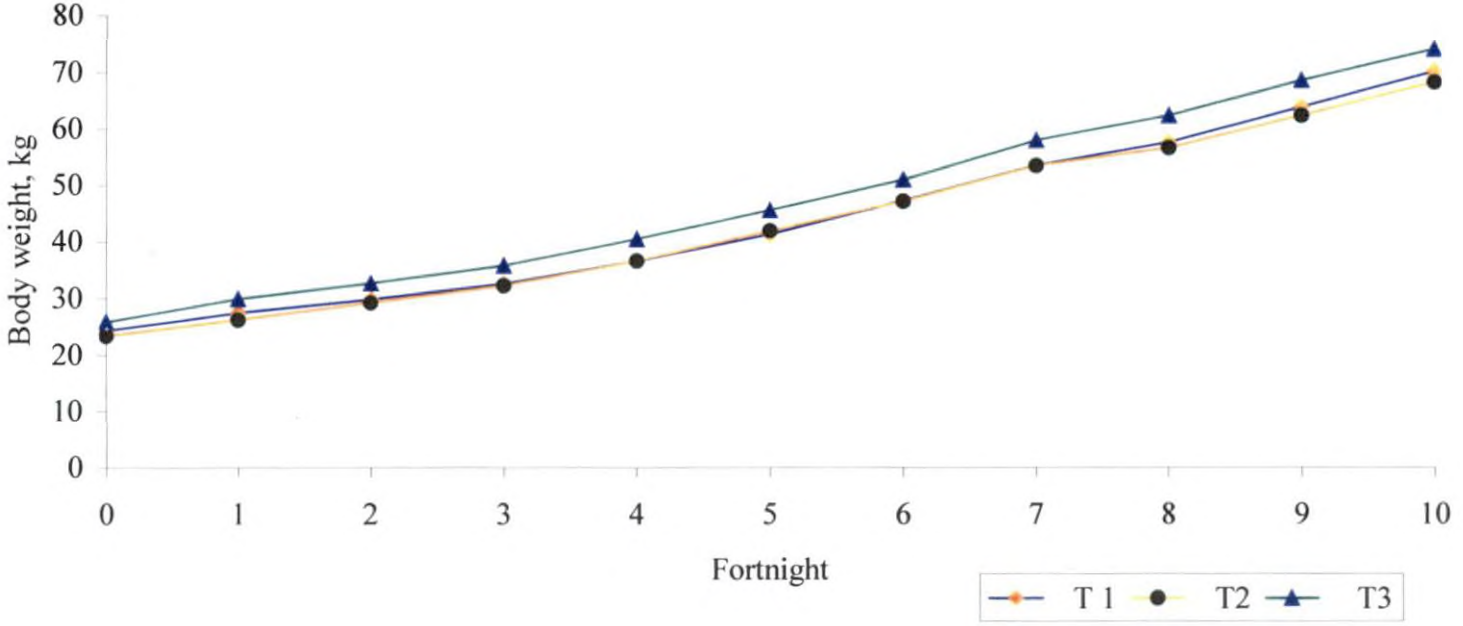

Fig. 1. Fortnightly average body weight of experimental calves

Table 5. Fortnightly cumulative average daily gain of experimental calves, g*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	208 ± 18	191 ± 30	272 ± 33	0.13
2	185 ± 23	197 ± 23	230 ± 29	0.44
3	184 ± 33	198 ± 24	221 ± 31	0.67
4	205 ± 30	221 ± 26	244 ± 30	0.63
5	227 ± 34	248 ± 21	263 ± 24	0.64
6	255 ± 33	265 ± 23	280 ± 19	0.80
7	278 ± 27	287 ± 17	306 ± 20	0.65
8	277 ± 23	277 ± 17	304 ± 19	0.57
9	293 ± 25	289 ± 20	317 ± 24	0.67
10	305 ± 27	299 ± 23	321 ± 24	0.79

*Average of six values with SE

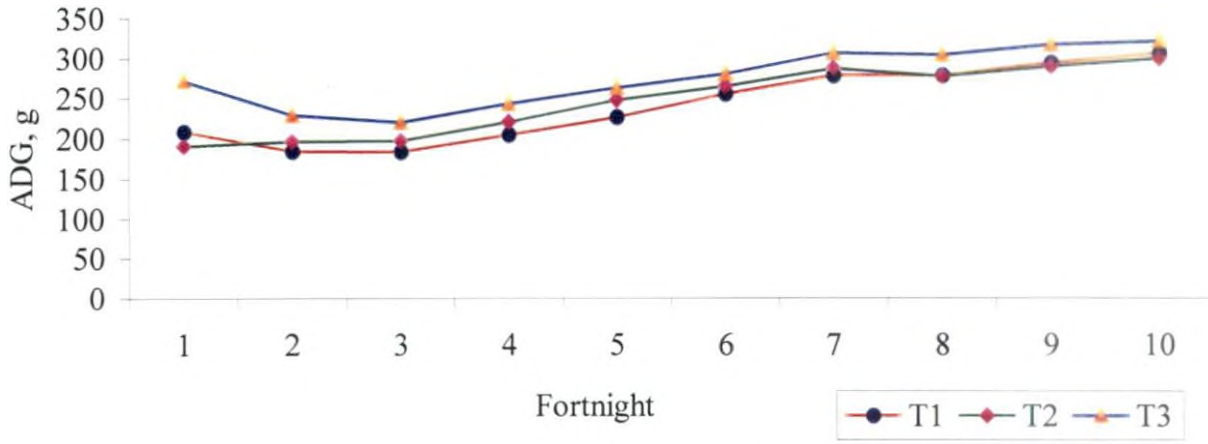

Fig. 2. Fortnightly cumulative average daily gain of experimental calves

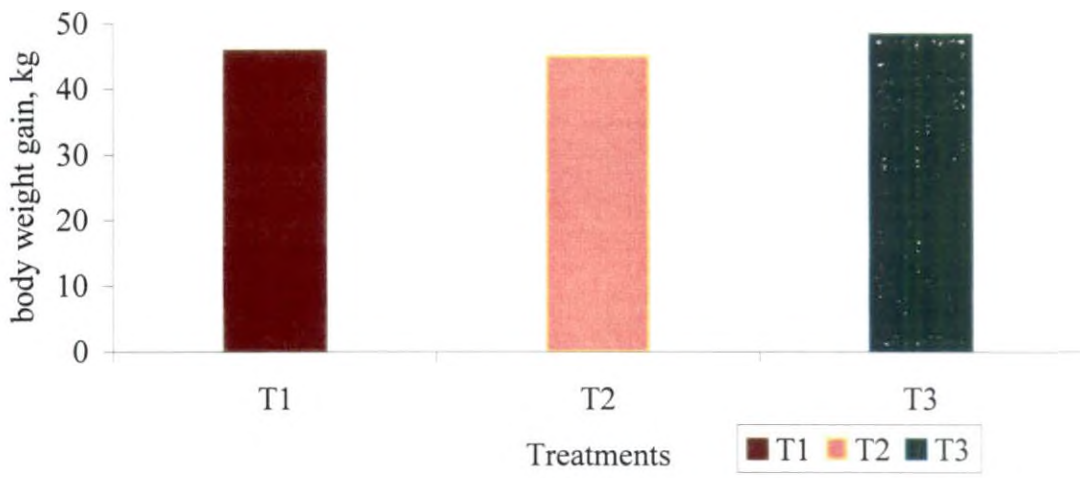

Fig. 3. Body weight gain of experimental calves

Table 6. Fortnightly average daily dry matter intake of experimental calves, kg*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	0.369 ± 0.017	0.368 ± 0.009	0.397 ± 0.015	0.32
2	0.467 ± 0.039	0.491 ± 0.033	0.527 ± 0.032	0.50
3	0.619 ± 0.073	0.701 ± 0.060	0.701 ± 0.067	0.61
4	0.933 ± 0.121	1.028 ± 0.084	1.071 ± 0.088	0.61
5	1.188 ± 0.101	1.270 ± 0.075	1.344 ± 0.089	0.48
6	1.482 ± 0.114	1.541 ± 0.065	1.726 ± 0.071	0.14
7	1.788 ± 0.152	1.794 ± 0.147	1.911 ± 0.120	0.78
8	2.018 ± 0.102	1.969 ± 0.148	2.238 ± 0.115	0.29
9	2.341^{ab} ± 0.072	2.179^{b} ± 0.138	2.596^{a} ± 0.083	0.03
10	2.682 ± 0.091	2.602 ± 0.106	2.807 ± 0.112	0.40

* Average of six values with SE

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

Table 7. Fortnightly cumulative average daily dry matter intake of experimental calves, kg *

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	0.369 ± 0.017	0.368 ± 0.009	0.397 ± 0.015	0.32
2	0.419 ± 0.027	0.430 ± 0.020	0.462 ± 0.021	0.41
3	0.486 ± 0.042	0.521 ± 0.032	0.542 ± 0.033	0.54
4	0.598 ± 0.061	0.648 ± 0.044	0.674 ± 0.044	0.56
5	0.716 ± 0.068	0.772 ± 0.050	0.808 ± 0.052	0.52
6	0.844 ± 0.075	0.900 ± 0.051	0.961 ± 0.053	0.41
7	0.979 ± 0.085	1.028 ± 0.063	1.097 ± 0.058	0.49
8	1.109 ± 0.085	1.146 ± 0.073	1.240 ± 0.064	0.45
9	1.246 ± 0.081	1.261 ± 0.079	1.390 ± 0.063	0.34
10	1.389 ± 0.080	1.430 ± 0.082	1.532 ± 0.064	0.34

* Average of six values with SE

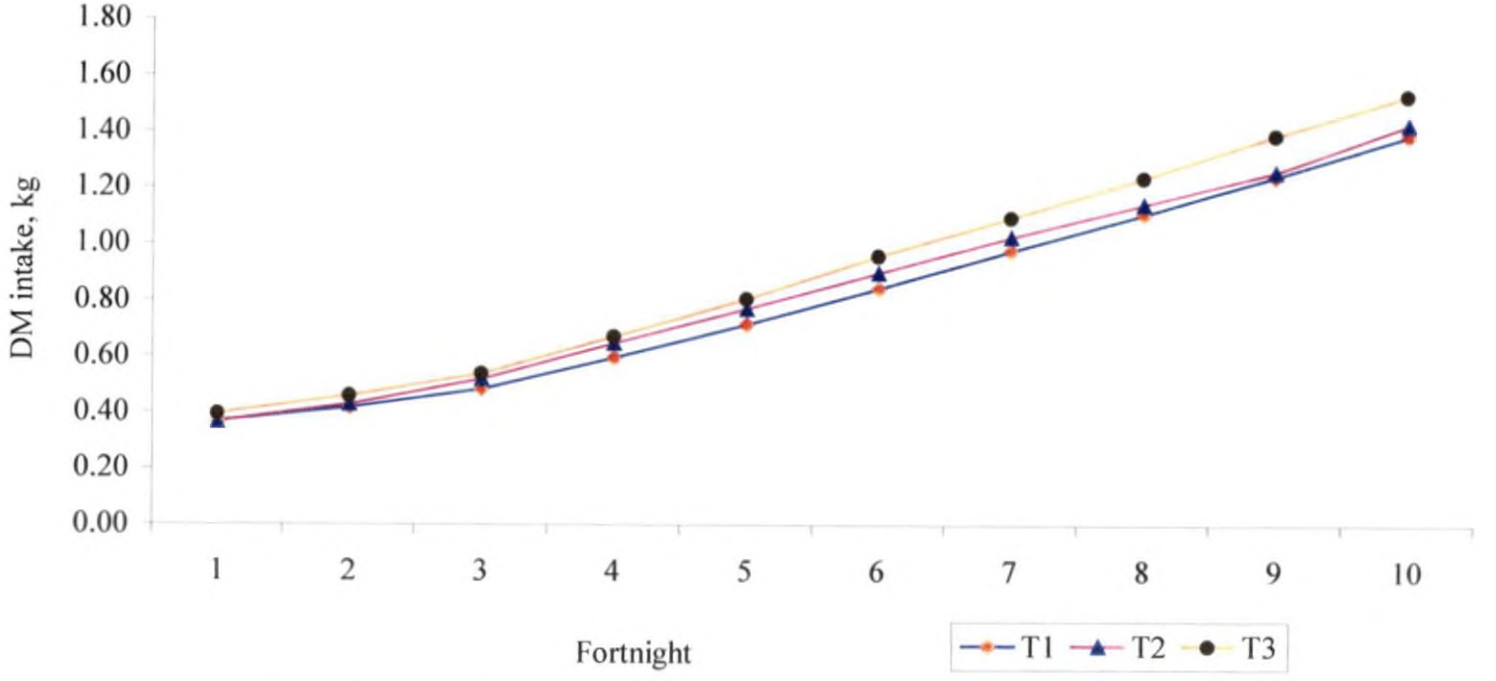

Fig. 4. Fortnightly cumulative average daily dry matter intake of experimental calves

Table 8. Fortnightly cumulative feed conversion efficiency of experimental calves (kg feed/kg gain)*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	1.83 ± 1.18	2.37 ± 0.61	1.60 ± 0.25	0.39
2	2.40 ± 0.26	2.39 ± 0.37	2.22 ± 0.35	0.91
3	2.92 ± 0.38	2.84 ± 0.41	2.70 ± 0.38	0.92
4	3.04 ± 0.23	3.07 ± 0.32	2.89 ± 0.22	0.87
5	3.29 ± 0.24	3.16 ± 0.18	3.12 ± 0.17	0.83
6	3.39 ± 0.21	3.45 ± 0.17	3.46 ± 0.16	0.96
7	3.55 ± 0.16	3.58 ± 0.11	3.60 ± 0.16	0.96
8	4.01 ± 0.13	4.13 ± 0.12	4.10 ± 0.16	0.82
9	4.29 ± 0.14	4.24 ± 0.18	4.45 ± 0.23	0.72
10	4.61 ± 0.18	4.85 ± 0.22	4.83 ± 0.24	0.68

* Average of six values with SE

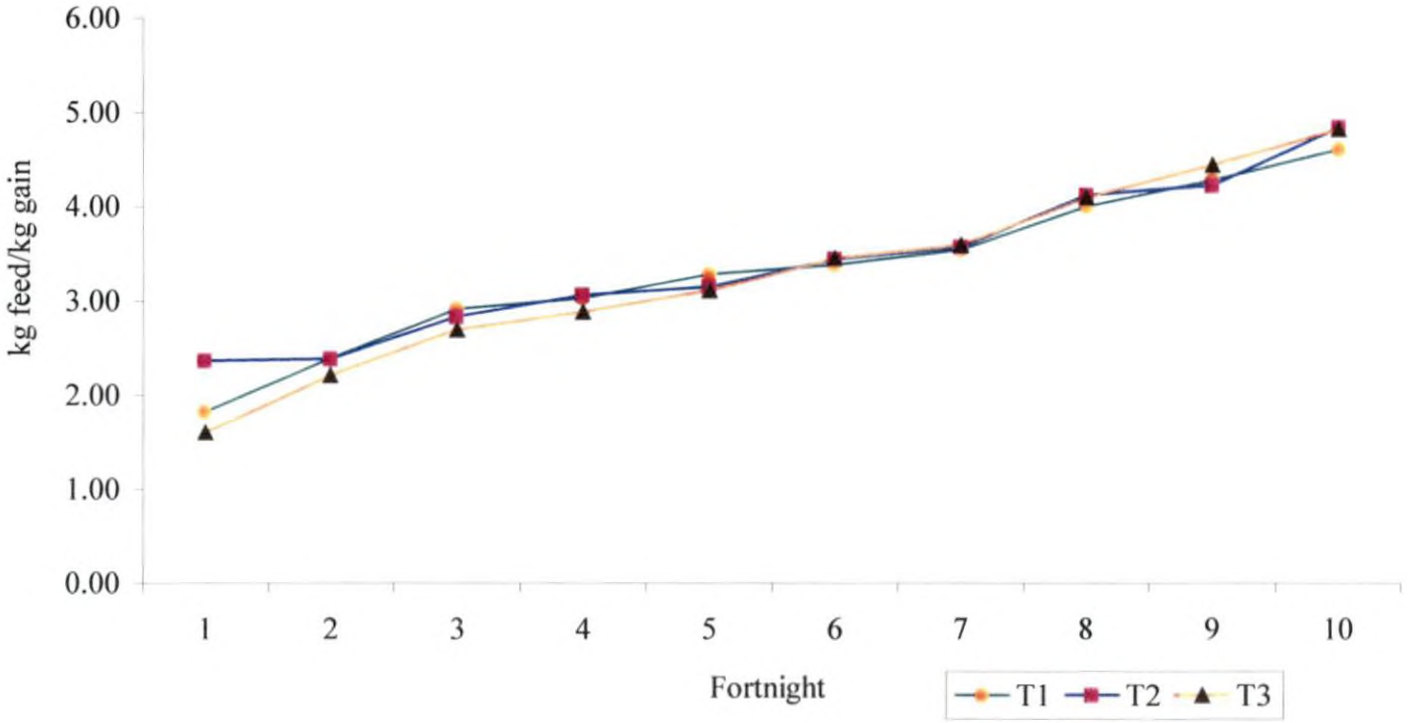

Fig. 5. Fortnightly cumulative mean feed efficiency ratio of experimental calves

Table 9. Summary of performance of experimental calves*

Items	Treatments			P value
	T_1	T_2	T_3	
Initial body weight, kg	24.33 ± 1.50	23.33 ± 0.49	25.83 ± 1.66	0.42
Final body weight, kg	70.15 ± 4.91	68.22 ± 3.60	74.12 ± 3.49	0.60
Total body weight gain, kg	45.82 ± 4.09	44.89 ± 3.54	48.29 ± 3.67	0.79
Average daily gain, g	305 ± 27	299 ± 23	321 ± 24	0.79
Total dry matter intake in 150 days (kg/calf)	208.71 ± 11.44	214.50 ± 12.58	230.49 ± 9.24	0.27
Average dry matter intake (kg/day/calf)	1.39 ± 0.07	1.43 ± 0.08	1.53 ± 0.06	0.34
Dry matter intake per 100 kg body weight, kg	2.76 ± 0.28	2.83 ± 0.25	2.83 ± 0.28	0.98
Feed efficiency (kg feed/kg gain)	4.61 ± 0.18	4.85 ± 0.22	4.83 ± 0.24	0.68

* Average of six values with SE

Table 10. Chemical composition of dung of experimental calves, %*

Item	Treatments			P value
	T_1	T_2	T_3	
Dry matter	19.98 ± 0.96	20.30 ± 0.44	19.43 ± 0.32	0.63
Crude protein	13.88 ± 0.42	12.64 ± 0.29	13.08 ± 0.54	0.15
Ether extract	1.83 ± 0.37	1.53 ± 0.15	1.61 ± 0.33	0.77
Crude fibre	21.96 ± 0.77	22.55 ± 0.76	22.21 ± 0.84	0.87
Total ash	20.70 ± 0.41	19.94 ± 0.38	19.33 ± 0.38	0.07
NFE	41.61 ± 1.27	43.33 ± 1.02	43.74 ± 1.18	0.41
Acid insoluble ash	13.61 ± 0.30	14.06 ± 0.62	13.16 ± 0.52	0.47
NDF	52.80 ± 1.44	54.08 ± 1.56	51.44 ± 2.79	0.66
ADF	41.26 ± 0.83	40.67 ± 1.49	39.40 ± 1.80	0.65
Calcium	1.29 ± 0.17	1.02 ± 0.07	1.09 ± 0.11	0.34
Phosphorus	0.74 ± 0.06	0.63 ± 0.05	0.70 ± 0.05	0.40

* Average of six values with SE

Table 11. Digestibility coefficient of nutrients of experimental calves, % *

Item	Treatments			P value
	T_1	T_2	T_3	
Dry matter	62.26 ± 1.64	59.15 ± 1.13	60.00 ± 1.95	0.38
Crude protein	64.92 ± 2.05	64.89 ± 0.84	64.91 ± 0.88	0.99
Crude fibre	66.21 ± 0.76	62.25 ± 2.44	65.17 ± 2.39	0.38
Ether extract	70.83 ± 4.20	72.40 ± 3.16	70.13 ± 7.77	0.95
NDF	61.39 ±1.01	58.32 ± 2.64	62.50 ± 3.06	0.46
ADF	49.81 ± 2.43	47.92 ± 2.86	51.52 ± 4.2	0.74
NFE	66.72 ± 2.57	62.64 ± 1.01	62.75 ± 2.10	0.29

* Average of six values with SE

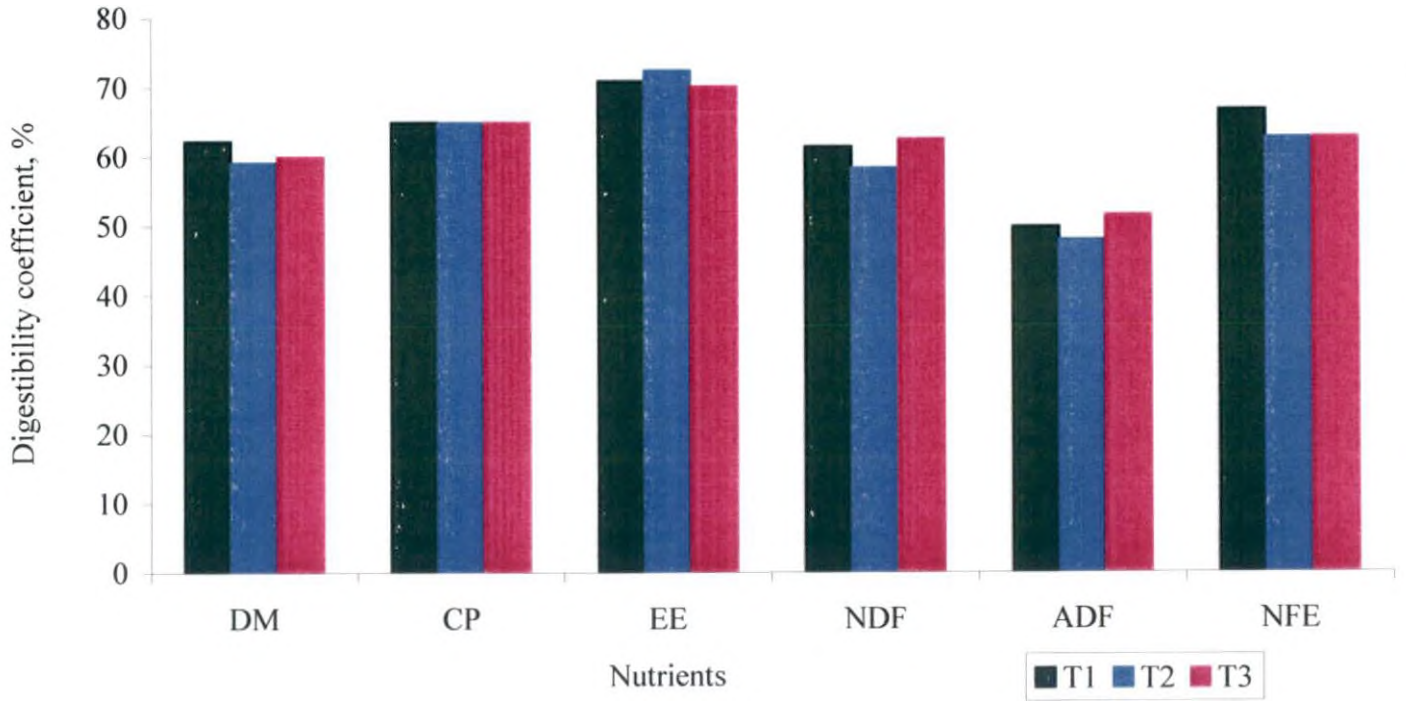

Fig. 6. Digestibility coefficient of nutrients of experimental calves

Table 12. Blood glucose of experimental calves, mg/dl *

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	87.82 ± 4.86	83.52 ± 2.62	85.79 ± 4.40	0.76
2	75.65 ± 3.08	76.43 ± 1.89	80.49 ± 3.08	0.42
3	78.69 ± 7.66	75.04 ± 5.56	67.14 ± 2.53	0.36
4	71.77 ± 6.23	66.62 ± 8.50	64.09 ± 5.55	0.72
5	79.23 ± 4.18	76.07 ± 4.09	66.10 ± 4.23	0.72
6	73.82 ± 1.68	72.99 ± 3.06	66.23 ± 3.88	0.18
7	83.46 ± 4.41	82.01 ± 1.58	76.87 ± 7.14	0.62
8	76.29 ± 3.28	74.43 ± 2.10	68.98 ± 3.04	0.20
9	75.36 ± 5.11	69.10 ± 5.16	67.82 ± 5.95	0.58
10	76.88 ± 5.71	74.09 ± 6.23	63.91 ± 3.62	0.22

* Average of six values with SE

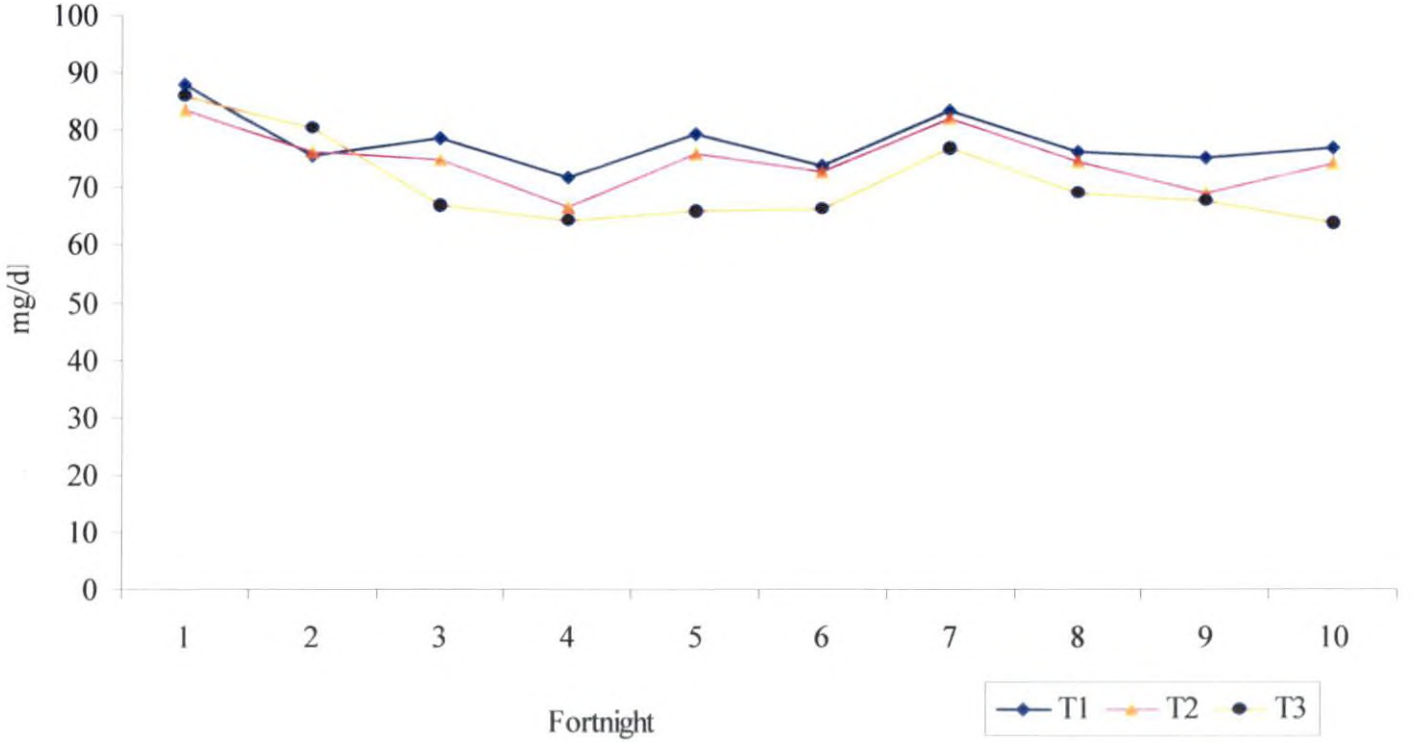

Fig. 7. Blood glucose of experimental calves

Table 13. Plasma AST of experimental calves, IU/dl*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	52.14 ± 8.18	60.51 ± 8.72	57.82 ± 2.84	0.70
2	39.11 ± 1.12	32.55 ± 4.28	47.60 ± 7.19	0.12
3	55.64 ± 1.96	52.20 ± 2.17	69.88 ± 8.58	0.06
4	56.71 ± 9.40	47.12 ± 6.09	49.38 ± 9.90	0.71
5	64.77 ± 3.84	64.26 ± 5.38	65.30 ± 7.01	0.99
6	65.75 ± 3.37	62.43 ± 2.54	63.49 ± 2.47	0.70
7	59.26 ± 2.49	68.58 ± 3.98	61.57 ± 2.48	0.11
8	56.60 ± 3.00	62.48 ± 2.42	61.61 ± 1.49	0.20
9	56.50 ± 2.46	60.05 ± 3.99	61.92 ± 1.94	0.43
10	53.16 ± 1.58	58.24 ± 2.16	60.25 ± 2.25	0.06

*Average of six values with SE

Table14. Total bilirubin of experimental calves, mg/dl*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	0.23 ± 0.03	0.20 ± 0.03	0.18 ± 0.04	0.62
2	0.18 ± 0.03	0.16 ± 0.03	0.20 ± 0.03	0.73
3	0.20 ± 0.03	0.23 ± 0.04	0.20 ± 0.03	0.78
4	0.16 ± 0.03	0.18 ± 0.04	0.16 ± 0.03	0.93
5	0.20 ± 0.03	0.23 ± 0.03	0.16 ± 0.03	0.41
6	0.11 ± 0.01	0.15 ± 0.02	0.11 ± 0.01	0.37
7	0.21 ± 0.03	0.18 ± 0.03	0.18 ± 0.04	0.73
8	0.18 ± 0.03	0.13 ± 0.02	0.15 ± 0.03	0.48
9	0.23 ± 0.04	0.15 ± 0.03	0.13 ± 0.02	0.11
10	0.18 ± 0.04	0.16 ± 0.03	0.13 ± 0.02	0.55

*Average of six values with SE

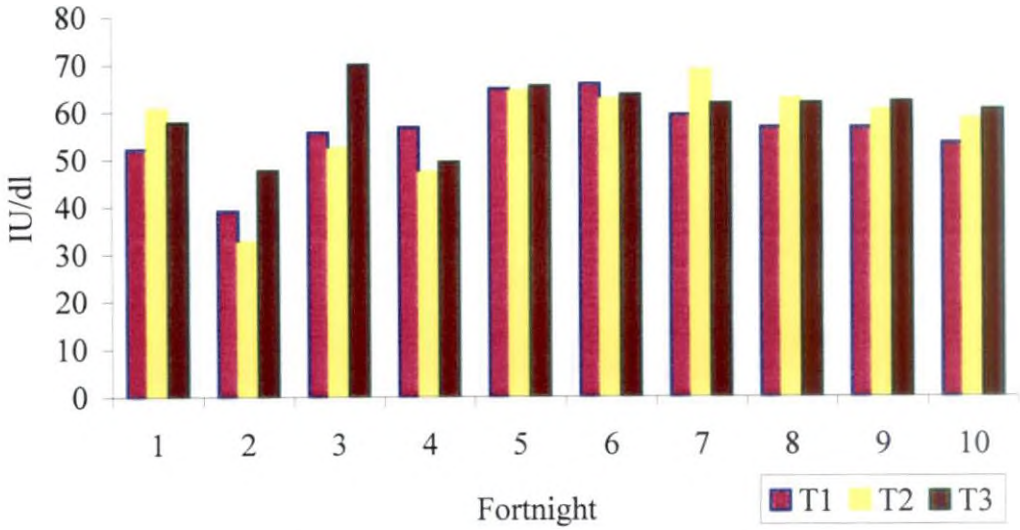

Fig. 8. Plasma AST of experimental calves

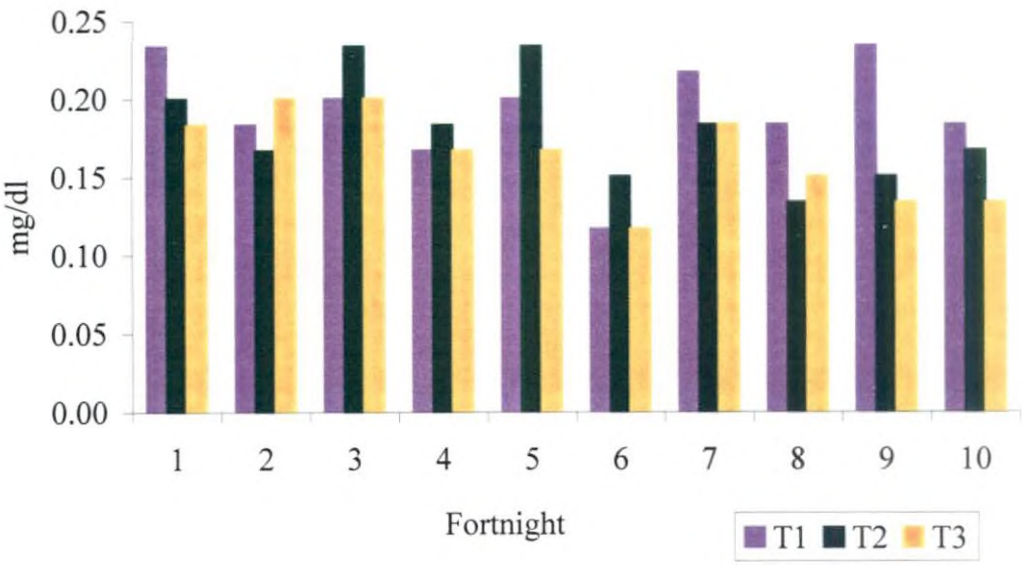

Fig. 9. Total bilirubin of experimental calves

Table 15. Blood urea nitrogen of experimental calves, mg/dl *

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	11.61 ± 0.88	11.90 ± 0.78	12.78 ± 1.24	0.71
2	13.14 ± 0.61	12.88 ± 0.83	13.67 ± 0.69	0.73
3	13.95 ± 1.90	13.39 ± 1.77	14.05 ± 0.94	0.95
4	13.91 ± 1.07	12.91 ± 0.99	13.81 ± 1.93	0.85
5	17.54 ± 1.19	17.46 ± 1.79	18.99 ± 1.82	0.76
6	12.64 ± 0.67	13.62 ± 0.65	14.55 ± 0.63	0.15
7	15.75 ± 1.03	16.76 ± 0.93	15.73 ± 1.19	0.73
8	13.49 ± 1.20	14.08 ± 1.10	14.23 ± 0.87	0.87
9	12.37 ± 0.78	10.86 ± 1.25	12.42 ± 1.47	0.59
10	10.24 ± 0.78	11.04 ± 1.39	12.17 ± 1.28	0.52

* Average of six values with SE

Table 16. Plasma creatinine of experimental calves, mg/dl *

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	1.18 ± 0.05	1.21 ± 0.05	1.11 ± 0.07	0.48
2	1.11 ± 0.10	1.24 ± 0.05	1.15 ± 0.04	0.43
3	1.25 ± 0.09	1.3 ± 0.09	1.14 ± 0.08	0.51
4	0.97 ± 0.08	1.08 ± 0.06	1.10 ± 0.07	0.46
5	1.04 ± 0.03	1.02 ± 0.06	1.12 ± 0.09	0.50
6	1.06 ± 0.12	1.04 ± 0.06	1.05 ± 0.08	0.98
7	1.14 ± 0.13	1.01 ± 0.14	0.98 ± 0.06	0.61
8	1.08 ± 0.07	0.94 ± 0.15	1.07 ± 0.05	0.59
9	0.68 ± 0.12	0.61 ± 0.11	0.56 ± 0.14	0.79
10	0.93 ± 0.07	0.68 ± 0.11	0.80 ± 0.11	0.26

* Average of six values with SE

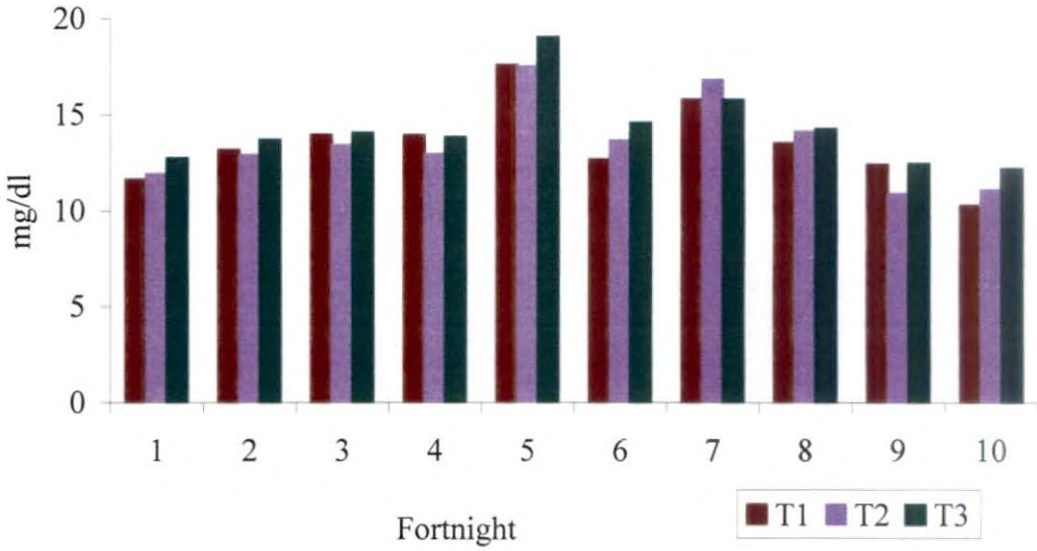

Fig.10. Blood urea nitrogen of experimental calves

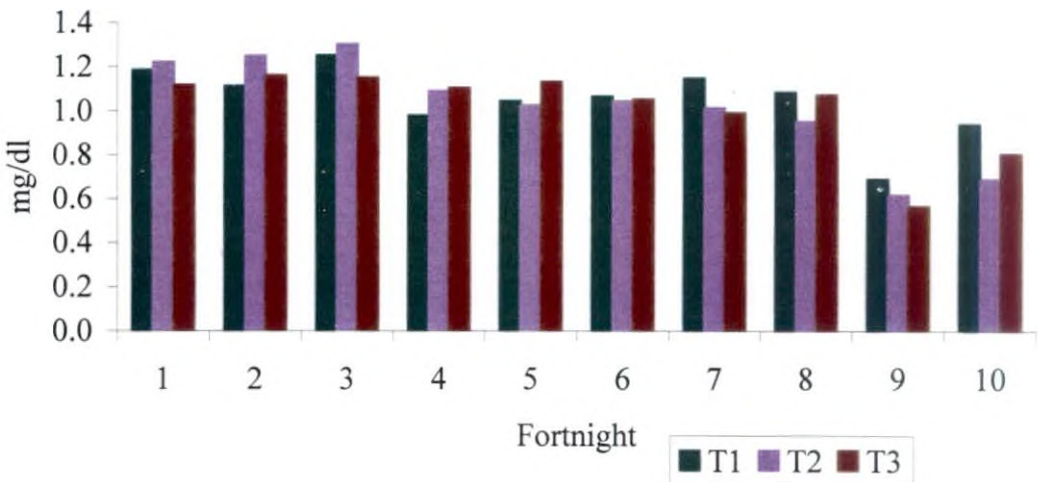

Fig. 11. Plasma creatinine of experimental calves

Table 17. Plasma total protein of experimental calves, g/dl*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	6.92 ± 0.15	6.81 ± 0.17	7.01 ± 0.17	0.69
2	6.80 ± 0.21	6.59 ± 0.16	6.83 ± 0.15	0.58
3	6.31 ± 0.17	6.74 ± 0.16	6.69 ± 0.19	0.22
4	6.55 ± 0.20	6.76 ± 0.23	6.47 ± 0.11	0.55
5	6.35 ± 0.11	6.30 ± 0.26	6.40 ± 0.07	0.91
6	6.58 ± 0.14	6.80 ± 0.09	6.69 ± 0.12	0.45
7	6.36 ± 0.22	6.46 ± 0.18	6.65 ± 0.17	0.57
8	6.68 ± 0.10	6.60 ± 0.19	6.91 ± 0.12	0.32
9	6.56 ± 0.11	6.71 ± 0.15	6.82 ± 0.12	0.38
10	6.64 ± 0.15	6.19 ± 0.17	6.65 ± 0.11	0.08

* Average of six values with SE

Table 18. Plasma albumin of experimental calves, g/dl *

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	2.74 ± 0.16	2.60 ± 0.06	3.08 ± 0.18	0.10
2	2.80 ± 0.14	2.73 ± 0.13	2.80 ± 0.09	0.88
3	2.97 ± 0.14	3.09 ± 0.10	2.91 ± 0.36	0.86
4	2.59 ± 0.16	2.64 ± 0.16	2.39 ± 0.26	0.64
5	2.87 ± 0.17	2.75 ± 0.17	2.83 ± 0.29	0.93
6	2.64 ± 0.21	2.99 ± 0.18	2.85 ± 0.17	0.45
7	3.01 ± 0.17	2.83 ± 0.02	3.19 ± 0.08	0.12
8	2.79 ± 0.15	2.75 ± 0.06	3.15 ± 0.16	0.11
9	2.66 ± 0.04	2.76 ± 0.04	2.84 ± 0.05	0.07
10	2.69 ± 0.31	2.83 ± 0.19	2.34 ± 0.42	0.56

* Average of six values with SE

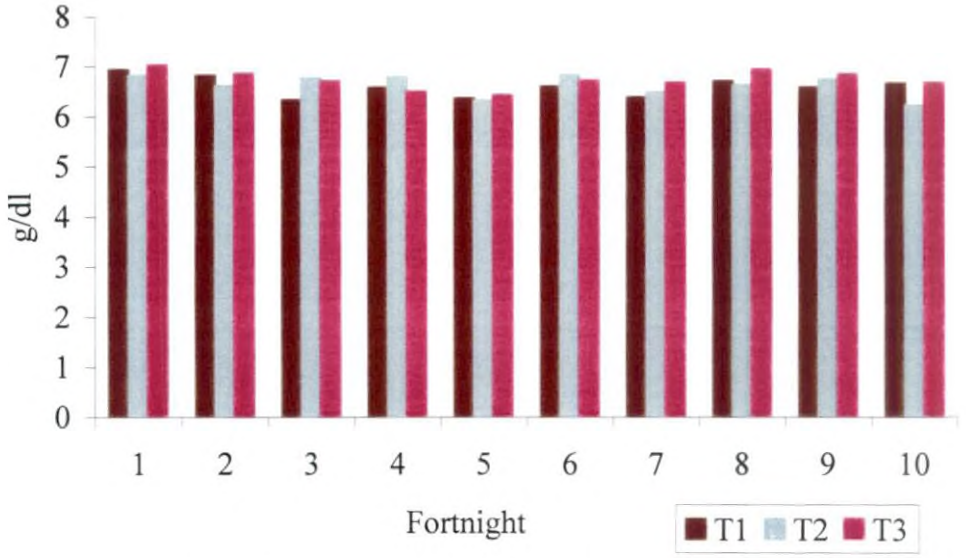

Fig. 12. Plasma total protein of experimental calves

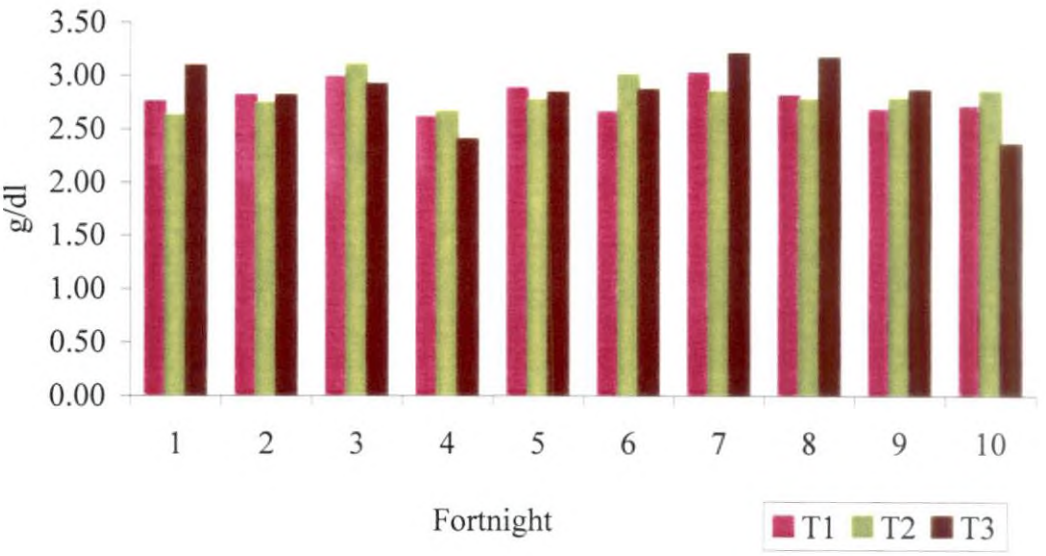

Fig. 13. Plasma albumin of experimental calves

Table 19. Plasma globulin of experimental calves, g/dl*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	4.17 ± 0.25	4.19 ± 0.13	3.93 ± 0.11	0.51
2	4.00 ± 0.16	3.86 ± 0.17	4.03 ± 0.12	0.73
3	3.34 ± 0.27	3.65 ± 0.11	3.78 ± 0.35	0.49
4	3.96 ± 0.12	4.12 ± 0.23	4.08 ± 0.24	0.85
5	3.48 ± 0.17	3.54 ± 0.32	3.57 ± 0.35	0.97
6	3.93 ± 0.21	3.81 ± 0.24	3.84 ± 0.16	0.91
7	3.35 ± 0.19	3.76 ± 0.14	3.46 ± 0.13	0.18
8	3.89 ± 0.21	3.84 ± 0.17	3.76 ± 0.27	0.92
9	3.89 ± 0.11	3.94 ± 0.18	3.97 ± 0.15	0.94
10	3.94 ± 0.20	3.36 ± 0.25	4.30 ± 0.49	0.17

* Average of six values with SE

Table 20. A: G ratio of experimental calves, *

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	0.68 ± 0.07	0.62 ± 0.02	0.79 ± 0.05	0.15
2	0.70 ± 0.04	0.71 ± 0.05	0.70 ± 0.03	0.96
3	0.93 ± 0.11	0.84 ± 0.03	0.83 ± 0.13	0.76
4	0.65 ± 0.04	0.65 ± 0.06	0.61 ± 0.10	0.89
5	0.84 ± 0.08	0.82 ± 0.10	0.86 ± 0.14	0.97
6	0.69 ± 0.08	0.81 ± 0.09	0.75 ± 0.07	0.62
7	0.91 ± 0.07	0.75 ± 0.03	0.92 ± 0.04	0.07
8	0.73 ± 0.07	0.72 ± 0.03	0.88 ± 0.12	0.38
9	0.68 ± 0.02	0.71 ± 0.04	0.72 ± 0.03	0.78
10	0.70 ± 0.10	0.89 ± 0.14	0.64 ± 0.18	0.49

* Average of six values with SE

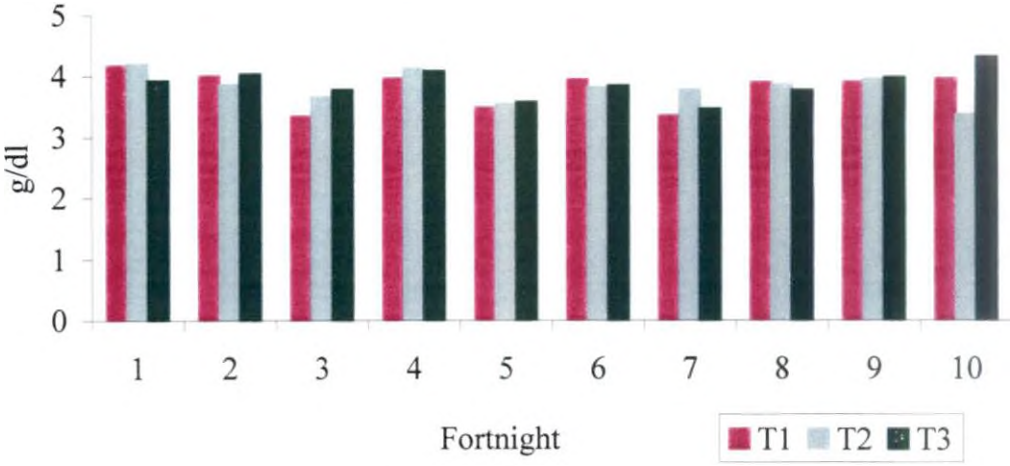

Fig. 14. Plasma globulin of experimental calves

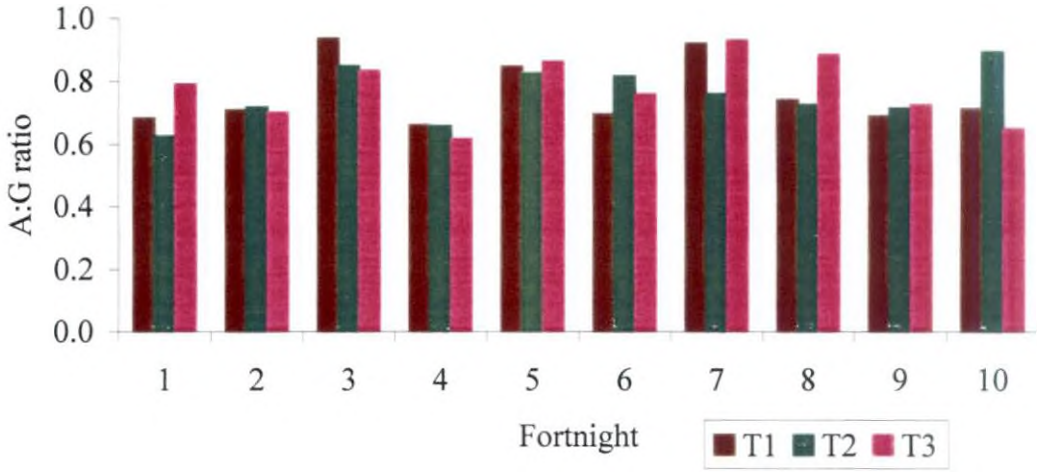

Fig. 15. A: G ratio of experimental calves

Table 21. Urinary urea excretion of experimental calves, g/l*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	28.37 ± 3.16	26.53 ± 1.91	23.80 ± 2.39	0.46
2	21.52 ± 2.76	21.45 ± 2.14	19.65 ± 1.70	0.80
3	23.84 ± 1.87	20.29 ± 2.09	20.66 ± 3.40	0.56
4	15.57 ± 1.92	16.11 ± 1.80	13.36 ± 1.44	0.51
5	9.54^{ab} ± 1.22	7.13 ^{b}± 0.69	14.15^{a} ± 2.26	0.01
6	9.22 ± 1.89	10.50 ± 2.34	14.84 ± 2.29	0.19
7	9.93 ± 2.04	11.79 ± 1.83	9.11 ± 2.53	0.67
8	5.13 ± 2.09	5.25 ± 0.77	6.21 ± 1.22	0.85
9	7.14 ± 2.38	7.38 ± 1.11	8.59 ± 0.90	0.79
10	8.91 ± 1.24	9.71 ± 1.11	8.89 ± 1.09	0.84

*Average of six values with SE
a, b –means with different superscripts in the same row differ significantly ($P<0.05$)

Table 22. Urinary creatinine excretion of experimental calves, g/l*

Fortnight	Treatments			P value
	T_1	T_2	T_3	
1	0.58 ± 0.04	0.59 ± 0.04	0.56 ± 0.03	0.90
2	0.57 ± 0.08	0.56 ± 0.03	0.60 ± 0.05	0.90
3	0.60 ± 0.15	0.57 ± 0.05	0.58 ± 0.08	0.98
4	0.65 ± 0.08	0.62 ± 0.04	0.58 ± 0.02	0.75
5	0.57 ± 0.05	0.53 ± 0.12	0.62 ± 0.11	0.81
6	0.65 ± 0.03	0.54 ± 0.04	0.69 ± 0.13	0.43
7	0.51 ± 0.09	0.61 ± 0.12	0.60 ± 0.05	0.72
8	0.74 ± 0.08	0.65 ± 0.09	0.68 ± 0.04	0.71
9	0.60 ± 0.04	0.61 ± 0.03	0.58 ± 0.03	0.86
10	0.61 ± 0.03	0.62 ± 0.05	0.60 ± 0.03	0.94

* Average of six values with SE

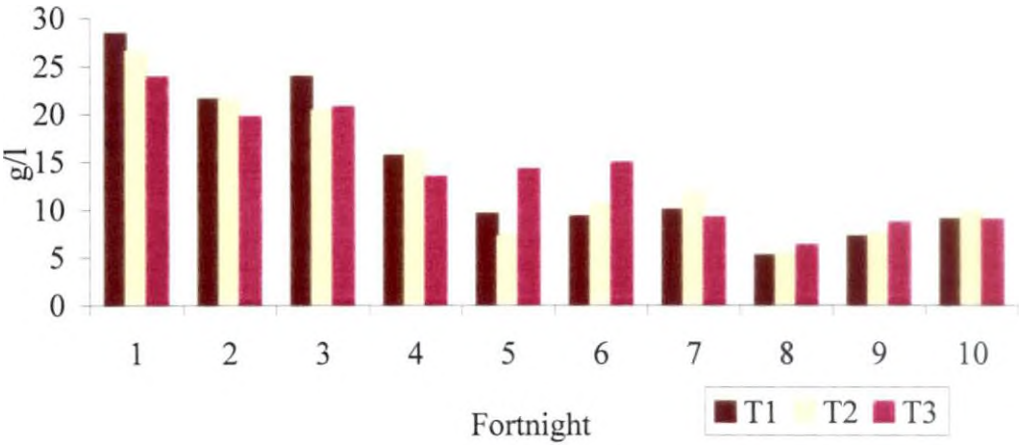

Fig. 16. Urinary urea excretion of experimental calves

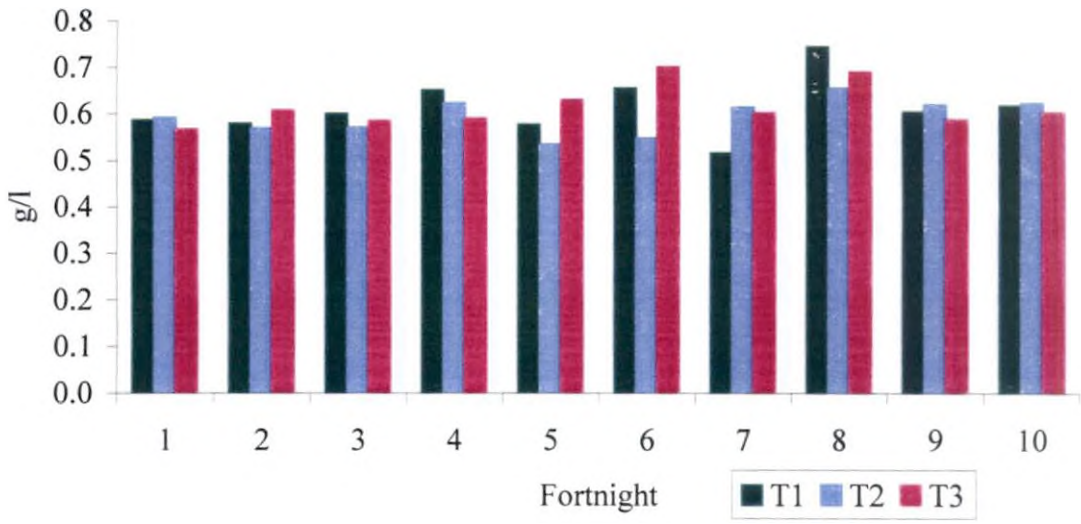

Fig. 17. Urinary creatinine excretion of experimental calves

Table 23. Rumen liquor parameter of experimental calves *

Parameter	Month	Treatments			P value
		T_1	T_2	T_3	
Rumen pH	2 nd	6.21 ± 0.05	6.33 ± 0.04	6.27 ± 0.05	0.24
	3 rd	6.44 ± 0.04	6.44 ± 0.08	6.33 ± 0.03	0.32
	4 th	6.70 ± 0.03	6.62 ± 0.07	6.63 ± 0.04	0.53
	5 th	6.73 ± 0.08	6.63 ± 0.13	6.81 ± 0.06	0.44
Methylene Blue Reduction Test (MBRT) (min)	2 nd	2.08 ± 0.15	2.08 ± 0.15	2.00 ± 0.12	0.89
	3 rd	2.00 ± 0.00	1.91 ± 0.08	1.91 ± 0.08	0.61
	4 th	1.33 ± 0.10	1.66 ± 0.10	1.33 ± 0.10	0.06
	5 th	1.08 ± 0.08	1.25 ± 0.11	1.16 ± 0.10	0.52
Rumen NH_3-N mg/dl	2 nd	11.56 ± 2.55	8.49 ± 2.14	10.97 ± 1.58	0.56
	3 rd	11.92 ± 3.06	8.98 ± 1.86	14.90 ± 2.99	0.32
	4 th	8.98 ± 1.47	20.61 ± 2.96	17.59 ± 4.60	0.06
	5 th	19.82 ± 3.98	16.66 ± 3.37	18.53 ± 1.95	0.78
Total volatile fatty acid mmol/l	2 nd	120.08 ± 13.45	105.41 ± 11.53	125.00 ± 12.63	0.53
	3 rd	123.16 ± 06.78	108.25 ± 6.84	115.16 ± 9.41	0.41
	4 th	85.66 ± 10.81	84.33 ± 8.32	86.41 ± 10.19	0.98
	5 th	85.50 ± 7.79	90.08 ± 8.29	90.66 ± 5.51	0.86

* Average of six values with SE

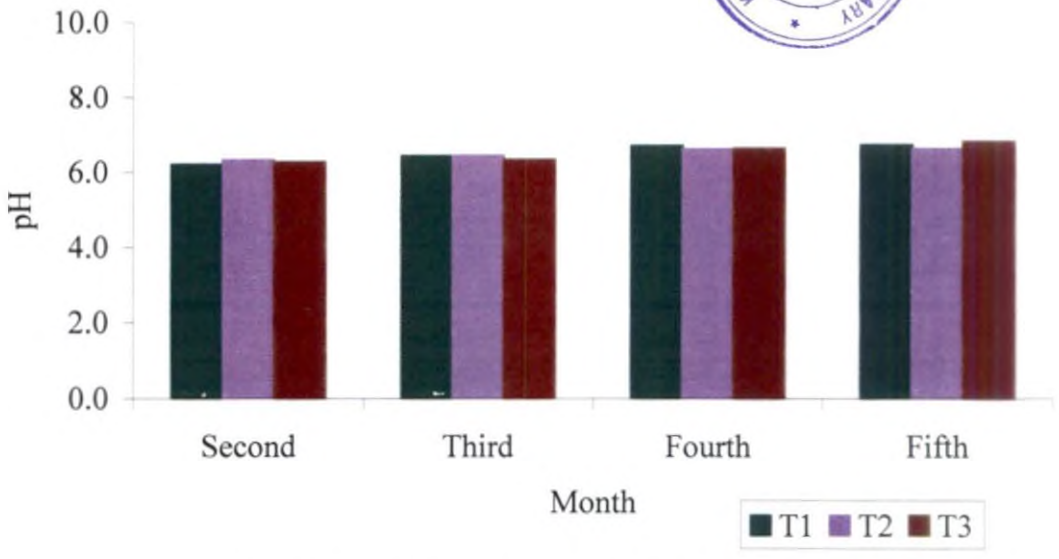

Fig. 18. Rumen pH of experimental calves

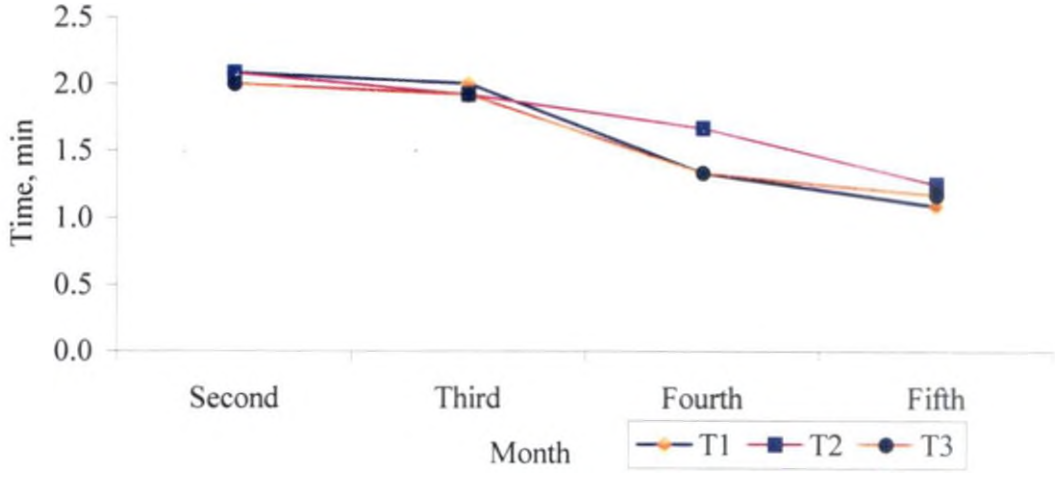

Fig. 19. Methylene Blue Reduction Test in experimental calves

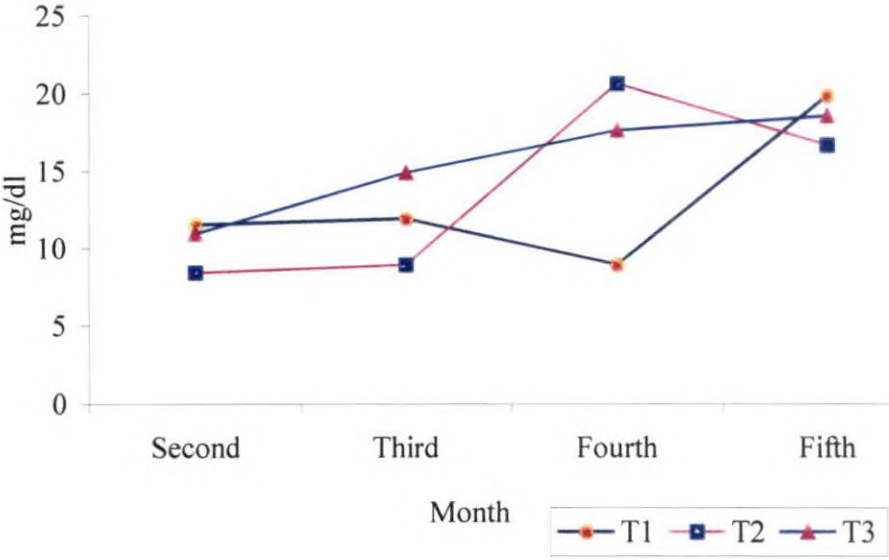

Fig. 20. Rumen NH3-N of experimental calves

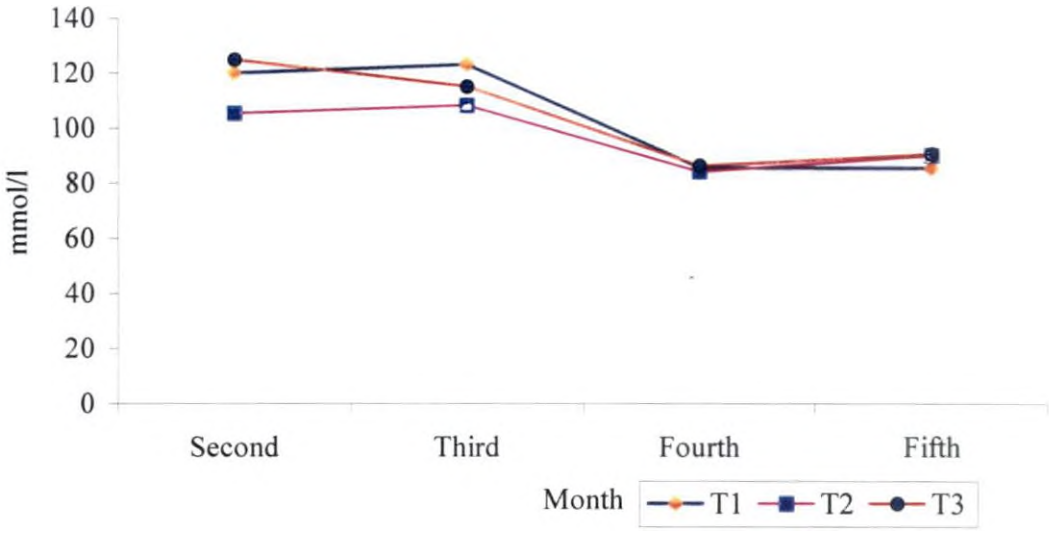

Fig. 21. Rumen Volatile fatty acid of experimental calves

Table 24. Protozoal activity in rumen liquor of experimental calves

Treatment	Replicate	2nd month	3rd month	4th month	5th month
T_1	1	-	+	+++	+++
	2	-	+	+ +	+++
	3	+	+++	+++	+++
	4	-	+	++	+++
	5	+	++	+++	+++
	6	+	+++	+++	+++
T_2	1	-	+	++	+++
	2	+	+	++	+++
	3	+	++	+++	+++
	4	+	+++	+++	+++
	5	++	+++	+++	+++
	6	+	++	+++	+++
T_3	1	+	+	+++	+++
	2	++	++	+++	+++
	3	++	+++	+++	+++
	4	+	++	+++	+++
	5	-	+	+++	+++
	6	++	++	+++	+++

- Nil
+ Less activity
++ Moderate activity
+++ Normal activity

Table 25. Economics of production of experimental calves *

Parameter	Treatments		
	T_1	T_2	T_3
Total milk intake (kg/calf)	169.75 ± 3.25	167.5 ± 2.5	175.0 ± 3.16
Total calf starter intake (kg/calf)	91.4 ± 4.00	91.52 ± 5.01	94.21 ± 3.41
Total grass intake (kg/calf)	205.13 ± 27.87	201.00 ± 30.56	254.76 ± 16.29
Total paddy straw intake (kg/calf)	63.27 ± 5.87	71.82 ± 2.63	70.36 ± 7.97
Total cost of feed (Rs/calf)	3366	3283	3413
Total weight gain (kg/calf)	45.82	44.89	48.29
Cost/kg gain (Rs)	73.45	73.13	70.67

* Average of six values with SE

Discussion

5. DISCUSSION

5.1 GROWTH RESPONSE

From the result presented in Table 3 and 4, it could be seen that there was no significant difference ($P>0.05$) in the average fortnightly body weight of calves maintained on three treatments T_1, T_2 and T_3. Similarly, total weight gain of calves maintained on three treatments did not differ significantly ($P>0.05$). The partial replacement of soyabean meal with urea did not limit the growth of calves might be due to the sufficient level of high quality protein available from soyabean meal and also the presence of microbial population in the rumen. This is in agreement with Kay *et al.* (1967). Similarly, Sharma *et al.* (1983) observed no significant difference when ten per cent of equivalent protein in groundnut cake was replaced with urea after third month. In contrary to this Stobo *et al.* (1967) observed significant reduction ($P< 0.05$) in urea fed group.

Data on fortnightly cumulative average daily gain (Table 5) indicated that there was no significant difference between three treatments T_1, T_2 and T_3. Leibholz and Kang (1973) found that there was no significant difference in average daily gain of calves fed with urea (0.71 kg per day) and soyabean meal or meat meal (0.70 kg per day) supplemented diet. These findings are in line with the present results. Contrary to above finding, Miron *et al.* (1968) and Daniel *et al.* (1986) observed significant reduction ($P<0.01$) in average daily gain in urea fed calves.

5.2 DRY MATTER INTAKE

Average dry matter intake (kg per day) and DMI per100 kg body weight were 1.39 and 2.76 kg for T_1, 1.43 and 2.83 kg for T_2, 1.53 and 2.83 kg for T_3, respectively. Fortnightly cumulative average DMI is illustrated in Fig. 4.

Fortnightly average dry matter intake did not differ significantly, except at ninth fortnight among treatments (Table 6).

The result observed in this study is in accordance with Kay *et al.* (1967); Miron *et al.* (1967); Morrill and Dayton (1978), who did not observe significant differences in DMI between urea and soyabean meal fed calves. Pande and Shukla (1979) also did not observe significant difference in DMI in male surti buffalo calves when 20 per cent DCP, recommended by Sen and Ray (1971) was replaced with urea. Similarly Bhakt *et al.* (1997) also did not observe any differences between groundnut cake and urea treated deoiled salseed meal fed calves.

5.3 FEED EFFICIENCY

The average feed to gain ratio obtained in the present study was 4.61, 4.85 and 4.83, respectively for the calves in the treatment T_1, T_2 and T_3, and the values are presented in Table 8. There was no significant difference between the treatments ($P>0.05$). This was in agreement with Brown *et al.* (1956), who did not observe significant ($P>0.05$) difference in feed efficiency ratio when low protein diet (6.5 per cent CP) was increased to 15.1 per cent CP by adding urea to the diet. Leibholz and Kang (1973) have obtained results in accordance with the present study.

In contradiction to this, Fiems *et al.* (1987) reported replacing soyabean meal with urea (half of the protein in the diets) gave poorer feed efficiency in calf. Similarly, Saha and Gupta (1988) also observed significantly poorer ($P<0.05$) feed efficiency while supplementing urea in the diet.

5.4 DIGESTIBILITY COEFFICIENT

Digestibility coefficient for dry matter observed in the present study was 62.26, 59.15 and 60.00 for the calves in the three treatments T_1, T_2 and T_3, respectively. There was no significant difference ($P>0.05$) in digestibility among the

treatments. In agreement with this present result, Bhakt *et al.* (1997) also reported that there was no difference in dry matter digestibility in calves when groundnut cake meal was replaced with urea treated deoiled sal seed meal. In contrast to this, Leibholz and Kang (1973) observed significantly higher ($P<0.05$) dry matter digestibility in urea supplemented diets.

Digestibility coefficient of crude protein, as presented in Table 11 was 64.92, 64.89 and 64.91 for the three treatments T_1, T_2 and T_3, respectively. There was no significant difference between treatments. In agreement with the present study, Pande and Shukla (1979) did not observe significant reduction in digestibility of crude protein when 20 per cent of digestible crude protein is replaced by urea in buffalo calves. Contrary to this Leibholz and Kang (1973) observed significantly higher ($P<0.05$) crude protein digestibility in urea supplemented diets (69.5 per cent) than those of control diet (66.4 per cent).

Digestibility coefficient for ether extract observed in the present study was 70.83, 72.40 and 70.13, respectively for the calves of the three treatments T_1, T_2 and T_3. There was no significant difference among treatments. In agreement with the present study, Sinha and Nath (1982) also observed no significant difference in ether extract digestibility when deoiled salseed meal (DSSM) was partially replaced with 3 per cent urea in crossbred female calves. In contrary, significant fall in the ether extract digestibility was observed in urea molasses liquid diet by Sahoo *et al.* (1992).

Digestibility coefficient for neutral detergent fibre observed in the present study was 61.39, 58.32 and 62.50, respectively for the three treatments T_1, T_2 and T_3. There was no significant difference among treatments. This study was in accordance with Sahoo *et al.* (1992) who did not observed significant difference in NDF digestibility when urea molasses liquid diet was fed to calves.

Digestibility coefficient for acid detergent fibre (ADF) observed in the present study was 49.81, 47.92 and 51.52, respectively for the three T1, T_2 and T_3. There was no significant difference among treatments. Jacobs and Leibholz (1978) observed that there were no significant differences in ADF digestibility by feeding poultry litter, which contains 60 per cent of nitrogen is in the form of NPN. The above findings are in line with the present study. Contrary to this Chalupa *et al.* (1963) observed urea feeding improved cellulose digestion.

5.5 BLOOD BIOCHEMICAL PARAMETERS

Blood glucose values of experimental animals varied from 63.91 to 87.92 mg per dl (Table 12), but there were no significant differences between the three treatments T_1, T_2 and T_3. The values for the calves of all treatments gradually declined till fourth fortnight and thereafter become steady. A decline in blood glucose was characteristic of young ruminants and suggested that this represented the change from primary dependence on abomasal digestion to dependence on ruminal digestion for energy (McCandless and Dye, 1950). Contrary to the present study, Eryavuz *et al.* (2003) in lambs observed glucose level significantly higher ($P<0.01$) in urea fed group than plant protein group.

Data on fortnightly AST of experimental calves are presented in the Table 13. The values varied from 32.55 to 69.88 IU per dl. No significant difference was observed between the treatments. In agreement with the present study, Bhakt *et al.* (1997) also observed no significant differences when urea treated deoiled salseed meal was fed to calves.

Data on total bilirubin of experimental calves are presented in the Table 14. The values varied between 0.11 to 0.23 mg per dl. There was no significant difference among treatments. This present study was in accordance with Sinha and Nath (1982) who observed no significant differences in crossbred female calves

when one group was fed with deoiled salseed meal and the other with three per cent urea.

Blood urea nitrogen (BUN) of calves during the experimental periods is given in Table 15. The values varied from 10.24 to 18.99 mg per dl. Partial replacement of vegetable protein with urea in the feed for the groups T_2 and T_3 had a trend for a higher BUN compared to those fed control ration without any significant difference. This was in agreement with Sinha and Nath (1982) who did not observe any significant difference in BUN value by partially replacing true protein with urea. In contrary to above, Leibholz and Kang (1973) observed that the concentration of urea in the blood plasma increased with increasing dietary crude protein content and was higher in calves given urea.

Data on creatinine of experimental calves are presented in the Table 16. The values varied between 0.56 to 1.3 mg per dl. The values were within the normal range in all the groups and they did not differ ($P>0.05$). Naik *et al.* (2005) observed that creatinine level did not differ significantly till two months of post feeding, thereafter those calves fed ammoniated wheat straw showed significantly higher ($P<0.001$) creatinine than those fed control diet.

Total protein of experimental calves are presented in the Table 17. The values ranges between 6.31 to 7.01 g per dl. and they did not differ significantly. There was no significant difference between treatments. This was in accordance with Bhakt *et al.* (1997) who observed, no significant difference when urea treated deoiled salseed meal replaced groundnut cake meal in calves. Contrary to this, Sinha and Nath (1982) observed that urea fed calves had significant reduction ($P<0.05$) in serum total protein (7.44 g per dl) than those fed control diet (8.56 g per dl).

Albumin, globulin and A:G ratio of experimental calves are presented in the Table 18, 19 and 20, respectively. The values varied between 2.39 to 3.19 g per dl,

3.34 to 4.30 g per dl and 0.61 to 0.92, respectively for the above parameter. There was no significant difference among the treatments. This is in agreement with Naik *et al.* (2005) who observed no significant difference in the above parameter when ammoniated wheat straw was fed to the buffalo calves.

5.6 URINARY PARAMETERS

Data on urinary urea excretion of experimental calves are presented in Table 21. The values varied between 5.13 and 28.37 g per litre. Though there was no significant difference between treatments except at fifth fortnight, there was a trend for an increase in urea excretion in urea fed groups compared to those fed control diet without urea. Similar to the present study, Sinha and Nath (1982) observed significant ($P<0.05$) difference in urinary nitrogen excretion in calves fed with deoiled salseed meal compared with three per cent urea fed calves.

Data on urinary creatinine of experimental calves are presented in Table 22. The values varied between 0.51 to 0.74 g per litre and treatments did not differ. This might be due to ration content do not influence excretion of creatinine concentration (Albin and Clanton, 1966). But Chetal *et al.* (1975) observed creatinine excretion differ significantly from day to day.

5.7 RUMEN LIQUOR PARAMETERS

Rumen pH for the calves maintained on three treatments T_1, T_2 and T_3 are presented in Table 23 and values ranged from 6.21 to 6.73, 6.33 to 6.63 and 6.27 to 6.81, respectively. There was no significant difference between groups. The increase in rumen pH with age is in agreement with Vazquez-Anon *et al.* (1993). In contrast to the present study, Elias (1988), observed a higher rumen pH for calves fed diet containing molasses with urea than those fed fish meal supplemented diet.

Methylene Blue Reduction Test (MBRT) to assess microbial activity of experimental calves are presented in Table 23. The time taken for reduction varied from 1.08 to 2.08 min. for T_1, 1.25 to 2.08 min. for T_2 and 1.17 to 2.00 min. for T_3. No significant difference was observed among the treatments. Contrary to this study, Chalupa *et al.* (1964) observed greater microbial activity when urea was the source of dietary nitrogen in growing steers.

Data on rumen VFA of experimental calves are presented in Table 23 and values varied from 85.5 to 123.16 mmol per litre for T_1, 84.33 to 108.25 mmol per litre for T_2 and 86.41 to 125.00 mmol per litre for T_3. Eventhough there was no significant difference among treatments, there was a trend for an increase in TVFA concentration in urea-supplemented groups than those fed unsupplemented diet. This is in agreement with Ahuja *et al.* (1972), who observed that there was an increase in TVFA when calves were fed urea containing diet. Singh *et al.* (1983) reported TVFA concentration increased up to 12 weeks and thereafter similar to adult values.

Data on rumen NH_3-N concentration of experimental calves are presented in Table 23 and values varied from 8.98 to 19.82 mg per dl for T_1, 8.49 to 20.61 mg per dl for T_2 and 10.97 to 18.53 mg per dl for T_3. The results obtained in the present study showed that the rumen NH_3-N concentration of urea supplemented groups had a trend for a higher NH_3-N compared to those fed unsupplemented group, however, the treatments did not differ significantly. This might be due to high degradability of urea, resulting in high production of NH_3 in the rumen. This is in agreement with Elias (1988) who observed insolubility of protein from fish meal resulting in low ammonia production in rumen than urea group.

Protozoal activity of experimental calves is presented in Table 24. The protozoal activity was directly proportional to age at its early stage. No significant

difference among treatments was observed. Singh *et al.* (1983) reported that protozoa made their first appearance in rumen contents at first month of age and their population get stabilized in the rumen only by fourth month of age was in agreement with the present study.

5.8 ECONOMICS OF GAIN

The feed cost per kilogram gain for the three treatments T_1, T_2 and T_3 were Rs.73.45, 73.13 and 70.67, respectively. Bhakt *et al.* (1997) also observed no significant difference in cost of production when 20 per cent of urea treated DSSM replace the groundnut cake meal.

Hence, it could be inferred from the study that urea could be utilized by calves from nine weeks of age without any deleterious effect.

Summary

SUMMARY

A study was conducted to assess the optimum age for the utilization of urea and also the health status of urea fed calves. Eighteen healthy female crossbred calves of below one week of age were selected and distributed into three groups as uniformly as possible with regard to age, weight and breed and were randomly allotted to three treatments T_1, T_2 and T_3. Calf starter as per BIS specification (Diet 1) and calf starter with 2 per cent urea (Diet 2) formed the experimental diets. Both the diets were iso-nitrogenous and iso-caloric. Calves in the T_1 group was fed with diet 1 from two weeks to five months, T_2 was fed with diet 1 from two to twelve weeks, later on with diet 2 till five months, T_3 was fed with diet 1 from two to eight weeks, later on with diet 2 till five months. All the calves received milk till they were three months of age. The quantity of calf starter fed to calves of each group was fixed as per standards (NRC, 1989). Grass and paddy straw were provided *ad libitum* to meet the dry matter requirement. Calves were provided with clean water round the clock throughout the trial duration of 150 days and were maintained under identical managemental condition. Individual records of daily intake of calf starter, milk, grass, paddy straw and fortnightly body weight were maintained throughout the trial. Blood biochemical parameters such as blood glucose, AST, total bilirubin, blood urea nitrogen, creatinine, total protein, albumin, globulin, A:G ratio and urinary parameters such as urea and creatinine were also estimated at fortnightly intervals. Rumen liquor was collected for the estimation of pH, NH_3-N, TVFA, protozoal activity, and MBRT at monthly interval from second to fifth month. 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.

Average daily gain was 305, 299 and 321 g, respectively and total body weight gain was 45.82, 44.89 and 48.29 kg, respectively for the calves in the treatments T_1, T_2, and T_3. Average dry matter intake (kg per day) was 1.39, 1.43 and

1.53 kg, respectively for the treatments T_1, T_2, and T_3. Fortnightly mean feed conversion efficiency (kg feed per kg gain) was 4.61, 4.85 and 4.83, respectively for the treatments T_1, T_2 and T_3 and the values were not significantly different ($P>0.05$). The digestibility coefficient of nutrients observed were 62.26, 59.15 and 60.00 for dry matter, 64.92, 64.89 and 64.91 for crude protein, 70.83, 72.40 and 70.13 for ether extract, 61.39, 58.32 and 62.50 for neutral detergent fibre, 49.81, 47.92 and 51.52 for acid detergent fibre for T_1, T_2 and T_3, respectively. There was no significant difference among the treatments ($P>0.05$).

No significant difference ($P>0.05$) was observed among treatments for blood glucose, AST, total bilirubin, BUN, creatinine, total protein, albumin, globulin, A:G ratio. The values ranged from 63.91 to 87.92 mg per dl for glucose, 32.55 to 69.88 IU per dl for AST, 0.11 to 0.23 mg per dl for total bilirubin, 10.24 to 18.99 mg per dl for BUN, 0.56 to 1.3 mg per dl for creatinine, 6.31 to 7.01 g per dl for total protein, 2.39 to 3.19 g per dl for albumin, 3.34 to 4.30 g per dl for globulin and 0.61 to 0.92 for A:G ratio.

Urinary urea and creatinine values varied between 5.13 to 28.37 and 0.51 to 0.74 g per litre, respectively. The values did not differ significantly among treatments.

Rumen pH of experimental calves for the three treatments T_1, T_2 and T_3 ranged from 6.21 to 6.73, 6.33 to 6.63 and 6.27 to 6.81, respectively. Methylene Blue Reduction Test (MBRT) to assess microbial activity for the three treatments varied from 1.08 to 2.08 min. for T_1, 1.25 to 2.08 min. for T_2 and 1.17 to 2.00 min. for T_3. Rumen VFA values varied from 85.5 to 123.16 mmol per litre for T_1, 84.33 to 108.25 mmol per litre for T_2 and 86.41 to 125.00 mmol per litre for T_3. Rumen NH_3-N values varied from 8.98 to 19.82 mg per dl for T_1, 8.49 to 20.61 mg per dl for T_2 and 10.97 to 18.53 mg per dl for T_3. There was no significant difference among the treatments.

Cost per kilogram body weight gain was Rs. 73.45, 73.13 and 70.67, respectively for T_1, T_2 and T_3. It could be inferred from the study that urea could be utilized by calves from nine weeks of age without any deleterious effect.

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UTILIZATION OF UREA AT DIFFERENT STAGES OF DEVELOPMENT OF RUMEN IN WEANED CALVES

RAJA, D.

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Faculty of Veterinary and Animal Sciences
Kerala Agricultural University, Thrissur

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Department of Animal Nutrition
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
MANNUTHY, THRISSUR-680651
KERALA, INDIA

ABSTRACT

An experiment was conducted with eighteen female cross bred calves below one week of age for 150 days to assess the optimum age for the utilization of urea and also the health status of urea fed calves. Calves were divided into three groups as uniformly as possible and allotted randomly to three treatments T_1, T_2 and T_3. Calf starter as per BIS specification (Diet 1) and calf starter with 2 per cent urea (Diet 2) formed the experimental diet. Both the diets were iso-nitrogenous and iso-caloric. Calves in the T_1 were fed with diet 1 from two weeks to five months. Calves in the T_2 were fed with diet 1 from two to twelve weeks, later on with diet 2 till five months. Calves in the T_3 were fed with diet 1 from two to eight weeks, later on with diet 2 till five months. Milk was fed till three months of age as per the requirement. Green grass and paddy straw were fed *ad libitum*.

Average daily gain and daily dry matter intake, respectively were 305 g and 1.39 kg for the calves in T_1, 299 g and 1.43 kg for the calves in T_2, and 321 g and 1.53 kg for the calves in T_3, and the values were not significantly different ($P>0.05$). Feed to gain ratio for T_1, T_2, and T_3 were 4.61, 4.85 and 4.83, respectively and were not significantly different among treatments. Blood biochemical parameter such as blood glucose, AST, total bilirubin, blood urea nitrogen, creatinine, total protein, albumin, globulin, A:G ratio did not show any significant difference. Urinary parameters such as urea and creatinine also did not show any significant difference but there was a trend for increased urea excretion in those calves fed urea. Rumen liquor parameter such as pH, MBRT, protozoal activity, TVFA, rumen NH_3-N also did not statistically differ ($P>0.05$). The digestibility coefficient of nutrients observed were 62.26, 59.15, and 60.00 for dry matter, 64.92, 64.89 and 64.91 for crude protein, 70.83, 72.40 and 70.13 for ether extract, 61.39, 58.32 and 62.50 for neutral detergent fibre, 49.81, 47.92 and 51.52 for acid detergent fibre for T_1, T_2 and T_3, respectively. There was no significant difference between the treatments. Cost per

kilogram body weight gain was Rs. 73.45, 73.13 and 70.67, respectively for T_1, T_2, and T_3. It could be inferred from the study that urea could be utilized by calves from nine weeks of age without any deleterious effect.