EVALUATION OF COMPLETE FEED FOR MEAT PRODUCTION IN CALVES

By

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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 **"EVALUATION OF COMPLETE FEED FOR MEAT PRODUCTION IN 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 **"EVALUATION OF COMPLETE FEED FOR MEAT PRODUCTION IN CALVES"** is a record of research work done independently by **Sri. Ajith .K.S.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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AJITH, K.S.

Dedicated to my
Parents and brother

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Introduction

1. INTRODUCTION

Kerala is a narrow strip of land between the western ghats on the east and the Arabian sea on the west, occupying 1.18 per cent of the area of India. The per capita availability of land is 0.13 hectare. Out of the 34 lakhs cattle in Kerala, 67 per cent of the cows are crossbreds of Jersey, Brown-Swiss, Holstein-Friesian or a mixture (Livestock Census, 1996).

On perusal of the quinquennial census reports for the years 1987 and 1996 reveals that our cattle population is almost stagnant. The male: female calf ratio of 1:1 at birth becomes 1:7.8 by the time the animal becomes adult. Male calves, which are forcefully weaned at second or third month of age or even later are neglected and fetch only very little value when sold for slaughter. The male calves available as a byproduct of intensive cross breeding programme are estimated to be about 15 lakhs every year. To maintain cow population static, only 30 per cent of heifer calves are to be maintained. Presently the state does not have any accepted system of rearing these surplus heifers for meat production. Eventually the unwanted heifers also grow into milch cows leading to deterioration in the quality of crossbred animals. Surplus weaned crossbred calves if reared under good management system could be sold at a premium price for meat. This will also enable a vigorous selection among heifer calves for improving the genetic potential of cows.

World over, veal and beef are costlier than other types of meat. But in Kerala it is the cheapest. The present demand of beef and veal is met by the cattle and buffaloes brought from the neighbouring states. The quality of beef from these animals is inferior as they are from older animals, which are slaughtered at the end of their productive life time. Majority of the population in Kerala are non-vegetarians and there are no religious taboos or ban on cow slaughter. The greater demand for good quality beef necessitates the rearing of crossbred bull calves and surplus heifer calves under good management system.

As a result of the shift in cropping pattern in favour of cash crops and marginalisation of operational holdings, there is continuous depletion in feed and fodder base. There is acute deficit of paddy straw in the state and so it is costlier. A state which procures roughage as well as concentrate from neighbouring states naturally would find concentrate feed cheaper than roughage especially when compared on net energy basis.

Feed conversion ratio of heifers fed on conventional feed is 1:8.1 (Sagathevan, 1995), a figure much higher than that of other animals. The feed conversion ratio of calves fed more on concentrate is between 1:3.3 (Block and Shellenberger, 1980 a) and 1: 6.1 (Bartle and Preston, 1992).

Monensin, an ionophore antibiotic is reported to improve feed efficiency of ruminants by increasing the propionate fraction of the rumen volatile fatty acid and reducing the methane production (Oientine, 1982). A ration low in fibre is likely to cause lactic acidosis and to a certain extent this can be prevented by adding monensin in the ration. Sodium bicarbonate can also be added to the complete feed to prevent acidosis.

Therefore, this experiment is an attempt to:

(1) Develop a suitable complete ration for calves for meat production

(2) Compare the performance of calves maintained under confinement and fed on complete feed with that of conventional feeding system

Review of Literature

2. REVIEW OF LITERATURE

2.1 Concept of complete feeding

Owen (1979) defined complete feed, as a uniform mixture of feed ingredients including concentrate and roughage mixed together in such a way that the animal is unable to make a selective feeding and the feed is given as such except water to satisfy the nutrient requirements. Borland and Kesler (1979) opined that the use of complete rations for post-weaned calves would be advantageous. The diet consumed by all animals can be defined more exactly and better balance of nutrient intake can be achieved by avoiding individual preferences.

In complete feed, all feed ingredients including roughages and concentrate are mixed in a uniform blend to ensure that a desired proportion of nutrients are present to meet requirements for maintenance, growth and production (Senger and Naik, 1996).

2.1.1 Low fibre complete rations

Macgregor *et al.* (1974) conducted an experiment in lactating Holstein cows by feeding them *ad libitum* with three complete rations containing 13, 18 and 23 per cent crude fibre. They observed superior results in animals given the ration containing 13 per cent fibre.

Marshall and Voigt (1975) reported that when roughage to concentrate ratios of complete ration were widened by 40:60 to 30:70 to 20:80, it was accompanied by non significant increase in dry matter intake and significant increase in milk production under *ad libitum* feeding in dairy cattle.

Vasilev *et al.* (1975) reported a higher dry matter intake and higher daily weight gain in beef cattle fed low fibre (8 per cent) complete ration.

Murdock and Wallenius (1980) fed calves on three complete rations having three different levels of fibre, viz., 10, 11 and 12 percent and found that rations with lesser fibre showed better growth.

Peak *et al.* (1991) got superior daily gain and feed efficiency in indigenous cattle fed on low fibre (8 per cent) complete diets in comparison to conventional ration consisting of concentrate and straw.

Better feed efficiency and growth were also reported by Biju (1998) and Dildeep (1999), with complete rations testing low (8 per cent) crude fibre in kids.

2.1.2 High concentrate diets for feedlot cattle

Newsome *et al.* (1985) studied on various cattle finishing systems and found that cattle from the drylot and forage plus extended grain groups gained faster than those from the all forage-plus-limited grain groups. Cattle from the forage plus extended grain groups had higher yield grades than cattle from the other groups.

Switching to an all concentrate dry rolled corn diet at 30, 45, 60 or 90 days during the feeding period tended to decrease total feed intake, compared to cattle fed 7.5 per cent roughage for entire trial. Feeding on all concentrate dry rolled corn diet at 30 days improved feed efficiency (5.7%) but reduced daily gain (7.1%) compared to feeding 7.5 per cent roughage diets. No difference in daily gain was noted among cattle fed 7.5 per cent roughage or on all concentrate dry rolled corn diet at 45, 60 or 90 days. Delaying the time of feeding the all concentrate diet from 90 days improved daily gain, but reduced feed efficiency and increased cost/gain compared to feeding the all concentrate diet at day 30 (Shain *et al.*, 1992).

Nour (1996) reported that daily live weight gain and relative weight increased with increasing feeding frequency in veal calves.

Diets containing 16 per cent crude protein and more than 70 per cent concentrate were beneficial to feedlot calves at the receiving end (Fluharty and Loerch, 1996).

2.1.3 Intensive feeding system of ruminants

Feeding high concentrate and restricted roughage rations in dairy cows decreased the number of cellulolytic and fibre digesting bacteria (Metzger *et al.*, 1976), while Meyer *et al.* (1986) reported that together with the high energy and feed intake in intensive system, defaunation may also occur in rumen which can decrease nitrogen recycling within the rumen and improve the net bacterial protein synthesis.

Viera (1986) reviewed experiments in which bacterial protein synthesis was measured in defaunated animals and reported an average of 41 per cent improvement in efficiency.

Franzolin and Dehority (1996) reported that maintenance of a protozoal population in ruminants fed high concentrate diets may be related to physiological conditions such as rate of fluid and particulate matter passage within each animal.

In intensely fed cattle, dry matter intake tended to be the highest with coarsely rolled grains and the gains were also higher on coarsely rolled corn diet (Secrist *et al.*, 1996).

Gabel (1997) studied extensive and intensive cattle production and found that energy intake in extensive system was less due to the poor quality of roughage whereas in intensive conditions dietary nutritive value allow high energy and feed intake.

2.1.4 Average daily gain (ADG), Feed conversion ratio (FCR), Dry matter (DM) intake and Digestibility coefficients

White and Reynolds (1969) reported that decreasing the dietary roughage content to near zero generally resulted in reduced cattle performance.

Marshall and Voigt (1975) observed that treatment means for DM intake, and body weight gain did not differ significantly indicating satisfactory animal performance on rations of corn silage and concentrate mixture fed *ad libitum* either as ensiled complete ration or blended at feeding time or fed as separate components in different feeding mangers in dairy cattle.

Borland and Kesler (1979) reported significant increment in height at withers and non significant increase in chest circumference in Holstein calves when fed commercial pellet based complete ration for ten weeks from eight weeks of age. They also got better feed to gain ratio when compared to control ration.

Block and Schellenberger (1980a) obtained better gain and a feed conversion efficiency of 3.30 in Holstein calves when fed on a commercially available pelleted ration, which was low in crude fibre when compared to conventional ration. They also obtained significant increase in height at withers in proportion to increase in body weight.

Reddy and Reddy (1985) obtained digestibility coefficient values of 50.39 and 55.00 per cent for ether extract in Nellore lambs fed on two different complete rations.

Devasia (1989) got a feed conversion efficiency of 13.70 and 14.80 and average daily gain of 356.6 g and 329.9 g in Jersey and Brown Swiss cross heifer calves respectively, of five to eleven months old when they were maintained for 28 fortnights.

Ram *et al.* (1990) obtained ether extract digestibility values of 51.80; 48.30 and 41.70 per cent in goats fed on three different complete rations.

Ushida *et al.* (1991) reported that rumen protozoa has a positive effect on hemicellulose digestion. They also observed that monensin depressed protozoal counts by 50 to 60 per cent. This defaunating effect of monensin supplementation was responsible for the decreased fibre digestibility observed in their studies.

Patle *et al.* (1992) observed that pelleting of complete feed increased its bulk density by 87 to 90 per cent

Gilbert *et al.* (1993) got significantly higher body length in calves fed high-energy diets, consisted of 70 per cent grain based concentrate than those fed normal diets.

Lower dry matter intake and lower crude protein digestibility in Angus crossbred steers fed 70 per cent concentrate than those fed 45 per cent concentrate was observed by Fluharty *et al.* (1994).

Patil and Honmode (1994) obtained digestibility coefficient values of 67.14, 61.03, 69.90, 35.25 and 65.56 for dry matter, organic matter, crude protein, crude fibre and nitrogen free extract respectively in Malpura lambs fed complete diets with 22 ppm monensin.

Three month buffalo calves when maintained on diet containing 75 per cent concentrate and 25 per cent roughage in comparison to 60 per cent and 40 per cent respectively gained better with better feed efficiency and lower dry matter intake (Sehgal *et al.*, 1994).

Pulina *et al.* (1995) got lower crude fibre digestibility figures in dairy ewes fed on a low fibre complete pelleted feed.

Sagathevan (1995) reported a feed conversion efficiency of 8.09 and average daily gain of 633.0 g in calves of six to nine months old when fed conventional ration for a duration of seven months, while Subramanian (1995) obtained a feed conversion efficiency of 6.96 and average daily gain of 487.0 g in crossbred calves of five to seven months when maintained on conventional ration for a period of 126 days.

The apparent digestibility coefficients of the total ration were unaffected by the method of concentrate feeding or concentrate intake by cows was reported by Agnew *et al.* (1996). However, modified acid detergent fibre apparent digestibility decreased as concentrate intake increased.

Hill *et al.* (1996) reported that in the second half of 137 day trial, crossbred steers fed 92 per cent concentrate and 8 per cent roughage with 12.5 and 13.5 per cent crude protein, had slightly lower weight gain and poorer feed efficiency than those fed higher protein, but having 18 per cent lower metabolizable energy value.

Preston *et al.* (1996) found that decreasing the roughage from five per cent to zero per cent increased gain efficiency and decreased DMI in steers fed feed supplemented with monensin.

Feeding compressed complete feed resulted in significantly higher intake of DM, and better digestibility of DM and all other nutrients than feeding the ingredients separately or in a mixture (Verma *et al.*, 1996).

Thomson *et al.* (1996) reported that when three levels of protein were given to finishing steers, the average daily gain linearly increased with increasing levels of crude protein.

Romero-Trevino *et al.* (1998) found that when Holstein heifers were fed 100 and 120 per cent NRC (1989) requirements, those fed with 120 per cent NRC tended to have higher ADG and improved feed conversion efficiency.

The total tract DM and organic matter digestibilities were not affected by crude protein concentrations ranging from 11 to 14 per cent, indicating that crude protein concentration may have affected the site of digestion, but not the extent of digestion in Holstein steers (Driedger *et al.*, 1998).

Reddy and Reddy (1999) obtained digestibility coefficient values of 67.63, 59.71, 60.29, 50.71, 66.47 and 60.29 respectively for dry matter, organic matter, crude protein, crude fibre, ether extract and nitrogen free extract in Ongole bull calves fed on diets with concentrate to roughage ratio of 60:40.

Carro *et al.* (2000) observed a linear decrease in crude fibre digestibility in sheep fed complete diets with decreasing roughage fraction from 80 per cent to 20 per cent.

A highly significant reduction in the digestibility of acid detergent fibre was observed with increase in proportions of concentrates in the diets of bulls (Patterson *et al.*; 2000).

Valdes *et al.* (2000) reported that when sheep were fed complete diets varying in concentrate from 20 to 80 per cent (20, 40, 60, 80) of the diet, there was a linear decrease in voluntary feed intake. The apparent digestibility of dry matter, organic matter and crude protein increased linearly with the proportion of concentrate in diet, whereas that of cellulose decreased quadratically, reaching a minimum value in the 80 per cent concentrate diet.

2.1.5 Reduced gain on low fibre diets

In a study with feedlot cattle, Loerch (1991) reported that the performance of cattle fed typical feedlot diets increased during the initial 112 days, after which it declined.

Similarly, Bartle and Preston (1991) found that feeding a 2 per cent roughage equivalent diet from day 22 through 84 days followed by 10 percent roughage equivalent till 133 day feeding period decreased dry matter intake and average daily gain but numerically improved gain efficiency in steers during the period. Increasing the roughage content from 2 to 10 per cent after day 84 stimulated feed intake and steer performance. The above dietary treatment, decreased the quantity of roughage fed (34 kg/steer) and feed costs ($ 4/steer).

These two findings suggest that dietary roughage can be reduced for a period of time during the feeding period without a detrimental effect on steer performance or health.

The use of limit feeding as a method of adaptation in feedlot calves reduced daily gain and carcass weight, however the method was found to be better in yearling calves (Choat *et al.*, 2001).

2.1.6 Morphological changes in rumen

Finely ground high concentrate diets, when fed continuously over a period of time, may result in excess acidity in the rumen. The clinical condition produced is called lactic acidosis and is characterised by reduced feed intake and rumen motility (Boshinova, 1976 and Wheeler and Noller, 1976).

Block and Shellenberger (1980a,b) reported that the calves fed commercially available pelleted complete ration showed long, branched, necrotic papillae that were keratotic and loosely attached. These workers postulated that the necrosis of the papillae could have been caused by rapid acid production around the papillae when easily fermentable materials touched the rumen wall.

The prolonged acidity in the rumen can bring about morphological changes in the epithelium of the rumen (parakeratosis) with a consequent decrease in digestibility (Ensminger *et al.*, 1990).

Bartle and Preston (1992) reported clumping of the papillae and change in the colour of rumen epithelium in steers fed high concentrate ration with 2 per cent roughage equivalent.

Biju (1998) and Dildeep (1999) also observed that the rumen papillae of high concentrate ration fed kids were long, slender and branched. Parakeratosis of rumen papillae and cytoplasmic vacuolation could also be seen.

2.1.7 Liver abscess

Stock *et al.* (1987) found that the high moisture content of the diet fed, in conjunction with processing, most likely contributed to the high incidence of liver abscess compared to feeding dry corn.

Similarly, Bartle and Preston (1991) stated that steers with the greatest intake during the concentrate step up period were more likely to develop severe liver abscess, which reduces performance.

2.2 Addition of buffers and supplements to high concentrate rations

Nagaraja *et al.* (1981) found that the intraruminal administration of lasalocid or monensin (1.3 mg/kg body weight) effectively prevented glucose or corn induced lactic acidosis in cattle.

The supplementation of tylosin or monensin may be of benefit in diets of crossbred steers and heifers, which were fed high concentrate diets, where the potential of liver abscess incidence is high (Mc-Cully *et al.*, 1996).

A study by Holthaus *et al.* (1996) revealed that zeolite formulations may be used in replacement of the sodium-bi-carbonate without any negative effects on rumen function.

Antimicrobial growth promoters played an important role by improving the utilization of protein and other nutrients in a range of animal species whose weight gains were improved by 2.8 to 15.7 and feed conversion efficiency by 2.0 to 8.6 per cent (Schwaz, 1997).

Arseneau *et al.* (2001) stated that early weaned steers fed high concentrate diets supplemented with either laidomycin propionate or monensin had similar feedlot performance and carcass characteristics.

2.2.1 Ionophore supplementation

Earley *et al.* (1996) opined that only minor differences occur in feed intake and digestive physiology in steers receiving bambermycins, lasalocid and control diets having forage based diets.

A study by Delcurto *et al.* (1996) revealed that bambermycins, as well as monensin and lasalocid, improve the nutritional physiology of steers fed on concentrate diet by accommodating greater intake and digestibility.

Antibiotics increased gain efficiency by decreasing dry matter intake (Preston *et al.*, 1996).

2.2.1.1 Monensin supplementation

Raun *et al.* (1976) supplemented experimental diets of calves with different levels of monensin, and found that a level of 33 ppm was optimum in terms of daily gain and feed efficiency.

Monensin improved the efficiency of production in growing ruminants and part of this production effect can be attributed to alteration of rumen function leading to increased molar proportion of propionate relative to acetate (Costa and Taylor, 1994).

Badawy *et al.* (1996) reported that pH values were not significantly affected by feeding on pelleted concentrate in buffalo heifers, mixed with monensin to supply 100 mg monensin/head. Monensin acts as a propionate enhancer and methane inhibitor and reduces ammonia production and protozoal population.

Surber and Bowman (1996) stated that monensin addition caused a protein sparing effect by reducing ruminal digestion of feed nitrogen, and increasing feed nitrogen flow to the abomasum.

Lana and Russell (1997) found out that monensin could spare amino acids which was supported by the observation that monensin decreased the specific gravity of deamination and increased bacterial protein at all combinations of lucerne and thimothy.

2.2.1.2 Mechanism of action of monensin

Monensin is an ionophore antibiotic used in the ration of feedlot beef cattle for improvement of both feed efficiency and rate of gain. The quantity of monensin for feed efficiency improvement has a range of 10-30 g/tonne of feed.

It favours rumen microflora in favour of propionate production and it decreases rumen acetic acid concentration with out affecting the total volatile fatty acid concentration. It also inhibits gas production with a decrease in rumen methane production. Feed lot cattle are routinely fed on high grain diets resulting in a build up of lactic acid which may lead to lactic acidosis. Monensin has the ability to reduce risk of acidosis, as it has an inhibitory effect on lactate producing organisms, without depressing major lactate fermenters (Oientine, 1982).

Bergen and Bates (1984) reported that monensin mediates primarily Na+ and H+ exchange. It interferes with the normal ion fluxes of bacterial cells. Gram positive bacteria depends on substrate level phosphorylation while many of the gram negative bacteria contain fumarate reductase which will survive in the presence of ionophores. So a selection towards gram negative bacteria occurs in the rumen.

2.2.1.3 Average daily gain (ADG), feed conversion ratio (FCR), dry matter (DM) intake and digestibility coefficients in monensin supplemented diets

Vuuren and Nel (1983) and Ricke *et al.* (1984) found no significant effect on the apparent digestibility of DM and crude protein in sheep fed monensin supplemented diets.

Goodrich *et al.* (1984) reported that monensin improved digestibility of DM in cattle.

Delfino *et al.* (1988) reported that heifers receiving 90 per cent concentrate ration containing monensin at the rate of 33 mg/kg DM had an average gain of 1.29 kg as against 1.24 kg per day in control animals.

Lee *et al.* (1990) reported that monensin increased the digestibility of dry matter and crude protein in Korean native goat.

Decreasing the forage in the diet from 20 per cent to 10 per cent increased average daily gain by 10.8 per cent and feed efficiency by 11.6 per cent with a decrease in DM intake, in studies conducted on feedlot cattle fed on grains with limited quantity of roughage, supplemented with monensin at the rate of 25 mg/kg feed (Zinn *et al.*, 1994).

Paisley and Horn (1996) reported that the addition of monensin decreased daily sorghum-bicolor based self limited energy supplement intake (on DM basis) from 5.03 to 1.44 lb/head. Higher live weight gain was achieved with much smaller amounts of the monensin containing supplement compared with greater amounts of a similar supplement without monensin.

Rogers *et al.* (1997) reported that the DM and organic matter digestibility increased during monensin supplementation and this effect disappeared after its withdrawal. They also found that monensin had no effect on post rumen organic matter digestion and starch digestion was not altered by monensin treatment.

2.2.2 Addition of sodium bicarbonate in the complete ration

Nicholson *et al.* (1960) reported higher dry matter intake in calves by the addition of sodium bicarbonate to high concentrate diets.

Kay *et al.* (1969) and Kromann and Meyer (1972) have shown a lower occurrence of bloat and parakeratosis in bicarbonate fed calves.

Improved performance was recorded in calves fed high concentrate diets when sodium bicarbonate was added to the ration (Kellaway *et al.*, 1977).

2.3 Carcass characteristics

Murphey *et al.* (1960) reported that single best indicator of beef carcass cutability was a subcutaneous fat thickness measured opposite to the 12th rib.

Nockels *et al.* (1978) observed no significant effect on dressing percentage in lambs fed on monensin supplemented diets. Delfino *et al.* (1988) also reported similar results in heifers.

Monensin at the rate of 19 mg/kg body weight in the ration of young bulls improved carcass quality in terms of hot carcass weight and dressing percentage (Gotthardt and Hart, 1990).

Stock *et al.* (1990) found no relationship between roughage level and quality grade of meat in a series of experiments involving several grains and processing methods.

Kent *et al.* (1991) opined that adjusted fat thickness over the *longissimus longus* muscle has been viewed as the best indicator of fatness and value of beef carcass.

Christenson *et al.* (1991) stated that production practices such as differing breeds and feeding regimens may not affect chuck muscle tenderness when steers are slaughtered at comparable fat levels. The age may not be closely related to intra muscular fat deposition. Fatness indicators (marbling, quality grade and intra muscle fat) were not significantly related to muscle tenderness. Although consumers can accurately evaluate beef tenderness, Huffman *et al.* (1996) suggested that 98 per cent of consumer ratings are consistent with Warner-Bratzler measure. They have suggested that a Warner-Bratzler shear force value of 4.1 will ensure consumer satisfaction of 98 per cent in both home and restaurants.

Sehgal *et al.* (1994) obtained a dressing percentage of 52.3 and 51.7 respectively in buffalo calves fed on 75 per cent and 40 per cent concentrate.

Jersey cross heifers have no significant advantage in performance, carcass and meat quality traits or efficiency in gain over the comparable Friesian crosses (Burke *et al.*, 1998).

Shackelford *et al.* (2001) opined that tenderness of beef is the primary determinant of satisfaction among consumers of US select top loin steaks and that a segment of consumers would pay a premium price to purchase guaranteed tender US select steaks.

A study by Wells *et al.* (2001) in crossbred steers revealed that both high level of energy and high level of protein are required to improve carcass quality in early weaned steers.

Oommen (2002) reviewing the data on the slaughter studies of crossbred Holstein male calves conducted in the Centre of Excellence in Meat Products Technology, opined that, within the live body weight group of 85 to 160 kg, a dressing percentage of 45 to 49 per cent, meat yield of 30 to 34 per cent and a meat bone ratio of 2.5 to 2.8 could be obtained.

2.4 Economics

Bartle and Preston (1992) reported that of the different roughage levels for growing and finishing cattle, 2/10 regime i.e., 2 per cent roughage for growing and 10 per cent for finishing was an effective economic strategy compared to 10/10 regimen. Decreasing the roughage content of finishing diets below levels that is typically fed (8 to 10%) reduced roughage use and diet cost ($ 3.75 to $ 8 per steer) and had no negative effect on steer performance or health. These alternative feeding practices may improve the profitability of the cattle feeding industry.

The cost of feed per body weight gain reported by Sehgal *et al.* (1994) in buffalo calves when fed on high concentrate (80 per cent) and medium concentrate (60 per cent) were 16.88 and 15.82 respectively.

Hill *et al.* (1996) conducted experiments by restricting the feed in steers and found that restricted feeding levels of less than 13 per cent for half the feeding period in heifers did not affect carcass composition. Additional protein was found beneficial until when feed restriction exceeded 7.25 per cent of *ad libitum.*

The benefit of adding growth promoters in animal feeds caused a total saving to the tune of 239 million kilogram dry matter/year in Germany (Schwaz, 1997).

Stanton *et al.* (1998) reported that lower level roughage in finishing Holstein steer diets may be an effective method to decrease cost of production, by decreasing inputs and improving feed efficiency while not affecting average daily gain or final selling weight.

Materials and Methods

3. MATERIALS AND METHODS

The experimental part of the present study titled "Evaluation of complete feed for meat production in calves" was carried out at the Livestock Research Station (LRS), Thiruvizhamkunnu, College of Veterinary and Animal Sciences of Kerala Agricultural University.

3.1 Animals

Eighteen crossbred calves (Zebu x Jersey and Zebu x Brown Swiss) of three to four months of age, born and reared in the farm were selected based on the birth weight and weight at three months. The selected group consisted of nine male calves and nine female calves. The animals were dewormed with Albendazole suspension (Albendazole 25 mg/ml, Wockhardt) and divided into three groups (Groups A, B and C) of six animals each, as uniformly as possible with regard to breed, age, body weight and sex. Each group of animals was kept separately with individual feed and water troughs, kept at appropriate height. All the animals were maintained under identical conditions of feeding and management. The animals were introduced into the respective experimental rations over a pre-experimental period of ten days. Duration of the experiment was five months. During the experimental period, the animals were dewormed, once in a month using Albendazole suspension. Dung samples were examined for endoparasitic ova every month.

Experimental rations

The experimental rations consisted of two complete rations (A and B) and a conventional control ration (C) consisting of a standard concentrate mixture and grass. The complete rations A and B contained concentrate ingredients and grass hay at five per cent and 15 per cent to meet a crude fibre content of eight per cent and 12 per cent respectively and were isoproteimic and isocaloric.

The ingredient composition of the experimental rations is shown in Table 1 and proximate composition in Table 2.

Table 1. Per cent ingredient composition of three rations

Ingredients	Ration A	Ration B	Ration C
Gingelly oil cake	15	15	15
Yellow maize	30	30	30
Grass hay	5	15	--
Black gram husk	10	10	10
Rice polish	20	15	12
Wheat bran	6	--	4.5
Groundnut cake	10	11	25
Mineral mixture	1	1	1
Salt	0.5	0.5	1
Calcium carbonate	1	1	1
Vitamin premix	0.5	0.5	0.5
Sodium bicarbonate	1	1	--

To 100 kg of the above three rations 250 g of "Supplevit M"* and 20 g of 'Coban 100'** (Elenco, USA), were added.

Sodium bicarbonate was added at the rate of one per cent to the complete rations. The mineral mixture added was that of Cacils India Ltd.***

Table 2. Per cent proximate composition of rations A, B, concentrate portion of ration C and green grass

Proximate composition	A	B	C	Green grass
Moisture	10.14	10.32	10.56	79.12
Organic matter*	89.61	89.39	89.81	84.46
Crude protein*	14.82	14.66	24.03	9.15
Ether extract*	3.48	3.16	4.08	1.19
Crude fibre*	8.28	11.90	7.70	32.18
Nitrogen free extract*	63.42	59.67	54.00	41.94
Total ash*	10.39	10.61	10.19	15.54
Acid insoluble ash*	1.36	1.73	1.16	0.94
Calcium*	1.31	1.22	1.52	0.92
Phosphorus*	0.82	0.71	0.89	0.11
Calculated TDN	69.7	69.2	70.9	15.4

* Expressed as dry matter percentage

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* Supplevit M contains Vitamin A 500,000 IU, Vitamin D_3 100,000 IU, Vitamin B_2 0.2 g, Vitamin E 75 units, Vitamin K 0.1 g, Calcium panthothenate 0.25 g, Nicotinamide 1.0 g, Vitamin B_{12} 0.6 mg, Choline chloride 15 g, Calcium 75 g, Manganese 2.75 g, Iodine 0.18 g, Iron 0.75 g, Zinc 1.5 g, Copper 0.2 g, Cobalt 0.045 g

** Coban 100 was the monensin preparation used . It contained 10 per cent monensin sodium

***Calcium (minimum) 24%, Phosphorus (minimum) 12%, Manganese (minimum) 0.12%, Copper (Minimum) 0.12%, Zinc (minimum) 0.35%, Magnesium (minimum) 6.5%, Iron (minimum) 0.5%, Iodine (minimum) 0.03%, Cobalt (minimum) 0.03%, Sulphur (minimum) 0.5%, Acid insoluble ash (maximum) 2% and Flourine (maximum) 0.4%

The feed ingredients were purchased from local sources. Hay was prepared using guinea grass (*Panicum maximum*). To ensure thorough mixing, monensin and vitamin mixture were premixed with wheat bran, before final mixing. The three experimental rations were processed in the feed mixing unit of LRS, Thiruvizhamkunnu. Representative samples of the rations were analysed for proximate principles as per standard procedure (AOAC, 1990). Calcium was estimated by the standard procedure (AOAC, 1990) and phosphorus by colorimetry (Ward and Johnston, 1962).

3.3 Methods

All the animals were maintained under stall-feeding system. The animals of group A and B were offered sufficient measured quantities of respective rations twice a day at scheduled timing on *ad libitum* basis. The left over feed was collected before subsequent days feeding and quantified. The concentrate portion of the control ration was offered to the animals of group C once daily. The roughage portion was offered on *ad libitum* basis. The proportion and quantity of the ration was reviewed according to the nutrient requirements. Moisture content of the grass offered to the control animals and left over grass were recorded to arrive at the quantity of dry matter intake from grass. Records of daily feed intake by each animal in the experimental groups were maintained. Individual records of fortnightly body weights and body measurements such as body length from the point of shoulder to pin bone, chest girth and height at withers of all the experimental animals were maintained.

3.4 Feed conversion ratio

The fortnightly feed conversion ratio of each animal was calculated by dividing the respective quantities of feed consumed by gain in body weight.

3.5 Digestion trial

Towards the end of the feeding experiment, a digestion trial was carried out using all the six animals of each group.

Feed was offered two times a day during the collection period and the left over feed was quantified. Representative samples of each feed, left over portion of the complete rations and concentrate feed and grass of the control ration were taken every day during the trial for proximate analysis.

Total collection method was employed for collection of dung. All precautions were taken to ensure the collection of the dung quantitatively, uncontaminated by urine or any feed residue or dirt. Dung was collected manually for seven days, as and when it was voided.

At 9.30 am every day the dung collected during the previous 24 hours was weighed accurately, mixed thoroughly and representative samples at the rate of two per cent of the total voided quantity were taken and stored in deep freezer.

The process of collection, weighing and sampling of the dung was continued till the end of the trial.

The dung samples of each animal collected during the digestion trial period were mixed and samples taken for proximate analysis. Proximate analysis of the feed and dung were carried out as per standard procedure (AOAC, 1990).

3.6 Dressing percentage, meat yield and meat bone ratio

On termination of the feeding experiment, three male animals from each group were slaughtered at the Centre of Excellence in Meat Science and Technology, College of Veterinary and Animal Sciences, Kerala Agricultural University to assess the dressing percentage, meat yield and meat bone ratio.

3.7 Histopathology

Two samples of rumen wall of 10 x 10 cm size were collected from each animal slaughtered, for histopathological examination. Samples of the tissues were preserved in 10 per cent neutral buffered formalin. They were processed by routine paraffin embedding techniques (Sheehan and Hrapchak, 1980). Paraffin sections cut at five to six micron thickness from the 18 samples of tissue were stained with haematoxylin and eosin (H&E) method (Bancroft and Cook, 1984).

3.8 Economic viability

From the data on expenditure (cost of animals, cost of feed, slaughter charges and miscellaneous expenses) and receipts (sale of meat and byproducts) the economic viability was worked out.

3.9 Statistical analysis

The data obtained were statistically analysed in the Department of Statistics, College of Veterinary and Animal Sciences using the statistical software 'Mstat'. The data on body weights and body measurements of each group was analysed to study the effect of feeding complete ration using a one factor randomized block design using the Analysis of covariance technique (ANOVA). The significantly different treatment means were compared using critical difference (CD) test (Snedecor and Cochran, 1980).

To test the statistical significance of the effect of complete feeding on dry matter intake, feed conversion efficiency, average daily dry matter intake, average daily body weight gain, average fortnightly feed conversion efficiency and digestibility coefficients of nutrients, a one factor completely randomized design using ANOVA technique was used and the significant treatment means compared using the least significant difference (LSD) test (Snedecor and Cochran, 1980).

Results

4. RESULTS

An experiment was carried out to evaluate the growth performance of three month old crossbred calves fed on two complete rations A and B (Group A and B) with crude fibre levels eight per cent and 12 per cent, respectively and to compare with those fed on control ration C (Group C) consisting of concentrate mixture and grass.

The results obtained in the present investigation are detailed under the following sub headings

4.1 Body weight

The body weight records of the animals at fortnightly intervals are presented in Tables 3 to 5 and represented in Fig. 1. Their consolidated data are presented in Table 6.

The average final body weight (kg) recorded in animals of the three groups namely A, B and C were 153.67 ± 6.91, 152.83 ± 7.41 and 127.00 ± 7.49 respectively. The cumulative weight gain (kg) of calves in group A, B and C were 103.00 ± 3.44, 101.42 ± 5.45 and 76.66 ± 5.14 respectively (Table 6).

Statistical analysis of the data on body weights using analysis of covariance technique and critical difference test indicated that animals fed on complete feed A and B were significantly better than control group ($P<0.01$), but there was no significant difference in body weights between animals of group A and B.

-During the experimental period, the animals fed on complete feed attained a body weight of 124 kg in the fourth month while the control animals attained the same weight only in fifth month.

4.2 Body measurements

The data on body length, chest girth and height at withers recorded at fortnightly intervals are presented in Tables 7 to 9, 11 to 13 and 15 to 17 respectively and represented in Fig. 2. Their consolidated data are presented in Tables 10, 14 and 18 respectively.

The average final body length (cm) at the end of the experiment were 101.75 ± 1.91, 103.83 ± 2.19 and 95.16 ± 0.76 respectively for animals of group A, B and C (Table 10). The average difference between the initial and final body length (cm) observed in the three groups A, B and C were 40.58 ± 0.83, 42.58 ± 2.37 and 36.33 ± 1.96 respectively (Table 10).

The final chest girth (cm) at the end of the experiment were 127.08 ± 3.12, 125.42 ± 1.99 and 118.58 ± 2.69 respectively for groups A, B and C (Table 14). The cumulative increase in chest girth (cm) observed in three groups namely A, B and C were 37.50 ± 1.44, 35.58 ± 3.96 and 34.58 ± 2.63 respectively (Table 14).

The final height at withers (cm) at the end of the experimental period were 115.58± 1.94, 116.08 ± 2.03 and 108.08 ± 1.17 respectively for groups , B and C (Table 18). The cumulative increase in height at withers (cm) obtained for the groups were 43.40 ± 1.47, 43.75 ± 1.85 and 34.25 ± 1.24 respectively for A, B and C groups (Table 18).

Statistical analysis using analysis of covariance technique using initial data as covariate revealed significant improvement ($P<0.01$) in body measurements such as body length and height at withers between animals of groups A and B with Group C, but no significant difference was observed in the case of chest girth measurement.

4.3 Dry matter intake

The average fortnightly dry matter consumption of the three groups during the experimental period is presented in Table 19 and represented in Fig. 3. The average fortnightly feed intake of the animals maintained on control ration (Group C) is presented in Table 20.

The average fortnightly dry matter intake (kg) of an animal in group A, B and C during the experimental period were 46.19 ± 0.76, 48.74 ± 0.67 and 47.51 ± 0.42 respectively which works out to 3.06, 3.22 and 3.58 per cent of body weight respectively (Table 19).

From the data on fortnightly dry matter consumption of the three groups during the experimental period, it can be seen that the animals consuming low fibre complete feed had lower dry matter intake. The dry matter intake expressed as percentage of body weight also followed the same trend.

4.4 Average daily body weight gain

The average daily body weight gain in weights of the animals maintained on the three experimental rations are shown in Table 21 and Fig. 4.

The average daily body weight (g) gain of calves maintained on rationsA, B and C were 668.83 ± 22.37, 658.55 ± 35.41 and 497.83 ± 33.35 respectively (Table 21).

Statistical analysis of the data on daily body weight gain using ANOVA technique showed significant improvement ($P<0.01$) in animals fed on complete ration A and B when compared to those fed on control ration.

The significant improvement in the daily body weight gain was evident from the third fortnight till the eighth fortnight.

4.5 Feed conversion efficiency

The feed conversion efficiency values of the three experimental groups are tabulated in Table 22. The cumulative feed conversion efficiency of animals in the three experimental groups are represented in Fig. 5.

The cumulative feed conversion efficiency obtained for the three groups A, B and C were 4.71 ± 0.15, 5.57 ± 0.37 and 6.99 ± 0.42 respectively (Table 22).

Analysis of the data using ANOVA technique showed significant improvement ($P<0.01$) between group A and C, ($P<0.05$) between group B and group C and ($P<0.05$) between group A and group B.

Significant improvement for feed conversion efficiency was evident during the third fortnight to eighth fortnight i.e., from day 42 to 112. The cumulative feed conversion efficiency also showed the same trend. The feed conversion efficiency during the period from third to eighth fortnights were calculated as 4.29, 5.10 and 9.55 for animals fed on complete ration A, B and control ration C respectively. Towards the end of the experiment three animals in group A showed symptoms indicative of laminitis.

4.6 Digestibility coefficients

The data on digestibility coefficients of dry matter, crude protein, ether extract, crude fibre and nitrogen free extract of animals belonging to the three groups are presented in Tables 23 to 25 and their consolidated data in Table 26, which is represented in Fig.6.

The average dry matter digestibility coefficients obtained for groups A, B and C were 62.25 ± 1.60, 61.79 ± 1.54 and 68.86 ± 1.28 respectively (Table 26).

The average crude protein digestibility obtained for groups A, B and C were 61.65 ± 1.75, 59.46 ± 1.59 and 67.39 ± 1.42 respectively (Table 26).

The average value obtained for the digestibility coefficient of crude fibre were 41.41 ± 2.25, 48.94 ± 1.29 and 62.92 ± 1.32 respectively for A, B and C groups (Table 26).

The average ether extract digestibility obtained for the three groups were 52.11 ± 1.76, 55.41 ± 2.95 and 57.41 ± 1.61 for groups A, B and C respectively (Table 26).

The average value of the digestibility coefficients for nitrogen free extract were 73.94 ± 1.40, 71.76 ± 1.56 and 74.67 ± 2.14 respectively for groups A, B and C (Table 26).

The data on digestible crude protein (DCP) and total digestible nutrient (TDN) intake per 100 g dry matter are presented in Table 27.

The analysis of the data using ANOVA technique shows that there is significant improvement in digestibility coefficients ($P<0.01$) between animals fed conventional ration C when compared to those fed on complete ration A and B in dry matter and crude fibre. There was a significant improvement in crude protein digestibility for group C animals compared to those of group A ($P<0.05$) and group B ($P<0.01$) (Table 26).

4.7 Carcass characteristics

The data on various carcass characteristics (Dressing percentage, Meat yield, Meat-bone ratio) are presented in Table 28 to 30 and represented in Fig. 7 to 9 .

The average dressing percentage of animals slaughtered from groups A, B and C were 50.80 ± 0.70, 51.3 ± 1.43 and 45.17 ± 1.25 respectively (Table 28).

The average meat yield of animals slaughtered from groups A, B and C were 34.60 ± 0.15, 35.30 ± 1.12 and 30.73 ± 1.24 respectively (Table 29).

The average meat bone ratio of calves slaughtered from groups A, B and C were 2.57 ± 0.02, 2.70 ± 0.09 and 2.47 ± 0.08 respectively (Table 30).

The data on the carcass characteristics were analysed using ANOVA technique and revealed no significant improvement in the carcass characteristics by feeding animals with different rations. Better carcass characteristics were obtained in animals fed on complete feed compared to those fed on conventional ration.

4.8 Histopathology of rumen epithelium

Representative microphotographs of the rumen epithelium of one animal from each of the three experimental groups are presented in Plates 1 to 3.

Microscopical examination of the samples of rumen epithelium from slaughtered animals reveals that parakeratosis was present in animals fed complete rations. Parakeratosis was not evident on histopathological examination in animals fed conventional control ration C.

Animals of group A exhibited long, slender rumen papillae. Pronounced thickening of the rumen papillae could also be noticed in this group. Parakeratosis of the papillae was distinctly seen in this group (Plate 1).

The animals of group B showed milder degree of parakeratosis. The papillae were wider with lower keratin deposition in superficial layers (Plate 2).

The rumen papillae of group C animals were blunt and short and showed no evidence of parakeratosis (Plate 3).

4.9 Economic viability

The economic viability of feeding the animals with complete ration versus conventional ration was studied. The expenditure of rearing the calves on three rations A, B and C was Rs.21967, Rs.21175 and Rs.19108.50 respectively (Table 31).

Cost of production per kilogram gain of the animals by rearing them on the two complete rations A and B and control ration C were calculated as Rs.32.63, Rs. 31.84 and Rs. 37.96 respectively (Table 32 and Fig.10).

Gross profit on maintaining the animals by feeding them on rations A, B and C were calculated as Rs.1399, Rs.1550 and Rs.632.25 (Table 33 and Fig.11).

Table 3. Body weights (kg) of calves recorded at fortnightly intervals (Group A)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	59	62	52	53	41	37	50.67± 4.02
1	66	64	56.5	55	45	45	55.25± 3.67
2	69	68	60.5	60	47	46	58.42 ± 4.06
3	85	83	69	75	58	57	71.17 ± 4.91
4	96	95	81	86	63	67	81.33 ± 5.67
5	108	102	94	97	73	77	91.83 ± 5.69
6	120	114	107	111	80	85	102.83 ± 6.69
7	131	127	119	119	92	97	114.17 ± 6.53
8	140	140	125	134	104	106	124.83 ± 6.66
9	153	156	130	138	110	123	135.00 ± 7.23
10	166	171	144	153	121	133	148.00 ± 7.85
11	171	174	150	156	131	140	153.67 ± 6.91
Cumulative increase in body weight	112	112	98	103	90	103	103.00±3.44

Table 4. Body weights (kg) of calves recorded at fortnightly intervals (Group B)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	62	54	54	49.5	41	48	51.42±2.88
1	69	64	59.5	52.5	46	54	57.50 ± 3.41
2	76	68.5	67.5	58	49	62	63.50 ± 3.83
3	87	77	76	69	61	67	72.83 ± 3.73
4	100	87	84	79	69	79	83.00 ± 4.22
5	113	94	96	87	75	86	91.83 ± 5.20
6	124	112	104	101	89	93	103.83 ± 5.22
7	135	117	110	115	97	102	112.67 ± 5.44
8	146	129	121	132	103	115	124.33 ± 6.06
9	157	134	130	142	114	120	132.83 ± 6.32
10	171	144	139	159	125.5	133	145.25 ± 6.91
11	180	152	147	168	133	137	152.83 ± 7.41
Cumulative increase in body weight	118	98	93	118.5	92	89	101.42 ± 5.45

Table 5. Body weights (kg) of calves recorded at fortnightly intervals (Group C)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	54	56	42	56	52	42	50.33±2.70
1	59	57	45	60	55	47	53.83 ± 2.58
2	69	69	53	71	66	52	63.33 ±3.48
3	71	73	56	75	72	57	67.33 ± 3.47
4	78	80	61	82	81	63	74.16 ± 3.89
5	87	89	69	89	90	68	82.00± 4.29
6	95	96	73	95	100	78	89.50±4.54
7	103	109	84	109	104	83	98.67 ± 4.90
8	105	111	87	123	113	89	104.67 ± 5.78
9	115	117	92	136	124	97	113.50 ± 6.75
10	118	126	97	140	131	99	118.50 ± 7.11
11	126	136	104	150	139	107	127.00±7.49
Cumulative increase in body weight	72	80	62	94	87	65	76.66 ± 5.14

Table 6. Average weight (kg) of calves recorded at fortnightly intervals with cumulative weight gain (kg) in three groups

Fortnights	Average body weight		
	Group A	Group B	Group C
0	50.67 ± 4.02	51.42 ± 2.88	50.33 ± 2.70
1	55.25 ± 3.67	57.50 ± 3.41	53.83 ± 2.58
2	58.42 ± 4.06	63.50 ± 3.83	63.33 ± 3.48
3	71.17 ± 4.91	72.83 ± 3.73	67.33 ± 3.47
4	81.33 ± 5.67^{A}	83.00 ± 4.22^{A}	74.16 ± 3.89^{B}
5	91.83 ± 5.69^{A}	91.83 ± 5.20^{A}	82.00 ± 4.29^{B}
6	102.83 ± 6.69^{A}	103.83 ± 5.22^{A}	89.50 ± 4.54^{B}
7	114.17 ± 6.53^{A}	112.67 ± 5.44^{A}	98.67 ± 4.90^{B}
8	124.83 ± 6.66^{A}	124.33 ± 6.06^{A}	104.67 ± 5.78^{B}
9	135.00 ± 7.23^{A}	132.83 ± 6.32^{A}	113.50 ± 6.75^{B}
10	148.00 ± 7.85^{A}	145.25 ± 6.91^{A}	118.50 ± 7.11^{B}
11	153.67 ± 6.91^{A}	152.83 ± 7.41^{A}	127.00 ± 7.49^{B}
Cumulative weight gain	103.00 ± 3.44^{A}	101.42 ± 5.45^{A}	76.66 ± 5.14^{B}

Means having different superscripts in upper case in a row are significantly different ($P<0.01$)

Table 7. Body length (cm) of calves recorded at fortnightly intervals (Group A)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	63	67.5	65	61	56.5	54	61.17 ± 2.09
1	65	69	66	63	58	56	62.83 ± 2.02
2	70	72	70	67	62	60	66.83 ± 1.97
3	72.5	72.5	71.5	68	66	62	68.75 ± 1.73
4	76	77	76	73	71	65	73.00 ± 1.84
5	81	84	82	78	75.5	71	78.58 ± 1.95
6	86	87.5	87	84	81	77	83.75 ± 1.66
7	91	96.5	93.5	89	88	84	90.33 ± 1.79
8	96	101	97	94	91	87	94.33 ± 1.99
9	101	106	102	99.5	96	91	99.25 ± 2.12
10	101	109	102.5	99.5	96.5	95	100.58 ± 2.03
11	102.5	110	103	100	98	97	101.75 ± 1.91
Cumulative increase in body length	39.5	42.5	38	39	41.5	43	40.58 ± 0.83

Table 8. Body length (cm)of calves recorded at fortnightly intervals (Group B)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	65	64.5	67	56	53	62	61.25 ± 2.26
1	67	66	70	57	55	65	63.33 ± 2.43
2	69	68	70	60	61	70	66.33 ± 1.87
3	73	68	74	63	63	72	68.83 ± 2.02
4	79	74	79	69	69	77	74.50 ± 1.89
5	80.5	77	85	69	72	81	77.42 ± 2.45
6	84	81.5	91	71	77	85	81.58 ± 2.80
7	87	85	96	76	81	89	85.67 ± 2.80
8	92	93	104.5	90	89	97	94.25 ± 2.34
9	95.5	99	110	97	94	102	99.58 ± 2.37
10	97	100	112	102.5	97.5	105	102.33 ± 2.29
11	98.5	102	113	104.5	99	106	103.83 ± 2.19
Cumulative increase in body length	33.5	37.5	46	48.5	46	44	42.58 ± 2.37

Table 9. Body length (cm) of calves recorded at fortnightly intervals (Group C)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	59	59	58	66	57	54	58.83 ± 1.62
1	60.5	60	60	67.5	61	57.5	61.08 ± 1.37
2	63	61	62	69	64	59.5	63.08 ± 1.34
3	67	65	67	72	67	63	66.83 ± 1.22
4	71	70.5	71	75	72	69	71.42 ± 0.82
5	75	75	74	78	75	73	75.00 ± 0.68
6	80	81.5	81	81	82	77	80.42 ± 0.73
7	84	85	84.5	83.5	86	81	84.00 ± 0.69
8	87	89	89	87	89.5	85	87.75 ± 0.70
9	90	93.5	93	89.5	92	88.5	91.08 ± 0.83
10	92	95	94.5	91	95	91	93.08 ± 0.80
11	95	96.5	96	93	97.5	93	95.16 ± 0.76
Cumulative increase in body length	36	37.5	38	27	40.5	39	36.33 ± 1.96

Table 10. Average length (cm) of calves recorded at fortnightly intervals with cumulative increase in length (cm) in the three groups

Fortnight	Average length (cm)		
	Group A	Group B	Group C
0	61.17 ± 2.09	61.25 ± 2.26	58.83 ± 1.62
1	62.83 ± 2.02	63.33 ± 2.43	61.08 ± 1.37
2	66.83 ± 1.97[a]	66.33 ± 1.87[a]	63.08 ± 1.34[b]
3	68.75 ± 1.73[a]	68.83 ± 2.02[a]	66.83 ± 1.22[b]
4	73.00 ± 1.84	74.50 ± 1.89[a]	71.42 ± 0.82[b]
5	78.58 ± 1.95[a]	77.42 ± 2.45[a]	75.00 ± 0.68[b]
6	83.75 ± 1.66[a]	81.58 ± 2.82	80.42 ± 0.73[b]
7	90.33 ± 1.79[A]	85.67 ± 2.80	84.00 ± 0.69[B]
8	94.33 ± 1.99[A]	94.25 ± 2.34[A]	87.75 ± 0.70[B]
9	99.25 ± 2.12[A]	99.58 ± 2.37[A]	91.08 ± 0.83[B]
10	100.58 ± 2.03[A]	102.33 ± 2.29[A]	93.08 ± 0.80[B]
11	101.75 ± 1.91[A]	103.83 ± 2.19[A]	95.16 ± 0.76[B]
Cumulative increase in body length	40.58 ± 0.83[A]	42.58 ± 2.37[A]	36.33 ± 1.96[B]

Means having different superscripts in upper case in a row are significantly different (P<0.01)
Means having different superscripts in lower case in a row are significantly different (P<0.05)

Table 11. Chest girth (cm) of calves recorded at fortnightly intervals (Group A)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	94	93	95.5	92	83	80	89.58 ± 2.63
1	96	94	96	95	85	81	91.17 ± 2.65
2	100	100	103	96.5	89	85	95.58 ± 2.89
3	103	104	106	97.5	92	88	98.42 ± 2.94
4	107	108.5	109	101	97	93	102.58 ± 2.71
5	111	112	115	106	102	96	107.00 ± 2.90
6	115.5	117	120	110	108	100	111.75 ± 2.97
7	119	121	128	115	113	103.5	116.58 ± 3.38
8	123	125	130	119	117	107.5	120.25 ± 3.16
9	127.5	128	135	123	122	111	124.42 ± 3.28
10	128	129	136.5	124	123	113	125.58 ± 3.18
11	129	130.5	138	126	124	115	127.08 ± 3.12
Cumulative increase in chest girth	35	37.5	42.5	34	41	35	37.50 ± 1.44

Table 12. Chest girth (cm) of calves recorded at fortnightly intervals (Group B)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	96	92.5	93	85	79.5	93	89.83 ± 2.55
1	98	95	96	87	81	96	92.17 ± 2.72
2	102	96	100	93	90	94	95.83 ± 1.83
3	104	99	102	96	94	97	98.67 ± 1.54
4	105.5	103	106	99	97	100	101.75 ± 1.49
5	106	108	108	105	102	103	105.33 ± 1.02
6	108	109	113	109	107	106	108.67 ± 0.99
7	112	111	117	113	111	109	112.17 ± 1.11
8	117	115	124.5	121	119.5	115	118.67 ± 1.53
9	119	120	129	126	126	119	123.17 ± 1.78
10	119	121	131	127.5	126	120.5	124.17 ± 1.93
11	120	121.5	132	129	128	122	125.42 ± 1.99
Cumulative increase in chest girth	24	29	39	44	48.5	29	35.58 ± 3.96

Table 13. Chest girth (cm) of calves recorded at fortnightly intervals (Group C)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	75	85	87	95	85	77	84.00 ± 2.95
1	77	87	87.5	98	88	79.5	86.17 ± 3.02
2	82	89	90	100	91	81	88.83 ± 2.82
3	87	94	93	102	97	83	92.67 ± 2.79
4	92	98	98.5	104.5	101	87	96.83 ± 2.58
5	96	103	104	107	106	91	101.17 ± 2.57
6	102	106	109	109	109	94	104.83 ± 2.44
7	103.5	110	113	111	113	97	107.92 ± 2.61
8	106	114	115	113.5	116	100	110.75 ± 2.59
9	109.5	119	119.5	114	119	102.5	113.92 ± 2.79
10	111	122	122	117	121	105	116.33 ± 2.85
11	114	124.5	124	118	123	108	118.58 ± 2.69
Cumulative increase in chest girth	39	39.5	37	23	38	31	34.58 ± 2.63

Table.14 Average chest girth (cm) of calves recorded at fortnightly intervals with cumulative increase in chest girth (cm) in the three groups

Fortnights	Average chest girth (cm)		
	Group A	Group B	Group C
0	89.58 ± 2.63	89.83 ± 2.55	84.00 ± 2.95
1	91.17 ± 2.65	92.17 ± 2.72	86.17 ± 3.02
2	95.58 ± 2.89	95.83 ± 1.83	88.83 ± 2.82
3	98.42 ± 2.94	98.67 ± 1.54	92.67 ± 2.79
4	102.58 ± 2.71	101.75 ± 1.49	96.83 ± 2.58
5	107.00 ± 2.90	105.33 ± 1.02	101.17 ± 2.57
6	111.75 ± 2.97	108.67 ± 0.99	104.83 ± 2.44
7	116.58 ± 3.38	112.17 ± 1.11	107.92 ± 2.61
8	120.25 ± 3.16	118.67 ± 1.53	110.75 ± 2.59
9	124.42 ± 3.28	123.17 ± 1.78	113.92 ± 2.79
10	125.58 ± 3.18	124.17 ± 1.93	116.33 ± 2.85
11	127.08 ± 3.12	125.42 ± 1.99	118.58 ± 2.69
Cumulative increase in chest girth	37.50 ± 1.44	35.58±3.96	34.58±2.63

Table 15. Height at withers (cm) of calves recorded at fortnightly intervals (Group A)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	73.5	73	74	72	71	70	72.25 ± 0.63
1	76	75	76	75	73	72	74.50 ± 0.67
2	81	84	83	82.5	78	78	81.08 ± 1.05
3	85	87.5	87	88	83	81	85.25 ± 1.14
4	90	91.5	95	92	85.5	85	89.83 ± 1.60
5	94	95	103	95.5	90.5	89	94.50 ± 2.00
6	98	99.5	108.5	100	96	95	99.50 ± 1.97
7	104	106	111	104	101	99	104.17 ± 1.70
8	107	111	114	109	104	102	107.83 ± 1.81
9	109	114	118	112.5	106.5	104	110.67 ± 2.10
10	113	118	120.5	115	109	109	114.06 ± 1.92
11	114	119.5	122	117	110	111	115.58 ± 1.94
Cumulative increase in height	40.9	46.5	48	45	39	41	43.40 ± 1.47

Table 16. Height at withers (cm) of calves recorded at fortnightly intervals (Group B)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	73	72.5	74	71.5	70	73	72.33 ± 0.57
1	75	74	76	74	72	75	74.33 ± 0.56
2	81	77.5	82	79	78.5	82	80.00 ± 0.78
3	85.5	83	88	85	85	87	85.58 ± 0.71
4	89	88	95.5	91	90	93.5	91.17 ± 1.16
5	92.50	92	102	94	97	99	96.08 ± 1.61
6	96	96	107	98	101.5	103	100.25 ± 1.79
7	101	99	111	103	105	107	104.33 ± 1.76
8	104	103	115.5	108	108	111	108.25 ± 1.88
9	108	105.5	120	111	111	115.5	111.83 ± 2.13
10	111	109	124	114	113.5	118	114.92 ± 2.20
11	112	111	124.5	115	115	119	116.08 ± 2.03
Cumulative increase in height	39	38.5	50.5	43.5	45	46	43.75 ± 1.85

Table 17. Height at withers (cm) of calves recorded at fortnightly intervals (Group C)

Fortnights	Replicate						Mean ± S.E.
	1	2	3	4	5	6	
0	72	74	75	76	72	74	73.83 ± 0.65
1	75	77	80	78.5	77	77	77.42 ± 0.69
2	79	80.5	83	82	81.5	81	81.17 ± 0.56
3	83	85	87.5	86	87	83.5	85.33 ± 0.75
4	86.5	89	90.5	87.5	91	86	88.41 ± 0.85
5	89.5	93	94	92	95.5	89	92.17 ± 1.04
6	94	98	98.5	97.5	100.5	91	96.58 ± 1.41
7	98	101	101	100	103	95	99.67 ± 1.15
8	100	104	102.5	102	105	97	101.75 ± 1.18
9	102	106	105	104	107.5	100	104.08 ± 1.11
10	104	108.5	107	107	109	102	106.25 ± 1.11
11	105	110	109	109.5	111	104	108.08 ± 1.17
Cumulative increase in height	33	36	34	33.5	39	30	34.25 ± 1.24

Table.18 Average body height at withers (cm) of calves recorded at fortnightly intervals with cumulative increase in body height at withers (cm) in the three groups

Fortnights	Average body height at withers (cm)		
	Group A	Group B	Group C
0	72.25 ± 0.63	72.33 ± 0.57	73.83 ± 0.65
1	74.50 ± 0.67	74.33 ± 0.56	77.42 ± 0.69
2	81.08 ± 1.05	80.00 ± 0.78	81.17 ± 0.56
3	85.25 ± 1.14	85.58 ± 0.71	85.33 ± 0.75
4	89.83 ± 1.60	91.17 ± 1.16	88.41 ± 0.85
5	94.50 ± 2.00	96.08 ± 1.61	92.17 ± 1.04
6	99.50 ± 1.97[a]	100.25 ± 1.79[a]	96.58 ± 1.41[b]
7	104.17 ± 1.70[a]	104.33 ± 1.76[a]	99.67 ± 1.15[b]
8	107.83 ± 1.82[A]	108.25 ± 1.88[A]	101.75 ± 1.18[B]
9	110.67 ± 2.10[A]	111.83 ± 2.13[A]	104.08 ± 1.11[B]
10	114.06 ± 1.92[A]	114.92 ± 2.20[A]	106.25 ± 1.11[B]
11	115.58 ± 1.94[A]	116.08 ± 2.03[A]	108.08 ± 1.17[B]
Cumulative increase in height	43.40±1.47[A]	43.75±1.85[A]	34.25±1.24[B]

Means having different superscripts in upper case in a row are significantly different (P<0.01)
Means having different superscripts in lower case in a row are significantly different (P<0.05)

Table 19. Average fortnightly dry matter intake (kg) per animal maintained on rations A, B and C.

Fortnights	Group A	Group B	Group C
1	34.96 ± 2.52	36.62 ± 0.22	38.72± 0.00
2	36.22 ± 4.46	37.61 ± 1.86	40.55 ± 0.12
3	41.51 ± 2.61	40.16 ± 2.38	45.80 ± 0.28
4	47.98 ± 0.89	47.88 ± 0.89	37.27 ± 1.62
5	39.99 ± 0.50	39.91 ± 0.50	48.17 ± 0.36
6	45.53 ± 1.14	51.13 ± 1.72	47.58 ± 0.30
7	39.99 ± 0.50^{A}	52.44 ± 0.81^{B}	52.97 ± 0.22^{B}
8	48.06 ± 1.49^{A}	56.45 ± 0.89^{B}	53.34 ± 0.39^{B}
9	52.58 ± 0.68	50.71 ± 0.69^{A}	56.50 ± 0.44^{B}
10	56.98 ± 0.48	62.72 ± 0.16^{A}	53.02 ± 0.69^{B}
11	67.33 ± $0.48a^{A}$	62.48 ± $1.67b^{A}$	53.72 ± 0.62^{B}
Average fortnightly dry matter intake	46.19 ± 0.76	48.74 ± 0.67	47.51 ± 0.42
DM intake expressed as percentage of body weight	3.06	3.22	3.58

Means having different superscript in upper case in a row are significantly different ($P< 0.01$)

Means having different superscript in lower case in a row are significantly different ($P<0.05$)

Table 20. Average fortnightly concentrate (kg) and grass (kg) intake (Dry matter) of the animals maintained on ration C

Fortnights	Concentrate intake(kg)	Grass intake (kg)
1	12.52 ± 0.00	26.20 ± 0.00
2	14.53 ± 0.00	26.02 ± 0.25
3	18.78 ± 0.00	27.02 ± 0.46
4	18.78 ± 0.00	18.49 ± 1.37
5	18.78 ± 0.00	29.39 ± 1.39
6	22.36 ± 0.00	25.22 ± 1.53
7	22.36 ± 0.00	29.98 ± 1.53
8	22.36 ± 0.00	28.30 ± 1.93
9	25.04 ± 0.00	31.46 ± 4.99
10	25.04 ± 0.00	27.98 ± 4.77
11	25.04 ± 0.00	28.68 ± 3.83

Table 21. Average daily gain (g) of calves maintained on rationsA, B and C

Fortnights	Group A	Group B	Group C
1	327.33 ± 72.78	434.33 ± 68.04	249.83 ± 0.04
2	226.17 ± 42.98	428.17 ± 59.05	654.67 ± 0.07
3	909.83 ± 86.42^{A}	666.67 ± 74.77^{A}	285.83 ± 41.28^{B}
4	726.10 ± 76.90^{A}	725.83 ± 59.53^{A}	476.167 ± 43.95^{B}
5	702.33 ± 62.41^{A}	630.83 ± 85.26^{A}	559.50 ± 46.76^{B}
6	785.67 ± 82.53^{a}	856.83 ± 120.00^{A}	535.66 ± 68.27^{Bb}
7	809.17 ± 51.08^{A}	630.83 ± 96.52^{B}	654.50 ± 121.41^{B}
8	761.50 ± 95.17^{A}	833.50 ± 103.69^{A}	413.67 ± 139.75^{B}
9	725.00 ± 169.84	607.17 ± 82.02	631.00 ± 89.29
10	856.83 ± 122.30^{A}	886.17 ± 84.19^{A}	357.17 ± 76.05^{B}
11	404.67 ± 77.53	577.50 ± 68.61	606.83 ± 35.70
Cumulative average daily gain	668.83± 22.37^{A}	658.55±35.41^{A}	497.83±33.35^{B}

Means having different superscript in upper case in a row are significantly different ($P < 0.01$)
Means having different superscript in lower case in a row are significantly different ($P < 0.05$)

Table 22. Average fortnightly feed conversion efficiency of calves maintained on rations A, B and C

Fortnights	Group A	Group B	Group C
1	11.21 ± 3.15	9.49 ± 1.68	14.95 ± 4.85
2	11.51 ± 2.49	10.90 ± 5.42	4.80 ± 0.71
3	3.65 ± 0.39^{A}	3.87 ± 1.03^{A}	12.96 ± 2.20^{B}
4	5.19 ± 0.89^{a}	4.86 ± 0.38^{a}	8.86 ± 0.66^{b}
5	3.94 ± 0.34^{a}	5.01 ± 0.57	6.15 ± 0.40^{b}
6	4.36 ± 0.43^{a}	4.65 ± 0.59^{a}	7.81 ± 1.06^{b}
7	3.62 ± 0.31^{a}	6.77 ± 1.11^{b}	6.32 ± 1.47^{b}
8	4.98 ± 0.85^{A}	5.44 ± 0.84^{A}	15.21 ± 4.07^{B}
9	7.17 ± 1.75	6.72 ± 1.12	7.50 ± 1.12
10	5.92 ± 1.69	5.38 ± 0.49	7.30 ± 1.90
11	14.28 ± 2.67	8.52 ± 1.37	6.43 ± 0.37
Cumulative feed conversion ratio	4.71±0.15^{aA}	5.57±0.37^{b}	6.99±0.42^{cB}

Means having different superscript in upper case in a row are significantly different (P< 0.01)

Means having different superscript in lower case in a row are significantly different (P<0.05)

Table 23. Digestibility coefficients of nutrients in calves maintained on ration A

Nutrients	Replicate						Mean ± SE
	1	2	3	4	5	6	
Dry matter	56.59	60.29	61.20	64.91	62.52	67.97	62.25 ± 1.60
Crude protein	55.20	60.73	62.69	60.80	61.92	68.55	61.65 ± 1.75
Ether extract	47.31	48.64	49.42	57.65	53.25	56.41	52.11 ± 1.76
Crude fibre	40.76	31.34	40.98	47.37	43.55	44.45	41.41 ± 2.25
Nitrogen free extract	67.91	73.78	73.90	74.24	75.35	78.48	73.94 ± 1.40

Table 24. Digestibility coefficients of nutrients in calves maintained on ration B

Nutrients	Replicate						Mean ± SE
	1	2	3	4	5	6	
Dry matter	60.68	62.18	57.53	59.17	68.43	62.77	61.79 ±1.54
Crude protein	60.26	53.64	60.25	62.17	56.16	64.30	59.46 ± 1.59
Ether extract	52.83	64.91	54.65	61.07	55.03	43.96	55.41 ± 2.95
Crude fibre	45.28	50.10	50.59	46.58	53.85	47.26	48.94 ± 1.29
Nitrogen free extract	75.64	71.86	66.88	68.52	76.60	71.09	71.76 ± 1.56

Table 25. Digestibility coefficients of nutrients in calves maintained on ration C

Nutrients	Replicate						Mean ± SE
	1	2	3	4	5	6	
Dry matter	65.76	72.19	69.56	67.09	65.76	72.81	68.86 ± 1.28
Crude protein	65.94	72.06	68.56	62.10	66.01	69.71	67.39 ± 1.42
Ether extract	52.10	54.39	61.46	61.94	58.71	55.88	57.41 ± 1.61
Crude fibre	63.73	57.80	61.58	62.26	64.80	67.38	62.92 ± 1.32
Nitrogen free extract	77.81	72.26	77.19	73.61	66.26	81.45	74.67 ± 2.14

Table 26. Consolidated data on digestibility coefficients of nutrients in animals maintained on rations A, B and C

Nutrients	Group A	Group B	Group C
Dry matter	62.25 ± 1.60^{A}	61.79 ± 1.54^{A}	68.86 ± 1.28^{B}
Crude protein	61.65 ± 1.75^{a}	59.46 ± 1.59^{A}	67.39 ± 1.42^{bB}
Ether extract	52.11 ± 1.76	55.41 ± 2.95	57.41 ± 1.61
Crude fibre	41.41 ± 2.25^{A}	48.94 ± 1.29^{A}	62.92 ± 1.32^{B}
Nitrogen free extract	73.94 ± 1.40	71.76 ± 1.56	74.67 ± 2.14

Means having different superscript in uppercase in a row are significantly different ($P<0.01$)
Means having different superscript in lower case in a row are significantly different ($P<0.05$)

Table 27. Digestible crude protein (DCP) and total digestible nutrient (TDN) per 100 g dry matter intake

Treatment	Intake in grams per 100 g of dry matter	
	DCP	TDN
Group A	9.13	63.23
Group B	8.45	61.04
Group C	10.72	63.22

Table 28. Dressing percentage of calves slaughtered from groups A,B and C

Groups	Replicate			Mean ±S E
	1	2	3	
A	50.00	50.20	52.20	50.80±0.70
B	52.40	48.50	53.10	51.30±1.43
C	47.20	45.40	42.97	45.17 ± 1.25

Table 29. Meat yield (expressed as percentage of live weight) of calves slaughtered from groups A, B and C

Replication	Meat yield		
	Group A	Group B	Group C
1	34.60	35.00	32.30
2	34.40	33.54	31.60
3	34.90	37.38	28.29
Mean ± SE	34.60±0.15	35.30±1.12	30.73±1.24

Table 30. Meat bone ratio of calves slaughtered from groups A, B and C

Replication	Meat bone ratio		
	Group A	Group B	Group C
1	2.58:1	2.67:1	2.52:1
2	2.53:1	2.55:1	2.59:1
3	2.61:1	2.88:1	2.31:1
	2.57 ± 0.02	2.70 ± 0.09	2.47 ± 0.08

Table 31. Economics – Expenditure (Rs.) of rearing calves on three rations

	Ration A	Ration B	Ration C
1. Initial cost of animals (6) @ Rs.200/animal	1200	1200	1200
2. Cost of feed @ Rs 5.85/kg for ration A Rs 5.87/kg for Ration B Rs 7.05/kg for concentrate portion of Ration C and Rs.0.75/kg green grass	20167	19375	17308.5
3. Miscellaneous (feeder, waterer, expenses on medicines, electricity etc.) @ Rs 50/animal	300	300	300
4. Slaughter charges @ Rs 50/animal	300	300	300
Total	21967	21175	19108.5

Table 32. Cost of production per kilogram gain (Rs.) of the animals maintained on rations A, B and C

	Treatments		
	Ration A	Ration B	Ration C
Total weight gain of six animals (kg)	618	608.5	456
Total feed intake on fresh basis (kg)	3447.4	3300.6	1420 kg concentrate + 9730 kg grass
Total feed cost (Rs.)	20167	19375	17308.5
Cost per kg gain (Rs.)	32.63	31.84	37.96

Table 33. Average revenue (Rs.) from animals maintained on the three rations

	Ration A	Ration B	Ration C
1. Average weight of animals (kg)	153.70	152.83	127
2. Dressing percentage	50.8	51.3	45.17
3. Sale proceeds of meat @ Rs. 60/kg	4685	4704	3442
4. Sale proceeds of skin @ Rs. 250/skin	250	250	250
5. Sale proceeds of head @ Rs. 50/head	50	50	50
6. Sale proceeds of offals @ Rs. 50/offal	50	50	50
7. Sale proceeds of legs @ Rs. 25/set of four legs	25	25	25
Total	5060	5079	3817
Total expenditure per animal	3661	3529	3184.75
Gross profit per animal in 5 months	1399	1550	632.25

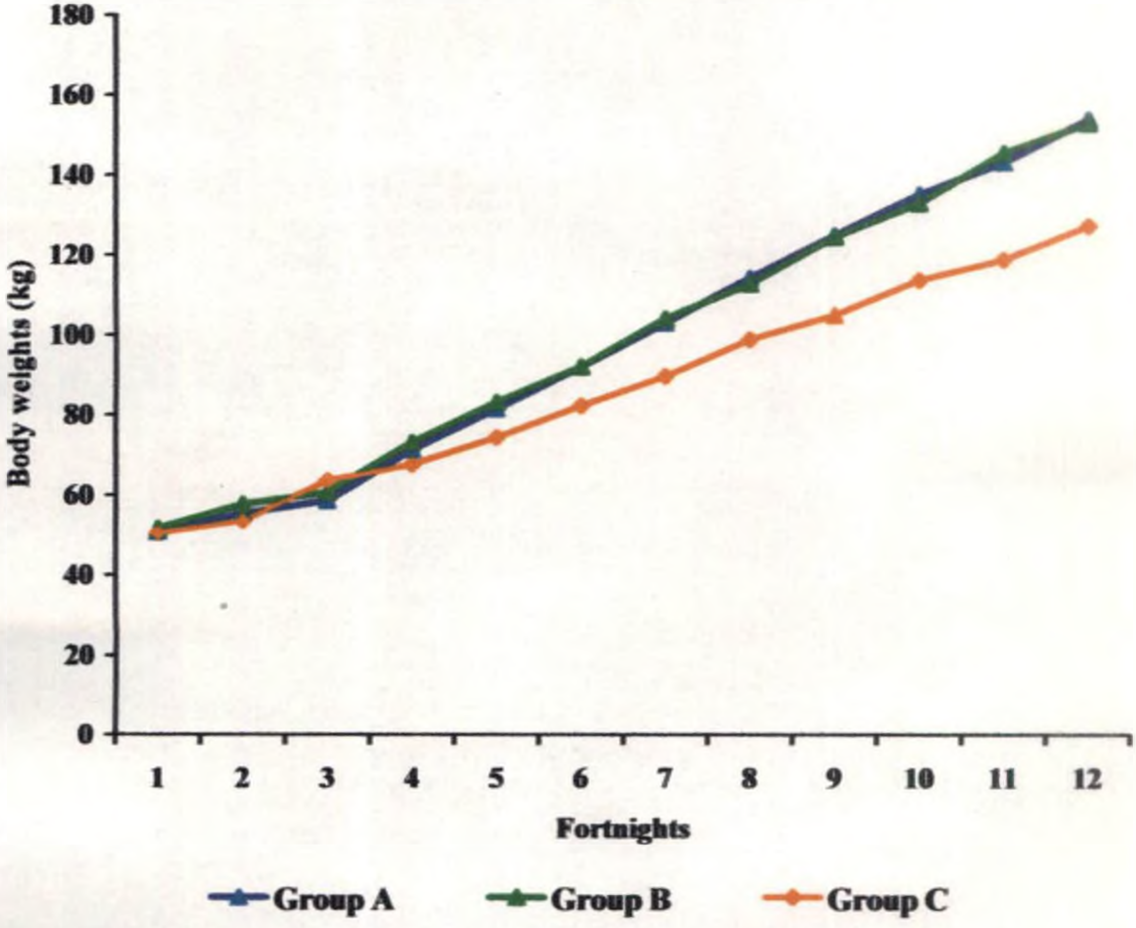


Fig. 1. Fortnightly body weights (kg) of animals maintained on the three rations

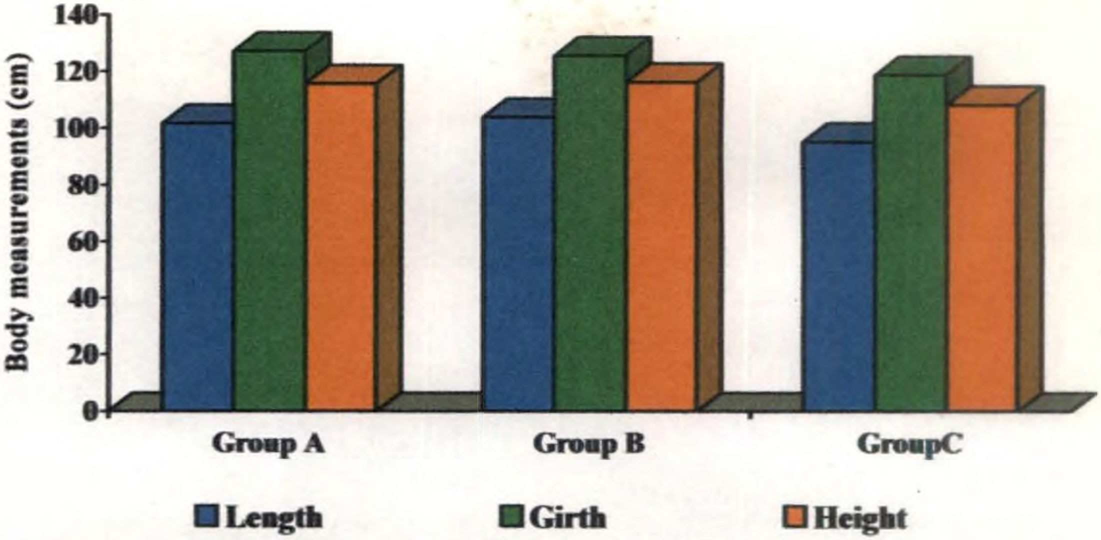


Fig. 2. Average body measurements (cm) of animals maintained on the three rations

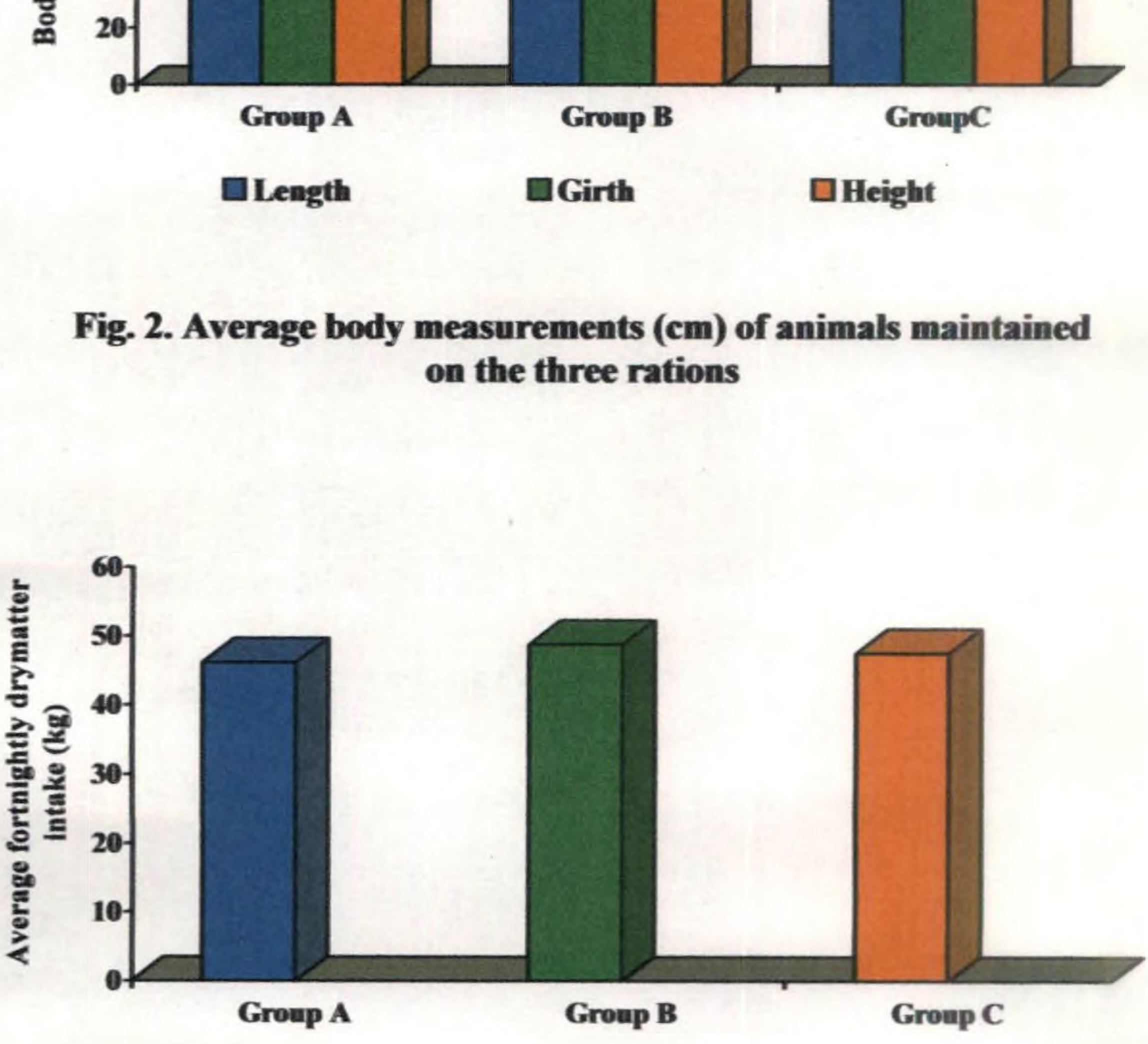


Fig. 3. Average fortnightly dry matter intake (kg) of animals maintained on the three rations

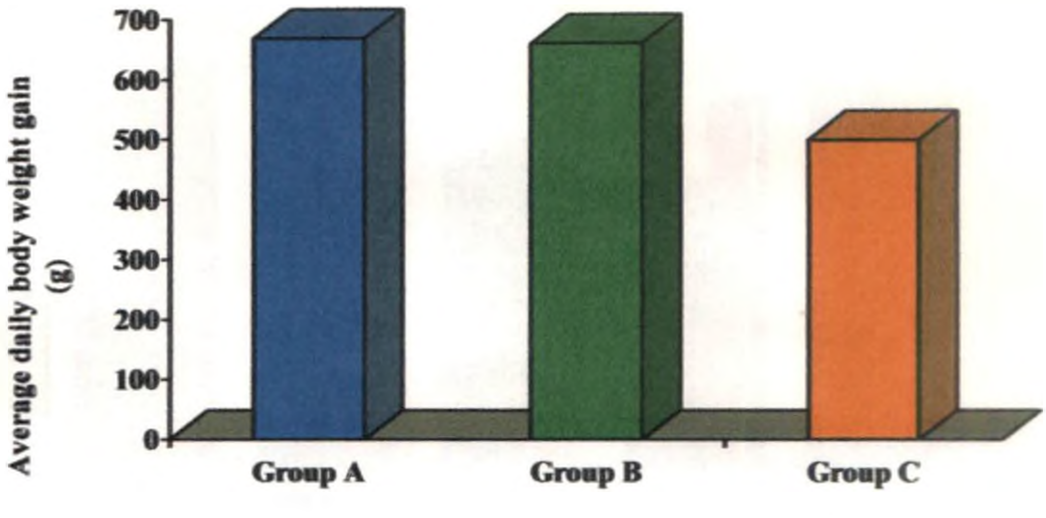


Fig. 4. Average daily body weight gain (g) of animals maintained on the three rations

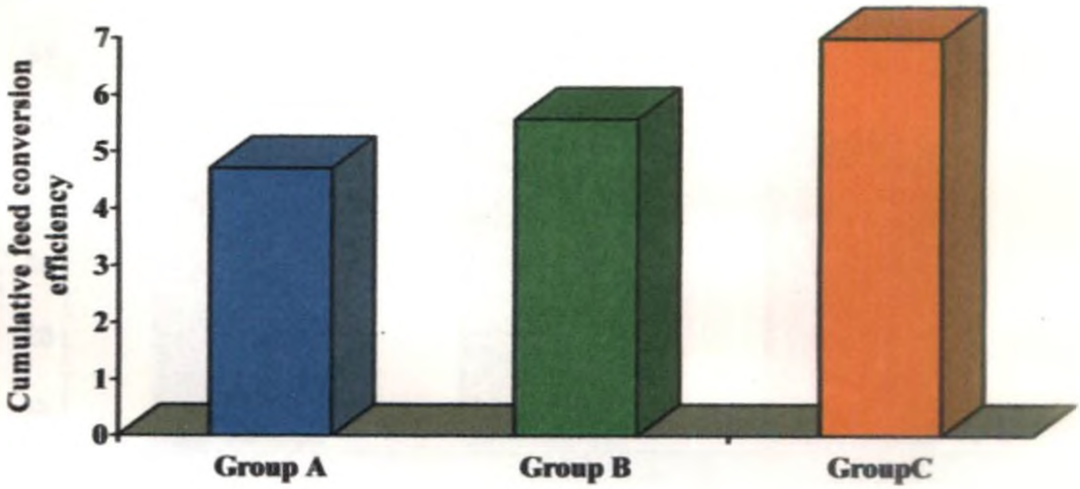


Fig. 5. Cumulative feed conversion efficiency of animals maintained on the three rations

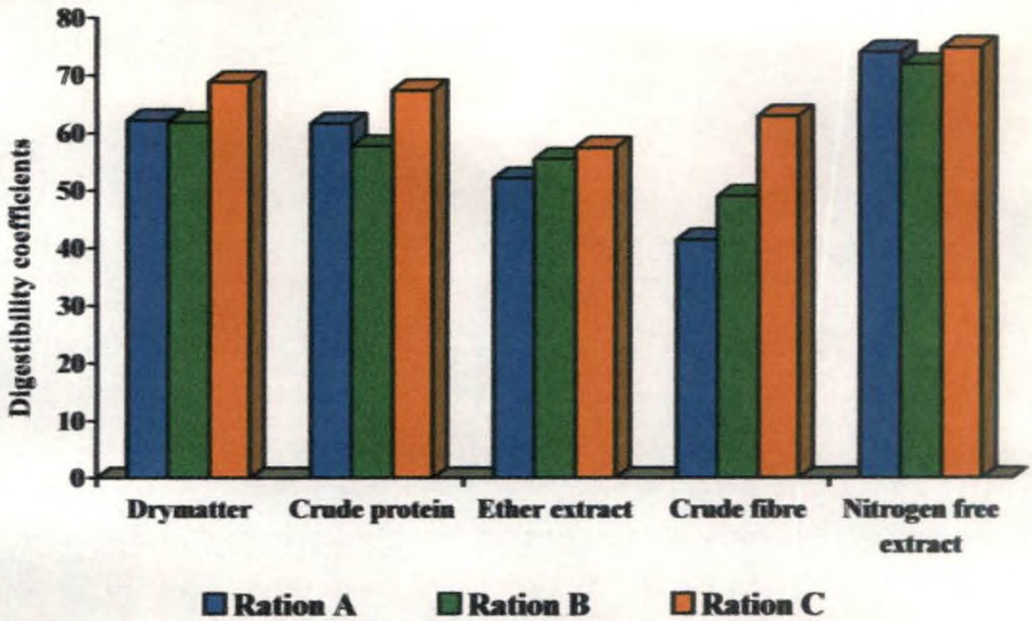


Fig. 6. Average digestibility coefficients of nutrients of the three rations

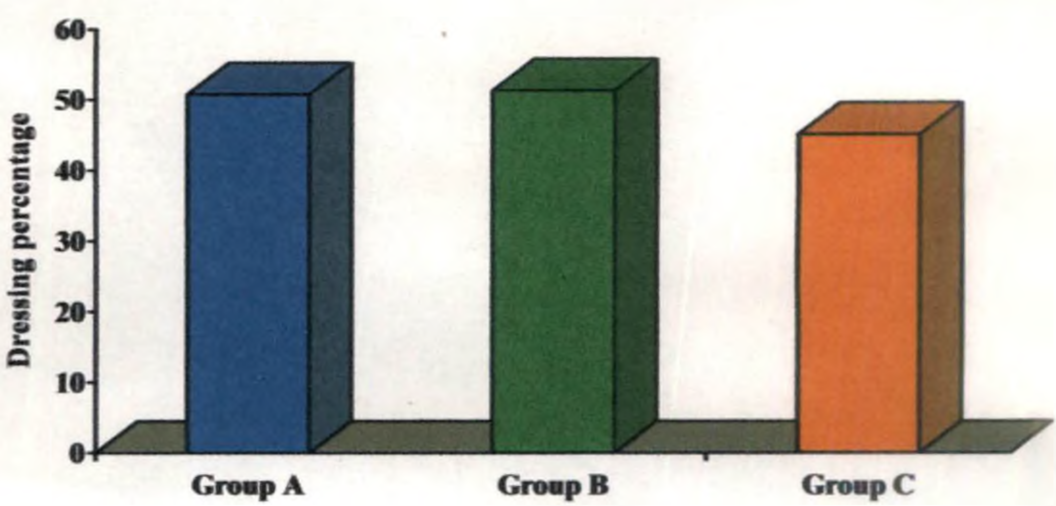


Fig. 7. Average dressing percentage of animals maintained on the three rations

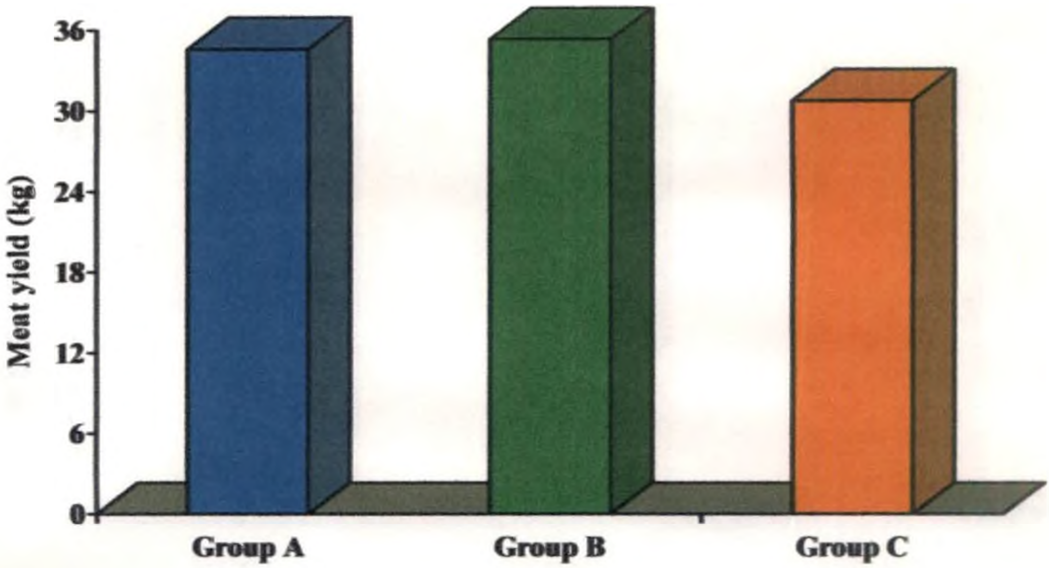


Fig. 8. Meat yield of animals maintained on the three rations

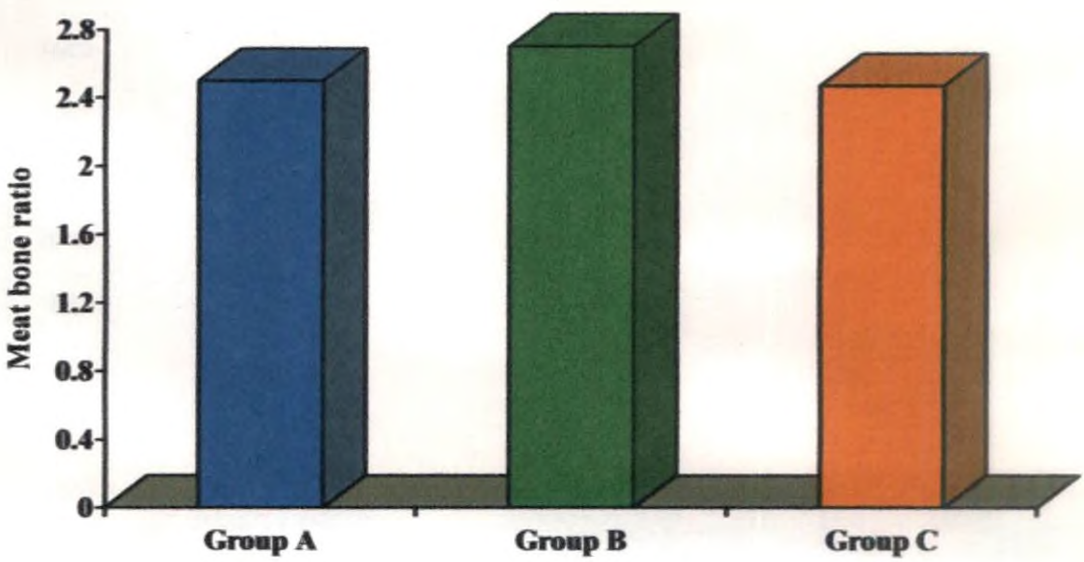


Fig. 9. Meat bone ratio of animals maintained on the three rations

Plate 1. Section of rumen epithelium from the animals of group A showing distinct parakeratosis (H&E x 100)

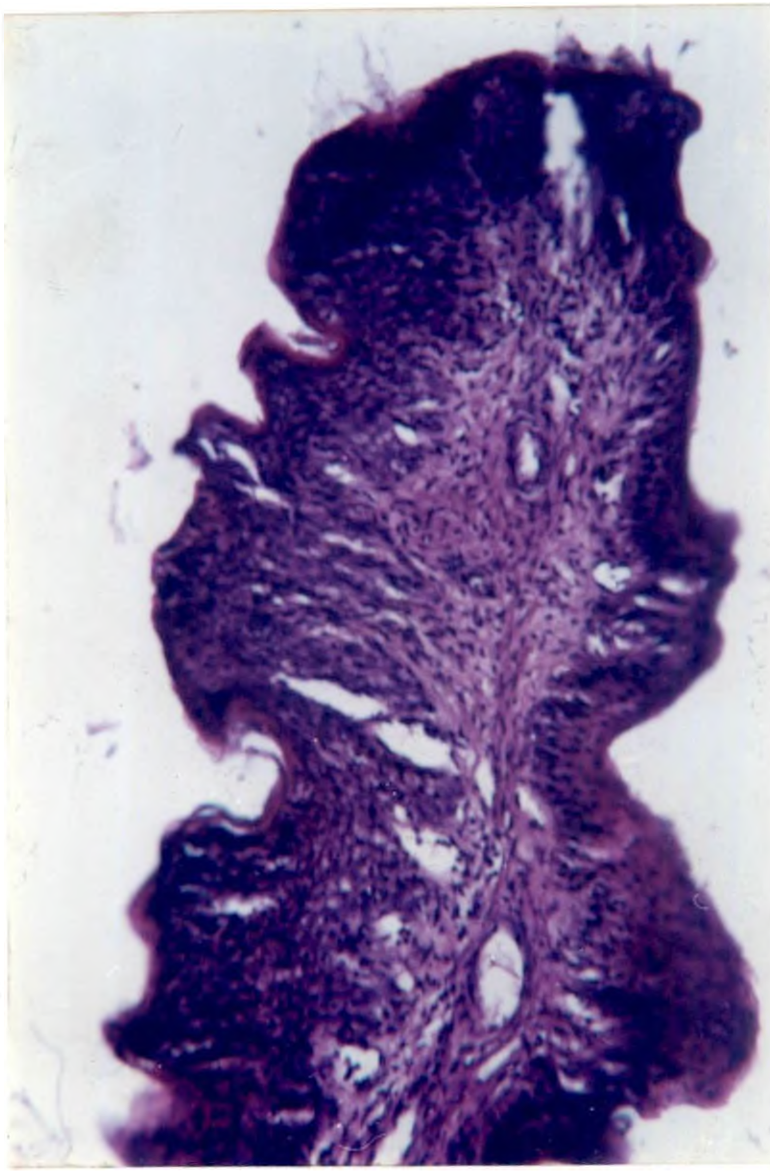


Plate 2. **Section of rumen epithelium from the animals of group B showing milder degree of parakeratosis (H&E x 100)**

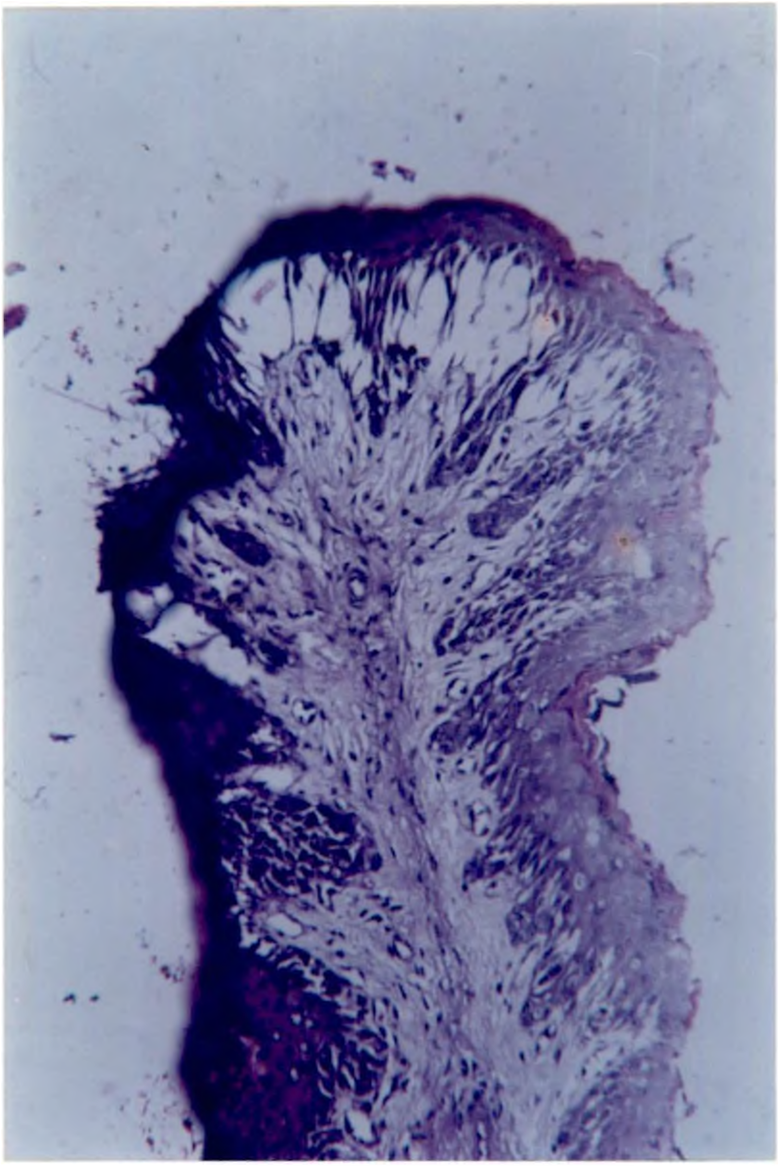
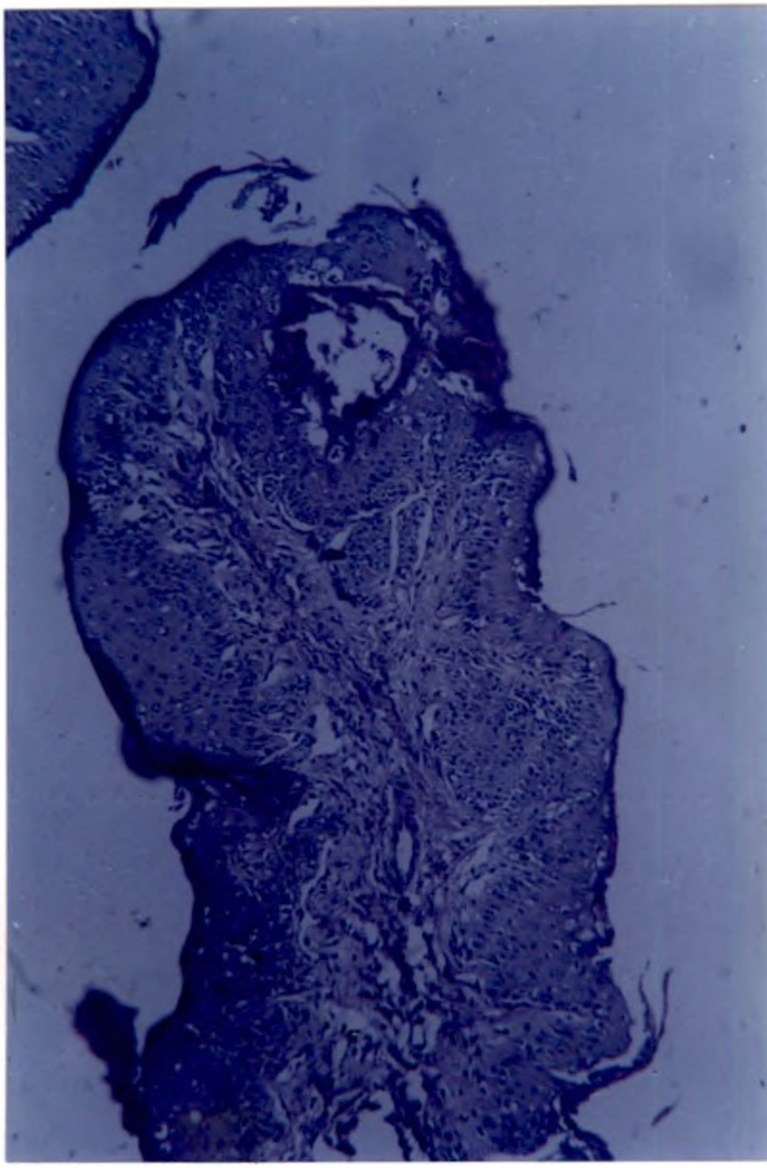


Plate 3. **Section of rumen epithelium from the animals of group C showing no evidence of parakeratosis (H&E x 100)**



Discussion

5. DISCUSSION

A study was carried out for the evaluation of complete feed for meat production in three-month-old crossbred calves. The animals of group A and B were fed on two complete rations A and B and their performance was compared with the animals fed conventional control ration (Group C).

The results obtained from the present investigation are discussed under the following sub-headings.

5.1 Growth

5.1.1 Body weight

The average final body weight (kg) recorded in animals of the three groups viz., A, B and C were 153.67 ± 6.91, 152.83 ± 7.41 and 127.00 ± 7.49 respectively The cumulative weight gain (kg) of calves in groupsA, B and C were 103.00 ± 3.44, 101.42 ± 5.45 and 76.66 ± 5.14 respectively (Table 6).

Statistical analysis of the data on body weights indicated that animals fed complete ration A and B were significantly higher ($P<0.01$) than those fed conventional ration (Ration C), but there was no significant difference in body weights between animals of group A and B.

Higher body weights were obtained by Delfino *et al.* (1988) in cattle, fed on 90 per cent concentrate rations containing monensin. Similarly Macgregor *et al.* (1974), Murdock and Wallenius (1980), Peak *et al.* (1991), Sehgal *et al.* (1994), Biju (1998) and Dildeep (1999) also reported better growth in low fibre diets and are in agreement with the present results. So complete feed with low fibre supports better growth.

5.2 Body measurements

5.2.1 Body length

The average body length (cm) at the end of the experiment were 101.75 ± 1.91; 103.83 ± 2.19 and 95.16 ± 0.76 respectively for animals of group A, B and C (Table 10). The average difference between the initial and final body length (cm) observed in the three groups A, B and C were 40.58 ± 0.83, 42.58 ± 2.37 and 36.33 ± 1.96 respectively (Table 10).

Statistically significant increase in body length was observed for animals of groups A and B with that of group C ($P<0.01$) with a consequent increase in body weight. Significantly higher body length was obtained in calves fed high energy diets consisted of 70 per cent grain based concentrate than those fed normal diets (Gilbert *et al.*, 1993). The significant increase in body length may have contributed to the significant increase in body weight.

5.2.2 Chest girth

The final chest girth (cm) at the end of the experiment was 127.08 ± 3.12, 125.42 ± 1.99 and 118.58 ± 2.69 respectively for groups A, B and C (Table 14). The cumulative increase in chest girth (cm) observed in three groups viz., A, B and C were 37.50 ± 1.44, 35.58 ± 3.96 and 34.58 ± 2.63 respectively (Table 14).

Statistical analysis of data indicated that there was no significant difference between animals of the three groups, although there was a significant difference in body weight.

Similar findings have been reported by Borland and Kesler (1979) in Holstein calves fed commercial pelleted complete feed, where non significant increase in chest girth was observed consequent to the significant increase in body weight.

5.2.3 Height at withers

The final height at withers (cm) at the end of the experiment period were 115.58 ± 1.94, 116.08 ± 2.03 and 108.08 ± 1.17 (Table 18). The cumulative increase in height at withers (cm) obtained for the groups were 43.40 ± 1.47, 43.75 ± 1.85 and 34.25 ± 1.24 respectively for A, B and C groups (Table 18).

Statistically significant increase in height ($P<0.01$) was observed between groups A and B with group C.

This result is in agreement with that of Borland and Kesler (1979) in calves fed commercial pelleted complete feed. Block and Shellenberger (1980a) also reported a significant increase in height at withers in proportion to increase in body weight in dairy calves fed commercially available pelleted rations when compared to those fed conventional rations.

5.3 Dry matter intake

The average fortnightly dry matter intake (kg) of an animal in groupsA, B and C for the experimental period were 46.19 ± 0.76, 48.74 ± 0.67 and 47.51 ± 0.42 respectively which works out to 3.06, 3.22 and 3.58 per cent of body weight respectively (Table 19).

There was no statistically significant difference between the three groups (Table 19). The animals in group A with lower fibre had lower dry matter intake.

The results are in agreement with Fluharty *et al.* (1994) and Sehgal *et al.* (1994) which showed lower dry matter intake when fed high concentrate feed.

Zinn *et al.* (1994) and Preston *et al.* (1996) reported a decrease in dry matter intake in steers fed feed supplemented with monensin and the effect was more in feed containing high concentrates with low fibre. The result of the present experiment is in agreement with the above findings.

5.4 Average daily body weight gain

The average daily gain of calves maintained on rationsA, B and C were 668.83 ± 22.37, 658.55 ± 35.41 and 497.83 ± 33.35 respectively (Table 21).

There was statistically significant improvement in body weight gain for groups A and B with group C from day 42 to day 112 and also in cumulative weight gain ($P<0.01$) (Table 21).

Group A animals had the highest daily gain followed by group B and C animals in the descending order.

Block and Shellenberger (1980a) and Sehgal *et al.* (1994) also reported enhanced gain on increased concentrate feeding. Zinn *et al.* (1994) reported increased average daily gain in monensin supplemented diets. These findings are in agreement with the present result.

5.5 Feed conversion efficiency

The cumulative feed conversion efficiency obtained for the three groups, A, B and C were 4.71 ± 0.15; 5.57 ± 0.37 and 6.99 ± 0.42 respectively (Table 22).

Statistical analysis of the data showed significant improvement for groups A and B with group C during the third fortnight to eighth fortnights i.e, from day 42 to day 112 (Table 22) and cumulative feed conversion efficiency also showed the same trend.

Feed conversion efficiency was found to be improved with decrease in dietary fibre level. Enhanced feed efficiency of group A may also be due to the effect of monensin which was more evident in high concentrate feed (Preston *et al.*, 1996).

Borland and Kesler (1979) reported improved feed conversion efficiency in calves fed commercial pelleted complete feed. Block and Shellenberger (1980a) obtained high feed efficiency in calves fed on low fibre feed. Bartle and Preston (1992) reported higher feed efficiency in concentrate fed feedlot cattle.

Romero-Trevino *et al.* (1998) found that increasing the feed allowance to 120 per cent of NRC recommendation resulted in better feed efficiency.

A steep decline in feed conversion efficiency was observed in group A during the last fortnight which may be consequent to the laminitis that was seen in three animals of group A.

5.6 *Digestibility coefficients*

5.6.1 Dry matter

The average dry matter digestibility coefficients obtained for groups A, B and C were 62.25 ± 1.60, 61.79 ± 1.54 and 68.86 ± 1.28 respectively (Table 26).

Statistical analysis of the data points out that there was significant improvement in dry matter digestibility for group C than groups A and B ($P<0.01$).

There are conflicting reports on the influence of monensin on digestibility of dry matter. Goodrich *et al.* (1984) and Rogers *et al.* (1997) reported that monensin enhances dry matter digestibility. On the other hand Vuuren and Nel (1983) and Ricke *et al.* (1984) reported that monensin does not influence dry matter digestibility.

In the present experiment the digestibility trial was carried out towards the last phase of the experiment when some histopathological changes might have taken place in the rumen due to continued feeding of high concentrate diets resulting in lower digestibility (Ensminger *et al.*, 1990). This explains comparatively lower digestibility in groups A and B. This observation is also supported by the lower feed conversion efficiency during the last phase of the experiment.

5.6.2 Crude protein

The average crude protein digestibility obtained for groups A, B and C were 61.65 ± 1.75, 59.46 ± 1.59 and 67.39 ± 1.42 respectively (Table 26). The statistical analysis of the data showed significant variation in crude protein digestibility between groups A and B with group C.

Borland and Kesler (1979) obtained a crude protein digestibility of 64.7 in Holstein calves fed 66 per cent concentrate based complete feed.

The lower digestibility figures obtained in the present experiment might be due to the histopathological changes occurred in the rumen due to the continued feeding of high concentrate diets resulting in lower digestibility (Ensminger *et al.*, 1990).

5.6.3 Crude fibre

The average values obtained for the digestibility coefficient of crude fibre were 41.41 ± 2.25, 48.94 ± 1.29 and 62.92 ± 1.32 for A, B and C groups respectively (Table 26).

There was statistically significant improvement for group C than groups A and B ($P<0.01$).

The lower crude fibre digestibility obtained for the low fibre diet in the present study is in agreement with the findings of Pulina *et al.* (1995). Possible reasons may be reduction in cellulolytic or fibre digesting bacteria (Metzger *et al.*, 1976) or a reduction in rumen protozoa (Ushida *et al.*, 1991) resulting in lowering the digestion of lingo-cellulose. Crude fibre from the concentrate fraction of feed is always less digestible. Moreover the crude fibre content of ration A and B were very low.

This result is in agreement with Carro *et al.* (2000) who reported a linear decrease in crude fibre digestibility in sheep fed complete diets with decreasing roughage fraction from 80 per cent to 20 per cent.

5.6.4 Ether extract

The average ether extract digestibility obtained for the three groups were 52.11 ± 1.76, 55.41 ± 2.95 and 57.41 ± 1.61 for A, B and C groups respectively (Table 26).

The analysis of data revealed no statistically significant difference between the treatment groups (Table 26).

The digestibility coefficient values of ether extract reported by Sehgal *et al.* (1994) in buffalo calves and by Reddy and Reddy (1999) in Ongole bulls were higher than that of the present study. The lower digestibility figures in present study might be consequent of the histopathological changes occurred in the rumen (Ensminger *et al.*, 1990).

5.6.5 Nitrogen free extract digestibility

The average value of the digestibility coefficients for nitrogen free extract were 73.94 ± 1.40, 71.76 ± 1.56 and 74.67 ± 2.14 respectively for groups A, B and C (Table 26). The analysis of data showed no statistically significant difference ($P<0.05$) between the three treatment groups.

The digestibility coefficient values obtained by Reddy and Reddy (1999) in Ongole bull calves were slightly lower than that obtained in the present experiment and may be due to the difference in breed and feed used.

5.6.6 Digestible crude protein (DCP) and total digestible nutrient (TDN) intake per 100 g dry matter intake

The DCP intake per 100 g of DM consumed were 9.13, 8.45 and 10.72 respectively for groups A, B and C (Table 27). The average DCP intake per animal per day were 294.90, 286.45 and 348.29 g respectively for the experimental groups A, B and C (calculated on the basis of average daily dry matter intake).

The TDN intake per 100 g dry matter consumed were 63.23, 61.04 and 63.22 respectively for groups A, B and C (Table 27). The average TDN intake per animal per day were 2042.33, 2069.26 and 2054.02 g respectively for the experimental groups A, B and C (calculated on the basis of average daily DM intake).

Growing cattle (growth rate 550 g/day) weighing 100 kg requires 323 g DCP and 1800 g TDN per day (ICAR, 1985). The above findings indicate that the DCP and TDN intake of the animals of the present study were sufficient to meet the requirements.

The cumulative weight gain of control group was significantly lower than those fed complete ration till the eighth fortnight of the experiment evidently due to the lower digestion of the roughage in the developing rumen. Eventhough the control group had higher intake of DCP and TDN, the growth was less during the initial period. After that period this group improved which may be due to the fuller development of rumen. This explains why the control group had lower weight gain.

5.7 Carcass characteristics

The average dressing percentage of animals slaughtered from groups A, B and C were 50.80 ± 0.70, 51.30 ± 1.43 and 45.17± 1.25 respectively (Table 28).

Sehgal *et al.* (1994) reported a dressing percentage of 52.3 and 51.7 respectively in buffalo calves fed on 75 per cent concentrate and 40 per cent concentrate.

The average meat yield obtained from the three groups A, B and C were 34.60 ± 0.15, 35.30 ± 1.12 and 30.73 ± 1.24 respectively (Table 29).

The average meat-bone ratio of calves slaughtered from groups A, B and C were 2.57 ± 0.02, 2.70 ± 0.09 and 2.47 ± 0.08 respectively (Table 30).

Analysis of data reveals no statistical significance between the treatment groups in any of the carcass characteristics.

Similar results were obtained by Nockels *et al.* (1978) and Delfino *et al.* (1988).

The above results compare well with the results of slaughter studies conducted at the Centre of Excellence in Meat Science and Technology of Kerala Agricultural University (Oommen, 2002).

5.8 Histopathological study of rumen epithelium

Microscopical examination of the samples of rumen tissue from slaughtered animals revealed that parakeratosis was present in animals belonging to group A and B. Parakeratosis was not evident on histopathological examination in animals belonging to group C.

High concentrate diets when fed continuously for prolonged period can result in lactic acidosis in ruminants as reported by Boshinova (1976), Wheeler and Noller (1976) and Block and Shellenberger (1980a,b). Ensminger *et al.* (1990) reported that prolonged acidity in rumen leads to morphological changes in the rumen epithelium leading to parakeratosis.

Bartle and Preston (1992) reported clumping of the papillae and change in the colour of the rumen epithelium which was also evident in the present study. Parakeratosis of the ruminal epithelium was reported by Biju (1998) and Dildeep (1999), earlier in studies involving kids fed high concentrate rations.

5.9 Economics

The feed cost/kg live weight gain (Rs.) in animals of groups A, B and C were 32.63, 31.84 and 37.96 respectively (Table 32).

Gross profit (Rs.) calculated from the study for the experimental period for the three groups were 1399, 1550 and 632.25 respectively (Table 33).

Bartle and Preston (1991, 1992) reported economical gain by reducing roughage intake in a study similar to this experiment. The cost of feed per body weight gain reported by Sehgal *et al.* (1994) in buffalo calves was Rs.16.88 and 15.82 respectively for high concentrate and medium concentrate ration. The reduced cost is due to the lower cost of concentrate feed ingredients where the study was conducted.

It can be concluded from the present study that maintaining surplus bull calves of three months of age on high concentrate complete ration is cheaper than rearing the calves by the traditional method of feeding concentrate and roughage. There was no appreciable difference in the performance of animals by maintaining them on complete feeds with eight and 12 per cent crude fibre levels. Animals can be brought to slaughter weight of 150 kg within a period of five months. By traditional method of feeding as in group C, 200 days will be needed (projected calculation) to attain the same body weight. However, the trend of lower weight gain with poor feed conversion efficiency coupled with histopathological changes in the rumen epithelium suggests that maintaining animals beyond 150 days in high concentrate complete feed may not be economical.

Summary

6. SUMMARY

An investigation was carried out to evaluate the growth performance of three months old crossbred calves fed on two complete rations differing in crude fibre levels in comparison to those fed a control ration consisting of concentrate mixture and grass.

The experiment was conducted at Livestock Research Station, Thiruvizhamkunnu, for five months, using eighteen animals of which nine animals were males and nine females. The animals were randomly grouped into three with A group receiving complete ration with eight per cent crude fibre (Ration A), B group with twelve per cent crude fibre (Ration B) and C group (control) with concentrate mixture and grass (Ration C).

The parameters of the study were fortnightly feed intake, body weights, body measurements, average daily body weight gain, feed conversion efficiency, digestibility coefficient of nutrients, dressing percentage, meat yield, meat bone ratio, histopathological changes of rumen epithelium and economics of production.

Body weights and body measurements except chest girth showed significant improvement in animals belonging to group A and B compared to those in group C. Animals in group A and B showed significantly higher average daily gain and better feed conversion efficiency than that of control group.

The digestibility coefficients of nutrients in the control animals were higher than those fed complete rations. Significant differences were being observed in dry matter, crude protein and crude fibre digestibility.

Carcass study was conducted at the end of the experiment by slaughtering three animals from each group. Improvement in carcass characteristics viz., dressing percentage, meat yield and meat bone ratio was observed in A and B groups compared to group C. The economics was worked out and found better gross profit with groups A and B compared to group C.

The following conclusions were derived from the present experiment.

1. The animals fed complete feed had higher final body weights and higher body weight gain through out the experimental period.
2. The dry matter intake by each animal expressed, as percentage of body weight was lower for animals fed complete rations compared to the control group.
3. The average fortnightly feed conversion efficiency of animals fed complete feed was significantly better from the third fortnight to eighth fortnight.
4. The body weights obtained for the animals of group A and B at fourth month could be achieved by the control animals only in fifth month.
5. Animals fed experimental ration had better carcass characteristics like dressing percentage, meat yield and meat-bone ratio.
6. Cost of feed per kilogram live weight gain was lower with consequent higher profit in experimental rations than the control.

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EVALUATION OF COMPLETE FEED FOR MEAT PRODUCTION IN CALVES

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ABSTRACT OF A THESIS

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ABSTRACT

An experiment was carried out in three months old crossbred calves with an aim to utilize male and surplus female calves for meat production. Eighteen crossbred calves were grouped into three, considering body weight, breed, sex and age. Animals of group A and B received complete feed consisting of a concentrate mixture and grass hay, with eight (Ration A) and twelve per cent crude fibre (Ration B) respectively, while the animals of group C received the conventional control ration consisting concentrate and green grass (Ration C). During the experimental period of five months fortnightly body weights and body measurements were recorded. The body weights and body measurements except chest girth showed significant increase ($P<0.01$) in the animal fed complete rations. The average daily body weight gain (ADG) showed significant increase ($P<0.01$) in animals fed eight per cent crude fibre complete ration than those fed control ration while the cumulative feed conversion efficiency was significantly higher for group A ($P<0.01$) and group B ($P<0.05$) than that of group C. The average daily body weight gain obtained in the experiment were 668.83 ± 22.37, 658.55 ± 35.41 and 497.83 ± 33.35 g/day and the cumulative feed conversion efficiency were 4.71 ± 0.15, 5.57 ± 0.37 and 6.99 ± 0.42 for A, B and C groups respectively. The digestibility coefficients for dry matter and crude fibre were significantly higher ($P<0.01$) for animals fed control ration than those fed complete rations, while crude protein digestibility was lower for ration A ($P<0.05$) and ration B ($P<0.01$) than that of control. The dressing percentage

obtained were 50.80 ± 0.70, 51.30 ± 1.43 and 45.17 ± 1.25 with a meat yield of 34.60 ± 0.15, 35.30 ± 1.12 and 30.73 ± 1.24 for A, B and C groups respectively. The gross profit per animals for five months was calculated as Rs.1399.00, Rs.1550.00 and Rs.632.25 for A, B and C groups respectively.