EVALUATION OF COMPLETE RATIONS FOR KIDS FOR MEAT PRODUCTION

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

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1999

DECLARATION

I hereby declare that the thesis entitled "**EVALUATION OF COMPLETE RATIONS FOR KIDS FOR MEAT PRODUCTION**" 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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CERTIFICATE

Certified that the thesis entitled "**EVALUATION OF COMPLETE RATIONS FOR KIDS FOR MEAT PRODUCTION**" is a record of research work done independently by **Sri. Dildeep, V.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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DILDEEP, V.

Dedicated

to

My Beloved Parents

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Introduction

INTRODUCTION

Ninety per cent of the world's goat population is concentrated in developing countries, of which 61 per cent is in Asia, 29 per cent in Africa and 4 per cent in South America. While 95 per cent of goats are raised for meat, only 5 per cent are meant for milk production (Anonymous, 1996).

Goats have retained their popularity as a source of animal protein, provided both by their meat and milk especially in areas where the climate is dry and the soil impoverished. Archaeological studies indicated that goats were kept in Egypt in the fourth millennium B.C., whereas carbon dating showed that goats were present in Jerico in 7000 B.C. (Zeuner, 1963).

India ranks first in goat population of the world with 118 million goats accounting for 19.86 per cent of the world stock. It is estimated that 466 million kg of chevon and 22 million litres of milk are produced from goats in the country, besides 109 million kg of skin, 40 metric tonnes of pashmina fibre and 85,000 metric tonnes of manure (FAO, 1993).

The importance of goat in the rural economy is evidenced by its unparallaled economic traits, ability to get acclimatized under diversified agro-climatic conditions, unfastidious nature in choosing available forage, high fertility and short generation interval and practically no religious restrictions for goat and its products among the diversified religious people in rural area.

Economically goat is ideally suited for poorer rural population especially for marginal and landless labourers by its low cost of maintenance, short term return on capital with low risk on capital investment and no involvement of extraneous labour. The entire rural family members especially women folk and children can be profitabily associated with goat management. Goats thrive and add to the rural economy even in areas where it is difficult to raise cows or buffaloes (Gopalakrishnan and Lal, 1996).

Husbandry systems are usually classified as intensive, semi-intensive and extensive. Intensive production systems involve either grazing on crops or cultivated pastures at high stocking rates, or zero-grazing. They are also frequently employed when forage production is low and concentrate feeding is high. (Economides and Louca, 1987).

The main limiting factor for goat and sheep production in India is the acute shortage of grazing and browsing resources, as more and more marginal and sub-marginal lands are brought under cultivation. Further, the quality as well as quantity of forage available from natural grazing lands are progressively diminishing due to excessive grazing pressure and also continuous neglect of grazing lands.

At present, only 4.4 per cent of the country's cropped area is under fodder crops and there is hardly any scope for expansion because of pressure on agricultural land for food and cash crops. The feed deficit in terms of metabolizable energy is 32 per cent for the animal resources (Reddy, 1991).

Hence, there is an urgent need for developing an alternate feeding system for small ruminants.

The concept of complete diets can be used to formulate low-cost balanced feed for small ruminants and also to ensure improved utilization of nutrients from agricultural residues. Extensive work has been done in India and many complete rations have been formulated utilizing various agricultural residues like sorghum straw, wheat straw, sunflower straw, paddy straw, tree leaves, cotton seed hulls, maize cobs, groundnut hulls, subabul-meal and forest dry grass. Complete feeds have been successfully tested in several experiments on small ruminants.

The extent of grazing facility is peculiar in Kerala due to the limited availability of per capita land and majority of goat owners are marginal farmers possessing less than 10 cents. Kids are allowed to remain with the doe until they are sold away for meat. This creates problems to the farmer by causing delay in subsequent pregnancy of the doe. Due to the limitation on land availability and shortage of fodder, goats in Kerala receive considerable proportion of concentrates compared to other states of India. Surplus male and female kids meant for meat production fed on concentrate ration alone under confinement are reported to grow very fast with a feed conversion rate of 1:4.

While six month old kids reared under extensive system were reported to weigh only 12 kg (Ralston, 1997) those animals reared under confinement on complete feeds supplemented with monensin attained a weight of 17-18 kg with a feed conversion ratio of 1:4 (Biju, 1998).

Monensin, an ionophore antibiotic is reported to improve feed efficiency of growing animals by increasing propionate fraction of rumen volatile fatty acid level and reducing the methane loss (Bergen and Bates, 1984).

In the present study pelleted complete concentrate type feeds containing animal protein supplements of high biological value along with an ionophore antibiotic is tried with a view to improve feed conversion efficiency of kids grown under intensive system of management.

Review of Literature

REVIEW OF LITERATURE

2.1 The concept of complete feeding

Marshall and Voigt (1974) opined that complete rations offer a means of controlling the ratio of nutrients consumed, reduces feed costs and helps inclusion of unpalatable ingredients without reduction in feed intake.

Owen (1979) has defined the complete feed as an uniform mixture of feed ingredients including roughage and concentrates processed in such a way as to avoid differential selection by the animal, given as a sole source of nutrients, except water and sometimes certain minerals.

Vanhorn *et al.* (1980) opined that feeding complete rations may simplify management if rations are of the right energy density to allow adequate growth without overfattening with free choice feeding. Complete rations usually are utilized best in winter feeding programmes, in drought periods, where pasture is not available or to supplement overstocked pastures.

Nadalyak and Ptashkin (1983) in their studies on the growth of lambs reared for meat, maintained on a complete feed mixture recorded a decreased heat production and gas formation in the rumen, reduced urinary nitrogen excretion and improved utilization of metabolisable energy and nitrogen for growth.

Reddy and Reddy (1985) who studied the effect of cotton straw based complete rations in Murrah buffaloes stated that complete feeds stimulate bacterial action in the rumen and feeding of complete feeds *ad lib* minimizes fluctuation in the rumen fermentation through a more uniform feed consumption. It also minimises labour, reduces wastage and helps to utilize waste materials economically in ration formulations.

Rao *et al.* (1995) opined that the concept of feeding complete rations to livestock is becoming popular, since it provides a balanced ration and a way of avoiding individual preferences that exists with conventional feeding systems.

2.1.1 Roughage to concentrate ratios in complete feed

Ronning and Laben (1966) fed four milled diets having hay to concentrate ratios of 90:10, 60:40. 30:70 and 0:100 to lactating cows. Milk yield was depressed on the 90:10 diet and over conditioning was noted in the two high concentrate groups.

Marshall and Voigt (1974) prepared 3 different complete rations for dairy cows with varying roughage to concentrate ratios of 40:60, 30:70 and 20:80. They observed that increasing the concentrate fraction was accompanied by corresponding increase in milk yield.

Reddy and Raghavan (1988) studied the feed lot performance of stall fed Telengana local goats fed on diets with different roughage to concentrate ratios, namely 70:30, 50:50, 30:70 and 10:90 until they reached 24 kg body weight. Average daily body weight gain and feed conversion efficiency were better with high concentrate diet. Retention of nitrogen, calcium and phosphorus increased significantly as the ratio of concentrate increased.

Wadhwani and Patel (1991) worked on the effect of feeding diets of different roughage to concentrate ratios namely 50:50, 65:35 and 80:20 on chevon production in Marwari goats. Feed efficiency for meat production was better with 50:50 ration.

Umoh and Halilu (1992) studied the effect of level of concentrate supplementation in growing rams which were given a concentrate diet to provide 100, 75, 50, 25 or 0% of their feed intake. Average daily gains were more with all concentrate diet. Most economic ration was with 75% concentrate ration.

Mc Clure *et al.* (1994) compared the performance of weaned lambs fed on orchard grass, alfalfa and an all-concentrate diet. Average daily gain and total gain were more with all concentrate diets, but the carcasses contained more of fat.

2.1.2 Intensive feeding system of small ruminants

Saini *et al.* (1987) studied the effect of different management systems on meat production in Barbari kids. They observed that the body weight gains from 90 to 180 days of age were significantly higher in the intensive system (5.57 kg) than with semi-intensive system (3.95 kg) and the extensive system (2.70 kg), the average growth rates per day being 61 g, 45 g and 30 g respectively.

Kumar *et al.* (1991) studied the effect of different protein and energy levels on growth in female kids of Gaddi breed and obtained a higher growth rate, chest girth and feed conversion efficiency with a higher level of energy.

Siquera *et al.* (1993) compared the performance of lambs reared in feed lot and on pasture. At 150 days of age, the feed lot animals had a higher body weight, mean daily gain and less mortality than pasture fed animals.

Nagpal *et al.* (1995) studied the effect of feeding system on the growth performance in male kids of Sirohi, Marwari and Kutchi kids and observed that intensively fed kids had higher body weights, carcass weights, dressing percentage,loin-eye area and lower bone content than those fed on semi intensive system.

Ralston (1997) studied the effect of different management systems on the growth in Malabari kids and obtained a better growth with intensive than extensive system.

2.1.3 Pelleted complete rations

Newland *et al.* (1962) showed that pelleting corn portion of a corn-alfalfa ration decreased the total feed consumption when compared with ground corn-alfalfa ration, while average daily gain remained the same.

Borland and Kesler (1979) studied the performance of Holstein calves fed on a commercial pelleted complete feed compared to those fed on corn silage or hay based rations and observed a considerable weight gain and increase in chest circumference.

Prokudin and Tashenov (1983) reported that pelleted complete feed decreased heat production and gas formation in the rumen of sheep.

Singal and Mudgal (1983) reported that pelleting of complete feed reduces digestibility of nutrients in the feed, but significant reduction is observed only with dry matter digestibility.

Reddy and Reddy (1985) experimented on the effect of pelleting on growth performance in Nellore sheep and recorded increased weight gains and nitrogen retention with pelleted rations compared to mash rations.

Reddy and Reddy (1985) studied the effect of feeding pelleted complete feeds on various nitrogen fractions and total VFA concentrations in the rumen fluid of sheep and observed that the concentration of total nitrogen, insoluble protein nitrogen and residual nitrogen were significantly higher in rumen fluid of sheep fed pelleted rations. The results also suggested that pelleting improves the utilization of low quality roughages by rumen microbes.

Chahal and Sharma (1992) studied the performance of kids fed mahua seed cake based pelleted complete feed. Untreated mahua seed cake based complete feed gave a daily average gain of 64.8 g with a feed cost/kg live weight gain of Rs.17.97.

Patle *et al.* (1992) evaluated two complete pelleted feeds and reported 87 and 90 per cent increase in bulk density by pelleting. The feed wastage was only 1.5 per cent when fed to crossbred heifers. The cost of processing of feeds was Rs.19.26 per quintal.

Reddy and Reddy (1994) evaluated the effect of pelleting on nutrient utilization in goats and sheep and recorded that pelleting increased DM intake and digestibilities of DM, organic matter, crude fibre, protein and nitrogen free extract. Pelleting also increased nitrogen and phosphorus retention.

2.1.4 Low fibre complete rations

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

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

Paek *et al.* (1991) obtained a superior daily gain and feed efficiency in native cattle fed on a low fibre (8%) complete ration when compared to a control group fed on rice straw and concentrate feed.

Biju (1998) experimented in 30 Malabari kids fed on complete rations having three different levels of fibre 8, 12 and 16 and obtained a better growth and daily gain with the 8 per cent fibre ration.

2.1.5 Addition of buffers to complete feed

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

Sodium and potassium bicarbonate have been used over the years as buffers to reverse depressions in milk fat in dairy cows fed on high grain diets (Emery and Brown, 1961).

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

Kellaway *et al.* (1977) reported improved performance by calves fed high concentrate diets when sodium bicarbonate was added to the ration.

Wheeler (1980) studied the effect of limestone buffers in complete diets on the performance of dairy cows and observed a higher digestibility of energy and crude protein.

Wheeler *et al.* (1980) obtained a reduced feed efficiency by the use of sodium bicarbonate in pelleted complete diets fed to dairy calves.

2.1.6 Health problems associated with feeding pelleted complete feeds

Rumen parakeratosis, liver abscess, bloat and joint stiffness have been observed in ruminants fed on rations containing low levels of roughage or no roughage at all. Thus a complete ration should contain atleast enough roughage to prevent the occurrence of these conditions (Kay *et al.* (1969).

2.1.6.1 Parakeratosis

Block and Shellenberger (1980a) evaluated the effects of three complete rations on the rumen characteristics of Holstein calves. The sections of rumen wall of calves fed pelleted complete rations showed papillae that were excessively long and branched, paddle shaped, parakeratotic and loosely attached to rumen wall. They opined that it could have been caused by high propionate and butyrate production in the rumen.

Block and Shellenberger (1980b) evaluated the effect of complete ration on the rumen papillary growth in dairy heifers. Pelleted rations caused a low density of long papillae, gross appearance of the tissues was moderately dark to very dark. Papillae were keratotic and variable in the degree of necrosis. They concluded that parakeratotic condition was probably due to a low 'scratch factor' content of the portion of the ration consumed by calves and sufficient abrasion should be provided by the feed to remove the keratin accumulating.

Ensminger *et al.* (1990) observed that the prolonged acidity in the rumen can bring about morphological changes in the epithelium of the rumen. The papillae of the rumen become enlarged and hardened and the condition is called parakeratosis.

2.1.7 Monensin supplementation of complete feeds

Monensin is an ionophore antibiotic compound produced by the fermentation of *Streptomyces cinnamonensis* (Havey and Hoehn, 1967).

Raun *et al.* (1976) studied the changes in ruminal fermentation pattern on addition of monensin and observed an increased level of propionate which lowers the heat increment, spares aminoacids normally used for gluconeogenesis and stimulates body protein synthesis resulting in better growth.

Joyner *et al.* (1979) reported a weight gain of 210 g/day in lambs fed on a diet supplemented with monensin @ 20 ppm per kilogram feed.

Bergen and Bates (1984) reported improved efficiency of production in cattle when monensin was supplemented in the ration by an improvement in efficiency of energy metabolism and nitrogen metabolism and by prevention of disorders like lactic acidosis, bloat and coccidiosis.

Bergen and Bates (1984) and Zinn and Borques (1993) reported decreased methanogenesis by monensin supplementation thereby providing more available metabolizable energy to the animal. They also reported a higher bypassability of dietary protein by the monensin supplementation.

Faulkner *et al.* (1985) reported that monensin increased the OM digestibility in steers fed on high fibre diets.

Lee *et al.* (1992) reported that monensin increased the digestibility of DM and CP.

Beede *et al.* (1994) reported that monensin, supplemented at the rate of 23 mg/kg feed in ration containing 17.5 per cent CP for goats, increased the digestibility coefficients of all the nutrients (DM, OM, CP, EE and NFE) significantly.

Patil and Honmonde (1994) reported an average weight gain of 113.78 g in Malpura lambs fed on a concentrate mixture containing monensin @ 22 ppm per kilogram feed.

Biju (1998) concluded that supplementing monensin in low fibre complete ration improves growth and feed efficiency to the extent of 111 g/d and 4.04 respectively in kids of three to four months of age, reared under intensive system, maintained for periods not exceeding 90 days.

2.1.7 Mechanism of action of monensin

Bergen and Bates (1984) explained the mode of action of monensin on the basis of transmembrane ion fluxes and the dissipation of cation and proton gradients. Monensin being an anion which is confined to the membrane interphase of the cells, stabilized by a polar environment, binds with a cation to form a lipophilic, cyclic, cation-ionophore complex, which can diffuse through the interior of the bimolecular membrane structure to reach the opposite side of the membrane, and the enclosed cation is released and the ionophore ion goes back to the initial phase. Monensin mediates primarily Na^+-H^+ exchange because the affinity of monensin for Na^+ is ten times that of K^+.

Interference of normal ion fluxes of bacterial cells, destroys primary membrane transport of cells. Cells respond to this metabolic insult by maintaining primary transport by expending metabolic energy. Cells like in Gram positive bacteria which depend on substrate level phosphorylation for ATP cannot meet this demand and get lysed while the Gram negative bacteria capable of electron transport for ATP synthesis, survive. Thus monensin promotes the growth of certain organisms only.

2.1.8 Average daily gain, dry matter intake, feed conversion efficiency and cost efficiency

Gangadevi (1981) fed Malabari cross kids on four concentrate mixtures differing in CP level namely 16, 18, 20 and 22 per cent and obtained an average daily gain of 76.5, 74.7, 70.5 and 77.9 g respectively. The average daily dry matter intake of kids fed 16, 18, 20 and 22 per cent CP were 3.8, 3.6, 2.7 and 3.4 kg/100 kg body weight respectively.

Reddy and Reddy (1985) fed Nellore sheep on four complete rations based on forest grass or sorghum straw either in mash or pelleted form and obtained an average daily gain (ADG) of 58.33 and 91.67 g for forest grass based diet and

55.21 and 85.94 g for sorghum straw based diets. Higher ADG was observed with pelleted ration. Dry matter intake/kg weight gain was 12.45, 10.39, 12.77 and 9.68 kg and the cost of feed per kg live weight gain was Rs.9.28, Rs. 8.63, Rs.9.45 and Rs. 8.05 respectively for complete rations based on sorghum straw and forest grass in mash and pellet form.

Saini *et al.* (1987) reported a daily body weight gain of 30 g in Barbari kids reared under intensive system of management.

Prasad *et al.* (1988) fed growing male Nellore sheep with complete diets varying in crude protein content, 8, 12 and 16. Average daily body weight gain were 85.9, 109.5 and 83.8 g and feed:gain ratio were 8.3, 5.9 and 6.6 respectively.

Wadhwani and Patel (1991) fed Marwari goats on complete diets having different roughage to concentrate ratio, 50:50, 65:35 and 80:20 and obtained a feed efficiency per kg live weight gain of 8.65, 11.56 and 12.55, and cost of feed per kg live weight gain of Rs. 18.27, 16.37 and 16.62 respectively.

Chahal and Sharma (1992) fed twenty, five to six month old Alpine x Beetal kids on four mahua seed cake based pelleted complete rations and obtained a weight gain/day of 92.80, 64.80, 72.00 and 54.00 g respectively. The feed/kg live weight gain (kg) were 9.06, 12.77, 10.74 and 14.20 respectively.

Rao *et al.* (1994) fed Jakhrana male goats on urea-ammoniated barley straw based complete rations and obtained an average daily DM intake of 2.52 ± 0.09 kg/100 kg body weight.

Rao *et al.* (1995) fed 12 adult Nellore rams on groundnut cake based four complete feeds and obtained a daily DM intake of 672.83, 622.76, 651.30 and 648.90 g respectively.

Skrivanova (1995) fed white short wooled goats from 12 days to 97 days with 3 different barley based complete feeds and obtained an average daily body weight gain of 188, 211 and 213 g. The goats ate 2.96, 2.87 and 2.75 kg DM/kg gain.

Ralston (1997) studied the effect of different management system on the growth in Malabari kids and obtained an average daily gain of 52.25 g in the intensively fed group.

Biju (1998) studied the effect of monensin supplementation in three complete rations having different levels of fibre namely 8, 12 and 16 per cent, on kids of 3 months of age for a feeding period of 13 weeks and obtained an average daily gain of 111.21, 88.74 and 65.22 g respectively. The average daily dry matter intake per animal were 3.26, 3.18 and 3.00 kg per 100 kg body weight respectively. The cumulative feed efficiency were 4.04, 4.29 and 5.06 and the cost per kg gain was Rs. 28.61, 31.68 and 38.59 respectively.

Deepa (1998) fed four month old Malabari kids on threecomplete rations having tapioca leaves, tea waste and gliricidia leaves as roughage sources and obtained a weight gain of 62.77, 59.38 and 53.21 g/d respectively for rations 1, 2 and 3. The average feed intake per kg $W^{0.75}$ were 81.47, 76.58 and 73.23 g, the feed conversion efficiency being 9.09, 9.33 and 9.63. The cost of production per kg gain were Rs.69.54, Rs.59.16 and Rs.60.43 for rations 1, 2 and 3 respectively.

2.1.9 Body measurements

Gangadevi (1981) observed an average body length, chest girth and height at withers of 52.0, 60.8 and 61.2 cm respectively in eight month old Malabari kids fed on a concentrate diet containing 16 per cent crude protein.

Ralston (1997) observed an average body length, chest girth and height at withers of 54.8, 57.1 and 51.3 cm in seven to eight month old Malabari kids maintained on a complete feed under intensive system.

Biju (1998) observed an average body length, chest girth and height at withers of 53.9, 58.1 and 59.4 cm respectively in six month old Malabari kids fed on a complete ration having 8% fibre and opined monensin does not have any influence on body measurements.

2.1.10 Nitrogen balance

Gangadevi (1981) fed Malabari crossbred kids on four concentrate mixtures varying in CP level, viz., 16, 18, 20 and 22 per cent and obtained a nitrogen retention of 5.4, 5.9, 6.0 and 7.6 g/d respectively.

Biju (1998) fed Malabari kids on three complete rations having different levels of fibre, viz., 8, 12 and 16 per cent with 16% CP and observed a nitrogen balance of 4.25 g/day in the 8% fibre ration.

2.1.11 Digestibility coefficients of nutrients

Ram *et al.* (1990) reported digestibility coefficients of dry matter, organic matter, crude protein, ether extract crude fibre and nitrogen free extract of 56.00, 59.70, 57.50, 51.80, 57.90, 60.30; 48.00, 52.40, 53.00, 48.30, 47.60, 53.70 and 49.60, 55.50, 44.10, 41.70, 63.50 and 55.99 per cent repectively for three different complete rations containing ammoniated wheat straw, in goats.

Chahal and Sharma (1992) observed that the digestibility coefficients in kids fed complete diets were 67.76 per cent for dry matter, 70.50 per cent for organic matter, 67.27 per cent for crude protein, 45.20 per cent for crude fibre 88.10 per cent for ether extract and 73.20 per cent for nitrogen free extract.

Rao *et al.* (1995) reported digestibility coefficient values of 54.00, 58.52, 64.21, 51.20, 72.36 and 59.84 per cent respectively for dry matter, organic matter, crude protein, crude fibre, ether extract and nitrogen free extract in Nellore rams fed on a complete ration.

Biju (1998) reported digestibility coefficient values of 75.59, 78.43, 76.58, 51.56, 66.50 and 85.56 per cent respectively for dry matter, organic matter, crude protein, crude fibre, ether extract and nitrogen free extract in Malabari kids fed on a complete ration having only 8 per cent crude fibre.

2.1.12 Dressing percentage

Ralston (1997) studied the effect of different management systems on the growth in Malabari kids and obtained an average dressing percentage of 49.15 in kids maintained on intensive system.

Biju (1998) obtained a dressing percentage of 50.74 ± 1.11 in 6 month old Malabari kids fed on a complete ration having only 8% crude fibre.

2.2 Use of meat cum bone meal/fish meal in growing ruminants

2.2.1 Rumen degradability

Sherrod and Tillmann (1962) stated that considerable proportion of the protein requirements of lactating and young growing ruminants are met by the bacterial protein. However, for achieving maximum performance escape protein has to be included in their diets.

Goering and Van Soest (1970) suggested that acid pepsin insoluble nitrogen is an estimate of indigestible protein in the abomasum. If a protein is resistant to acid pepsin hydrolysis it is likely to be indigestible in the lower gastro intestinal tract.

Mertens (1977) reported that increased feed intake enhanced the flow of undegraded protein out of the rumen.

Zinn *et al.* (1981) reported rumen nitrogen escape of meat cum bone meal as 70%.

Loerch *et al.* (1983a) opined that increases in nitrogen escaping the rumen can only be potentially beneficial to the ruminant if the escaped nitrogen is available for digestion in the abomasum and small intestine.

Loerch *et al.* (1983b) studied on the acid detergent insoluble nitrogen (ADIN) and acid pepsin insoluble nitrogen (APIN) of soyabean meal, blood meal and meat cum bone meal. The ADIN and APIN values were intermediate for meat cum bone meal.

Loerch *et al.* (1983b) reported the overall nitrogen degradability of meat cum bone meal to be 0.44 in comparison with 0.51 for soyabean meal containing diets in cattle.

Loerch *et al.* (1983b) determined the true nitrogen digestibility of meat cum bone meal and of soyabean meal in sheep using a regression technique and found them to be 0.86 and 1.00 respectively. In addition, proportionately less non-ammonia nitrogen disappeared from the gut between the proximal duodenum and terminal ileum when meat cum bone meal was fed (0.60) than when soyabean meal (0.67) was fed. There was no significant difference between diets in the quantities of amino acid nitrogen apparently absorbed from the small intestine. These suggest that meat cum bone meal residues resistant to rumen degradation were also more resistant to digestion in the small intestine than soyabean meal residues. These differences in digestibility probably resulted from the presence of Keratin proteins rather than Maillard products in the meat cum bone meal.

Rooke (1985) found that meat cum bone meal contains approximately 300 g glycine per kilogram of determined amino acids, whereas soyabean meal contains only about 50 g glycine per kilogram determined amino acids.

Namhyunglee *et al.* (1986) opined that lower degradability of meat cum bone meal can be attributed to the significantly larger amounts of glycine in meat cum bone meal.

Vogel *et al.* (1988) reported a rumen degradability of nitrogen of meat cum bone meal and fish meal to be 44.0 and 40.1% respectively.

Animal byproduct supplements have a high content of rumen undegradable protein. Therefore the inclusion of animal by-product meals like fish meal, meat cum bone meal, feather meal and blood meal can improve the supply of limiting aminoacids in the small intestine (Mantysaari *et al.* (1989 a).

Hussein *et al.* (1991) obtained an *in situ* crude protein degradation of 52.3% for fish meal in cattle.

Grubic *et al.* (1995) studied the degradability of protein in fish meal, meat cum bone meal and meat meal *in vivo* using three rumen-cannulated sheep. Crude protein degradability were 26.96, 44.92 and 43.25 per cent for fish meal, meat and bone meal and meat meal respectively.

2.2.2 Amino acid profile

Orskov *et al.* (1971) and Mercer *et al.* (1980) reported an increased concentration of essential amino acids especially lysine and methionine in the duodenal digesta of animals fed fish meal diets.

Afolabi *et al.* (1984) observed that threonine was the limiting amino acid in all cases of animal protein supplementation. Feeding experiments with rats showed that fish meals had high true digestibility, net protein utilization, protein efficiency ratio and biological values compared with those for casein.

Rooke (1985) worked on the nutritive values of feed proteins and feed protein residues resistant to degradation by rumen microorganisms and observed an increase in the proportion of essential aminoacids and therefore higher biological value of fish meal protein after rumen incubation.

Nam-hyunglee *et al.*(1986) studied the digestion by sheep fed barley and maize based diets containing either meat cum bone meal or soyabean meal and observed that the quantities of total nitrogen and amino acid nitrogen leaving the terminal ileum and the quantities of total nitrogen voided in the faces were greater when meat cum bone meal containing diets were fed.

Mantysaari *et al.* (1989b) opined that amino acid profile of the protein entering the intestine explains better protein utilization of cows on a fish meal diet.

Susmel *et al.* (1989) studied the change in aminoacid composition of different protein sources like soyabean meal, fish meal, dried brewer's grain and ensiled leucerne and observed that fish meal had the lowest degradability for essential amino acids, branched chain amino acids and total nitrogen. The undegraded fraction of fish meal had a significantly higher proportion of essential amino acids. Lysine and methionine content was highest in fish meal. The essential amino acid index of the feed residues post incubation relative to casein and meat was higher in fish meal.

2.2.3 Effect on growth and nutrition

Loerch and Berger (1981) fed soybean meal and meat cum bone meal as isonitrogenous supplements to steers and lambs and found no differences in animal performance.

Stock *et al.* (1981), Viera *et al.* (1985) and Thonney and Hogue (1986) have reported an increased supply of high quality undegraded protein being responsible for improved growth and protein efficiency of animals fed animal by-product protein meals especially with diets containing fish meal.

Cottril *et al.* (1982) suggested that fish meal may have a positive impact on microbial efficiency in young growing cattle.

Sampath *et al.* (1984) reported a nitrogen balance of 16.7 g/day in bullocks when 500-650 g meat meal was supplemented daily in their diets.

Smith *et al.* (1985) reported a positive response in body weight gain in heifers fed with supplemented fish meal diets.

Bhaskar *et al.* (1986) studied the usefulness of meat meal as an ingredient in concentrate mixtures of growing calves by replacing 7 per cent groundnut cake from basal ration with meat meal. They found no significant differences in nutrient digestibility, nutritive value of total ration and retention of nitrogen, calcium and phosphorus between the groups.

However, Thonney *et al.* (1987) did not find a positive response of daily gain by fishmeal supplementation compared with soyabean meal supplementation in pastured heifers.

Cisjuk and Lindberg (1988) studied the responses in feed intake, digestibility and nitrogen retention in lactating dairy goats fed increasing amounts of urea and fish meal. They obtained a gradual decrease in buffer soluble crude protein and effective rumen degradability of crude protein in concentrates with added fish meal. The relative feed intake decreased with increasing urea and fish meal supplementation, the organic matter digestibility being similar on all diets. Crude fibre digestibility varied between diets but was positively related to the amount of buffer soluble crude protein. Nitrogen balances were not influenced by diets and was on an average 1.919 g/day.

Hegedus *et al.* (1989) concluded that meat cum bone meal is a good source of riboflavin, niacin, pantothenic acid and biotin, but was low in pyridoxine and thiamine.

Mantysaari *et al.* (1989a) studied the performance of growing dairy heifers fed diets containing soyabean meal or animal by-product meal. They were freely given maize silage with soyabean meal, fish meal or meat cum bone meal. There were no significant differences in growth, dry matter intake and feed conversion efficiency between treatments. Dry matter intake tended to be lower in heifers given fish meal diets.

Mantysaari *et al.* (1989a) reported that protein efficiency (protein output/protein input) was higher for heifers fed meat cum bone meal compared to those fed on fish meal.

Mantysaari *et al.* (1989b) reported a better feed conversion ratio (DMI/Milk yield) in cows fed fish meal diet. They also opined that digestibility of protein entering the small intestine is an important factor for protein utilization in ruminants.

Prokopenko *et al.* (1989) studied the chemical composition of meat cum bone meal prepared using different drying methods. They reported that meal dried under forced air and that dried traditionally contained (per kg DM) metabolizable energy 11.7 and 12.8 MJ, crude protein 571 and 497 g, fat 91 and 130 g, fibre 40 and 47 g, calcium 10 and 10 g and phosphorus 4.8 and 5.4 g respectively.

Vipond *et al.* (1989) studied the response of fish meal supplementation in lambs and observed that lambs supplemented with fish meal gained more weight when compared to lambs not given fish meal.

Tan and Bryant (1991) studied the response of lambs to isonitrogenous diets containing rape seed meal or fish meal. They observed that live weight gains were more in fish meal group during the experimental period of seven weeks.

Andrighetto and Bailoni (1994) studied the effect of different animal protein sources on digestive and metabolic parameters in dairy goats. They observed that meat meal supplemented diet recorded a lower rumen pH, lower acetate to propionate ratio than a hydrolysed feather meal plus blood meal supplemented diet and had a higher digestibility for dry matter, protein and fibre fraction and higher level of total volatile fatty acids and ammonia nitrogen concentration in the rumen fluid.

Hag and Shargi (1996) reported an improved live weight gain in exotic Cashmere breed goats supplemented with fish meal. Fish meal supplements greatly improved digestibility of crude fibre, ADF, NDF, cellulose and hemicellulose.

2.2.4 Effect on calcium and phosphorus metabolism

Bouchard *et al.* (1980) compared the effect of few sources of protein, meat cum bone meal and soyabean meal in concentrate part of veal calf rations and observed that meat cum bone meal can replace soybean meal with the advantage of supplying sufficient amount of calcium and phosphorus to meet the calf's requirements for maintenance and growth.

Fishwick and Hemmingway (1989) studied the influence of meat cum bone meal as dietary phosphorus sources for growing sheep. They reported an increased growth when meat and bone meal was supplemented to provide an additional 1.75 g phosphorus daily.

Sell and Jeffrey (1996) studied on the availability for poults of phosphorus from meat cum bone meals of different particle size. Regression analysis of the data obtained showed that increases in body weight and tibia ash were linearly related to percentage of dietary phosphorus and to quantity of phosphorus consumed.

2.2.5 Effect on carcass characteristics and milk production

Bouchard *et al.* (1980) obtained a paler meat in veal calves fed on meat cum bone meal compared to soybean meal. Meat cum bone meal also resulted in larger rib-eye area.

Hadjipanayiotou *et al.* (1988) conducted studies by comparing the performance of suckling Chios ewes and Damascus goats fed on three barley based diets with protein supplements soybean oil meal (SBM) or with all SBM replaced by fish meal (FM). They reported a lesser degradability for SBM supplemented with FM compared to control. Ewes given fish meal had higher milk yield than those given the control diet containing SBM alone as protein supplement. Protein content of goat milk was higher with FM supplement.

Tayer and Bryant (1988) found that supplementing fish meal @ 45 g/animal/day in the diet of store lambs increased fleece and offal weights and fleece free empty body gains. However, addition of fish meal had no effect on the growth pattern of the animals.

2.2.6 Effect on palatability

Palatability problems with fish meal have been reported in dairy cows by Oldham *et al.* (1985). They reported that cows restricted their day matter intake when the ration included 8% fish meal, but not at 5% level.

Mantysaari *et al.* (1989b) reported that the dry matter intake appeared to be lower for cows fed fish meal diets than other diets and suggested that it may be due to the fish taste in the feed.

Chestnut (1992) studied the effect of different levels of supplementation of fish meal in finishing lambs. They found that optimum level of fish meal supplementation was between 40 and 80 g/day animal.

2.2.7 Economic aspects

Gibb and Baker (1992) conducted studies on the use of fish meal and monensin as supplements to grass silage in steers from 5 month of age to slaughter. They reported a significantly increased live weight, empty body and carcass weight gains when both fish meal and monensin were supplemented. Supplementing fish meal alone or monensin alone produced lesser body weight gains but better than control animals receiving neither fish meal nor monensin. They obtained an improved cost effectiveness with monensin over fish meal.

Vipond *et al.* (1992) worked on the effect of fish meal supplementation on the finishing systems for lambs and economic evaluation indicated a financial advantage from fish meal supplementation.

Neary *et al.* (1995) opined that economic considerations should be used when choosing ingredients for finishing diets for lambs since source and level of dietary crude protein had only small effects on lambs performance or carcass traits.

Hag and Shargi (1996) studied on the live weight gains in Cashmere breed goats and observed that meat production cost was decreased by 31% by feeding the fish meal supplemented diet.

Materials and Methods

MATERIALS AND METHODS

The experiment was conducted in the Goat and Sheep Farm attached to the Veterinary College of the Kerala Agricultural University.

3.1 Housing and management of animals

Thirty Malabari kids of three to four months of age, of both sexes from the Kerala Agricultural University Goat and Sheep Farm were selected for the study. The animals were dewormed using Albendazole suspension (Albendazole 25 mg/ml, Wockhardt) and dipped in diluted Butox (Deltamethrin 1.25%, Hoechst) solution to eliminate parasites. The animals were divided randomly into three groups (Group 1, Group 2 and Group 3) as uniformly as possible with regard to age, body weight and sex. The male and female animals in each group were housed separately. Group feeding was practised. Each pen was provided with a feed trough and waterer kept at appropriate height. All the animals were maintained on identical conditions of management.

3.2 Experimental duration

The experimental duration lasted for 13 weeks and a pre-experimental period of 2 weeks during which the animals were made accustomed to the experimental conditions. During the course of the experiment the animals were dewormed monthlyusing Albendazole suspension.

3.3 Experimental Ration

Three complete pelleted rations were prepared. Ration-1 served as the control. Ration-2 incorporated meat cum bone meal at 5 per cent level replacing gingelly oil cake of basal ration and ration 3 incorporated fish meal at 5 per cent level repalcing gingelly oil cake of basal ration. The rations were formulated to be isoproteimic and isocaloric to contain 16 per cent CP and 70 per cent TDN.

Table 1. Ingredient composition of complete rations (%)

Ingredients		Ration 1	Ration 2	Ration 3
1.	Groundnut cake (expellar)	5	5	5
2.	Gingelly oil cake	5	-	-
3.	Meat cum bone meal	-	5	-
4.	Fish meal	-	-	5
5.	Yellow maize	26	26	26
6.	Wheat bran	56	56	56
7.	Lucerne meal	5	5	5
8.	Mineral mixture	1.5	1.5	1.5
9.	Common salt	0.5	0.5	0.5
10.	Sodium bicarbonate	1	1	1

Twenty gram of 'Coban 100' (Elanco USA) containing monensin available as 10 per cent monensin sodium and 50 g of Indomix (Nicholas Piramel India Ltd.) containing vitamin A 40,000 IU, Vitamin B_2 20 mg and vitamin D_3 5,000 IU per gram were added to 100 kg of the above three rations.

The mineral mixture added was 'Keyes Forte' (KSE Ltd Irinjalakuda) for cattle having an ingredient composition calcium (min) 24%, phosphorus (min) 12%, manganese (min) 0.15%, copper (min) 0.15%, zinc (min) 0.38%, magnesium (min) 6.5%, iron (min) 0.5%, iodine (min) 0.03%, cobalt (min) 0.02%, sulphur (min) 0.5%, acid insoluble ash (max) 2% and fluorine (max) 0.4%.

Each formulation was ground coarsely and premix containing vitamin, mineral mixture, so dium bicarbonate and monensin were incorporated by thorough hand mixing . The ground feed was sprayed with water to increase the moisture content to 25% and cold pelleted in a pelleting machine (Supplied by M/s Cremach Designs, Baroda) with a die size 12 mm diameter. The pellets were seived to remove the dust and placed in a mammoth oven at 60°C overnight to remove excess moisture.

3.4 Methods

Pelleted complete rations 1, 2 and 3 were fed to animals of group 1, 2 and 3 respectively. Feed was offered thrice daily at the scheduled timings on *ad libitum* basis. The left over pellets were collected every day, weighed and tested for moisture content.

The kids were weighed at weekly intervals and records of daily feed intake were maintained throughout the course of study. Body measurements such as body length, chest girth and height at withers were measured weekly for each animal.

At the end of 13 weeks a digestion cum metabolism trial was carried out on four male animals from each group. Animals were kept in metabolism cages and all precautions were taken to maintain sufficient intake of feed. Water was made available during the period. A measured amount of experimental diet on *ad libitum* basis was provided to the animals of the respective groups and the wastage quantified. Balance feed was collected daily and tested for dry matter to arrive at daily intake of dry matter.

3.5 Collection of dung and Urine

Animals were kept in cages for a preliminary period of two days followed by 5 days collection period. Total collection method was followed for both dung and urine. The cage floors were scraped clean every morning and the scurf removed. The dung was collected manually and kept in plastic containers as and when voided.

Specially made rubber lined funnel conduits were used for collecting urine. The total quantity collected was stored in amber coloured bottles containing 20 ml of 25% sulphuric acid as preservative. Representative samples of both dung and urine at the rate of 10 per cent of the total voided quantity were taken every day in air tight plastic bags and plastic bottles respectively and stored in deep freezer. At the time of analysis samples from each animal were pooled and mixed and representative samples taken.

3.6 Proximate analysis

Proximate analysis of the feed and dung samples were done as per the standard procedure (AOAC, 1990). Feed samples were analysed for estimation of calcium, sodium and potassium using atomic absorption spectrophotometer (Perkin-Elmer model 3110). Phosphorus content of feed was estimated by colorimetric method using a Spectronic 20 (Ward and Johnston, 1962).

The nitrogen content of urine samples was estimated as per Kjeldahl method (AOAC, 1990).

Coefficient of digestibility of nutrients and nitrogen balance were calculated.

3.7 Carcass yield study

At the end of the experiment three male animals from each group were slaughtered at the Meat Technology Unit attached to Veterinary College, Mannuthy, to record the dressing percentage.

3.8 Histopathologic studies

Rumen wall samples of each animal slaughtered were preserved in 10 per cent neutral buffered formalin. Tissue sections of appropriate sizes were cut and processed by paraffin embedding technique (Armed Forces Institute of Pathology, 1968). The sections were stained by Haematoxylin and Eosin and were permanently mounted using 'DPX' mountant. The permanent slides were photographed using Carl-Zeiss photo microscope.

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 as well as between males and females of the groups were statistically analysed to study the effect of animal protein inclusionusing a one factor randomized block design using the Analysis of covariance technique. 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 animal protein inclusion on the dry matter intake, feed conversion efficiency, average daily dry matter intake, average daily gain, average weekly feed conversion efficiency, digestibility coefficients of nutrients and nitrogen balance, a one factor completely randomised design using ANOVA technique was used and the significant treatment means compared using the least significant difference (LSD) test (Snedecor and Cochran, 1980).

Results

RESULTS

The results of the present study are presented in the tables under various subheadings.

4.1 Composition of the complete rations

The percentage composition of the three complete rations are presented in Table 2.

4.2 Body weight

The body weight of kids recorded at weekly intervals are presented in Tables 3 to 5 and depicted in Figures 1 and 2. Their consolidated data are presented in Table 6. Sex-wise comparison of the consolidated data on body weight is presented in Table 8. The statistical analysis of the data on weekly body weights and cumulative weight gain are given in Table 7.

4.3 Body measurements

The data on body length, chest girth and height at withers of the groups 1, 2 and 3 at weekly intervals are presented in Tables 18 to 20, 21 to 23 and 24 to 26 respectively and depicted in Figure 3. Their consolidated data are presented in Tables 27, 28 and 29 respectively. Their statistical analysis are given in Tables 30, 31 and 32 respectively.

4.4 Dry matter intake

The average daily dry matter intake of ten animals per week during the period of 13 weeks are presented in Table 9 and depicted in Figure 4. Its statistical analysis is given in Table 10. Sex wise comparison of the dry matter intake of the three groups are presented in Table 11 and depicted in Figure 5.

4.5 Average daily body weight gain

The average daily body weight gain of the three groups are presented in Table 12 and depicted in Figure 6. Its statistical analysis is given in Table 13. Sex-wise comparison of the daily gain of the three groups are presented in Table 14 and depicted in Figure 7.

4.6 Feed conversion efficiency

The data on average weekly feed conversion efficiency and cumulative feed efficiency of the three groups are presented in Table 15 and depicted in Figure 8. Its statistical analysis is given in Table 16. Sex-wise comparison of the cumulative feed efficiency of the three groups are presented in Table 17 and depicted in Figure 9.

4.7 Digestibility coefficients

The data on digestibility coefficients of dry matter, organic matter, crude protein, ether extract, crude fibre and nitrogen free extract of the animals fed on three complete rations are presented in Tables 33 to 35 and depicted in Figures 10 to 15. The consolidated data on the above are given in Table 36 and their statistical analysis presented in Tables 37 to 42.

The data on digestible crude protein (DCP) and total digestible nutrient (TDN) intake per 100 g dry matter intake are presented in Table 47.

4.8 Nitrogen balance

The data on nitrogen balance and per cent retention of nitrogen of the three groups are presented in Tables 43 to 45 and the statistical analysis on percentage retention of nitrogen is given in Table 46.

4.9 Dressing percentage

The dressing percentage of animals slaughtered from the groups are presented in Table 48 and depicted in Figure 16. Its statistical analysis is given in Table 49.

4.10 Histopathology of rumen epithelium

Microphotographs of rumen tissue from the three groups are presented in Plates 1 to 3.

4.11 Economics

The cost of production per kg gain of the animals maintained on the three rations are given in Table 51 and depicted in Figure 17. Expenditure of rearing kids on the three diet treatments are tabulated in Table 50. The gross profit calculated for 10 animals in 13 weeks from the three groups are presented in Table 52 and depicted in Figure 18.

Table 2. Percentage composition of the three complete rations

Nutrients	Ration 1	Ration 2	Ration 3
1. Moisture	11.30	11.21	10.85
2. Organic matter	94.37	93.40	93.80
3. Crude protein	16.27	16.79	16.35
4. Ether extract	4.33	4.61	4.20
5. Crude fibre	7.98	8.12	7.81
6. Nitrogen free extract	65.79	63.88	65.44
7. Total ash	5.63	6.60	6.20
8. Acid insoluble ash	1.46	1.61	1.71
9. Calcium	1.53	2.65	2.33
10. Phosphorus	0.92	0.84	0.88
11. Potassium	0.88	0.93	0.87
12. Sodium	0.13	0.20	0.23

Table 3. Body weight (kg) of kids recorded at weekly intervals (Group – 1)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	12..3	11.7	8.3	7.2	7.4	8.0	9.3	8.0	8.5	9.2	8.99 ± 0.52
1	13.5	12.8	8.9	8.2	8.6	9.1	10.4	9.0	9.2	10.8	10.05 ± 0.55
2	15.2	14.5	9.3	8.7	9.3	10.3	11.8	9.8	9.8	11.8	11.05 ± 0.68
3	18.7	16.0	10.3	9.2	9.8	12.3	14.3	10.1	11.0	12.5	12.42 ± 0.92
4	19.7	16.2	13.2	11.6	11.8	14.8	16.2	11.9	13.2	13.8	14.24 ± 0.77
5	21.5	16.8	14.5	13.2	13.2	15.9	17.9	13.5	15.3	14.9	15.67 ± 0.77
6	22.3	15.5	16.0	14.0	14.8	17.1	18.7	14.5	15.8	15.8	16.45 ± 0.74
7	21.9	17.0	17.3	14.1	14.6	17.6	19.3	15.0	16.2	16.3	16.93 ± 0.70
8	21.7	18.4	17.7	15.1	15.7	18.8	19.7	16.5	16.4	18.0	17.80 ± 0.60
9	21.0	20.0	18.1	15.8	16.4	19.3	21.2	17.5	16.9	18.4	18.46 ± 0.56
10	23.5	21.4	18.1	17.0	16.8	19.9	21.9	19.2	18.5	20.1	19.64 ± 0.65
11	24.1	21.5	20.3	18.3	18.4	20.9	22.8	19.5	20.4	21.3	20.75 ± 0.55
12	23.8	22.8	21.0	19.5	19.5	22.0	23.4	20.5	21.3	22.0	21.58 ± 0.45
13	25.2	23.0	22.0	21.0	21.0	24.0	24.0	22.0	21.9	23.0	22.71 ± 0.41
Cumulative weight gain = 13.72 ± 0.36											

Table 4. Body weight (kg) of kids recorded at weekly intervals (Group – 2)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	12.4	12.8	8.0	5.9	8.2	8.8	6.8	7.5	10.5	8.3	8.92 ± 0.69
1	14.8	14.4	9.6	6.8	9.3	9.7	8.4	8.6	11.9	10.8	10.43 ± 0.78
2	15.7	15.4	9.9	7.3	9.8	10.5	9.8	9.6	13.8	12.4	11.42 ± 0.83
3	17.3	16.7	10.8	8.4	10.7	12.3	11.2	10.8	15.3	14.6	12.12 + 0.89
4	19.6	18.7	12.1	10.4	13.0	14.6	13.5	12.8	17.6	16.8	14.91 ± 0.93
5	21.3	19.3	14.5	12.5	15.5	15.7	15.5	15.0	19.2	18.0	16.65 ± 0.81
6	22.7	20.5	15.3	12.6	14.6	17.3	16.7	17.1	21.0	19.8	17.76 ± 0.95
7	23.8	22.1	16.5	13.9	14.6	18.0	17.3	18.5	22.1	20.6	18.74 ± 1.00
8	25.0	23.7	17.2	15.8	17.1	18.8	17.9	19.0	22.6	21.3	19.84 ± 0.94
9	26.6	24.6	18.5	17.5	16.9	21.0	18.7	19.3	23.1	21.8	20.80 ± 0.96
10	27.8	25.3	19.7	18.4	17.8	22.0	19.2	19.6	23.7	22.0	21.55 ± 0.97
11	28.1	26.0	20.3	19.6	17.8	22.3	19.6	20.3	23.8	22.5	22.03 ± 0.96
12	28.3	26.5	21.2	19.8	18.6	22.6	19.8	20.8	23.9	22.8	22.33 ± 0.97
13	28.5	27.0	22.0	20.1	20.1	23.0	20.0	21.1	24.2	22.8	22.88 ± 0.88
Cumulative weight gain = 13.96 ± 0.32											

Table 5. Body weight (kg) of kids recorded at weekly intervals (Group – 3)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	12.2	14.2	7.2	7.2	7.1	8.4	9.5	7.6	8.2	8.8	9.04 ± 0.71
1	14.0	16.2	9.1	9.0	8.7	9.0	10.5	8.9	9.2	9.4	10.73 ± 0.81
2	14.4	17.5	10.4	10.0	9.4	9.8	11.3	9.8	10.0	10.3	11.29 ± 0.78
3	14.7	18.6	11.2	10.8	9.8	10.5	12.0	10.6	10.4	11.0	11.96 ± 0.81
4	16.2	20.1	13.3	13.1	11.5	12.2	13.5	11.8	12.6	12.1	13.64 ± 0.79
5	16.9	21.5	15.3	13.6	12.7	13.6	15.3	13.3	13.7	12.8	14.87 ± 0.80
6	17.3	21.3	15.0	15.1	13.3	14.1	15.3	13.5	14.1	13.4	15.24 ± 0.73
7	19.5	21.9	16.2	15.2	13.3	14.8	15.7	13.6	15.0	14.1	15.93 ± 0.82
8	19.3	22.0	16.6	17.2	15.4	16.6	17.0	15.3	16.7	15.0	17.11 ± 0.63
9	20.0	23.5	17.7	18.3	16.6	16.9	17.3	15.8	17.8	15.4	17.93 ± 0.70
10	19.1	26.0	19.5	20.0	18.2	18.2	18.4	15.9	19.4	16.4	19.11 ± 0.83
11	20.5	26.4	20.0	19.2	18.5	18.9	18.0	17.2	20.2	17.4	19.63 ± 0.79
12	21.5	25.5	20.1	20.1	18.7	20.0	18.6	16.8	20.5	17.3	19.91 ± 0.73
13	21.7	25.8	20.1	20.5	18.8	20.0	18.8	17.2	20.6	17.5	20.10 ± 0.73
Cumulative weight gain = 11.06 ± 0.49											

Table 6. Average body weight (kg) recorded at weekly intervals with cumulative weight gain (kg) of kids in the three groups

Weeks	Average body weight		
	Group 1	Group 2	Group 3
0	8.99 ± 0.52	8.92 ± 0.69	9.04 ± 0.71
1	10.05 ± 0.55	10.43 ± 0.78	10.73 ± 0.81
2	11.05 ± 0.68	11.42 ± 0.83	11.29 ± 0.78
3	12.42 ± 0.92	12.12 ± 0.89	11.96 ± 0.81
4	14.24 ± 0.77	14.91 ± 0.93	13.64 ± 0.79
5	15.67 ± 0.77	16.65 ± 0.81	14.87 ± 0.80
6	16.45 ± 0.74	17.76 ± 0.95	15.24 ± 0.73
7	16.93 ± 0.70	18.74 ± 1.00	15.93 ± 0.82
8	17.80 ± 0.60	19.84 ± 0.94	17.11 ± 0.63
9	18.46 ± 0.56	20.80 ± 0.96	17.93 ± 0.70
10	19.64 ± 0.65	21.55 ± 0.97	19.11 ± 0.83
11	20.75 ± 0.55	22.03 ± 0.96	19.63 ± 0.79
12	21.58 ± 0.45	22.33 ± 0.97	19.91 ± 0.73
13	22.71 ± 0.41	22.88 ± 0.88	20.10 ± 0.73
Cumulative weight gain	13.72 ± 0.36^{a}	13.96 ± 0.32^{a}	11.06 ± 0.49^{b}

a, b Means of the same row with different superscript differ

Table 7. Analysis of covariance – weekly body weight (kg) and cumulative weight gain (kg)

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	0.148	0.525	14.064	0.239
2	0.207	0.483	13.616	0.625
3	0.566	2.348	14.296	1.547
4	0.536	4.897	17.034	1.902
5	0.838	9.180*	18.442	2.035
6	1.653	17.876*	24.917	3.065
7	1.956	22.279**	20.184	2.591
8	0.614	21.940**	17.046	2.156
9	0.670	25.036**	14.292	2.646
10	0.815	18.090*	17.054	3.594
11	0.930	15.716*	12.132	2.903
12	1.140	17.621**	9.845	2.352
13	1.102	25.832**	14.436	2.143

* Significant at 5 per cent level
** Significant at 1 per cent level

Table 8. Average body weight (kg) recorded at weekly intervals with cumulative weight gain (kg) of male/female kids in the three groups

Weeks	Group 1		Group 2		Group 3	
	Male	Female	Male	Female	Male	Female
0	9.38 ± 0.97	8.60 ± 0.25	9.46 ± 1.20	8.38 ± 0.56	9.58 ± 1.35	8.50 ± 0.28
1	10.40 ± 1.01	9.70 ± 0.33	10.98 ± 1.39	9.13 ± 0.67	11.40 ± 1.39	9.40 ± 0.26
2	11.40± 1.27	10.70 ± 0.41	11.62 ± 1.49	11.22 ± 0.73	12.34 ± 1.40	10.24 ± 0.25
3	12.80 ± 1.71	12.04 ± 0.89	12.78 ± 1.59	12.84 ± 0.81	13.02 ± 1.45	10.90 ± 0.26
4	14.50 ± 1.38	13.98 ± 0.65	14.76 ± 1.65	15.06 ± 0.83	13.93 ± 1.46	12.44 ± 0.26
5	15.84 ± 1.40	15.50 ± 0.64	16.62 ± 1.44	16.68 ± 0.73	16.00 ± 1.39	13.74 ± 0.38
6	16.52 ± 1.33	16.38 ± 0.64	17.14 ± 1.70	18.38 ± 0.76	16.40 ± 1.23	14.08 ± 0.30
7	16.98 ± 1.24	16.88 ± 0.65	18.18 ± 1.80	19.30 ± 0.80	17.22 ± 1.38	14.64 ± 0.32
8	17.72 ± 1.04	17.88 ± 0.58	19.76 ± 1.70	19.92 ± 0.78	18.10 ± 1.04	16.12 ± 0.36
9	18.26 ± 0.90	18.66 ± 0.58	20.82 ± 1.78	20.78 ± 0.72	19.22 ± 1.08	16.64 ± 0.40
10	19.36 ± 1.18	19.92 ± 0.49	21.80 ± 1.79	21.30 ± 0.75	20.56 ± 1.24	17.66 ± 0.58
11	20.52 ± 0.96	20.98 ± 0.49	22.36 ± 1.78	21.70 ± 0.69	20.92 ± 1.26	18.34 ± 0.49
12	21.32 ± 0.77	21.84 ± 0.43	22.88 ± 1.71	21.98 ± 0.66	21.18 ± 1.04	18.64 ± 0.65
13	22.44 ± 0.70	22.98 ± 0.41	23.54 ± 1.58	22.22 ± 0.66	21.38 ± 1.07	18.82 ± 0.60
Cumulative weight gain	13.06 ± 0.42	14.38 ± 0.41	14.08 ± 0.66	13.84 ± 0.21	11.80 ± 0.59	10.32 ± 0.64

Table 9. Average daily dry matter intake (kg) of ten animals maintained on rations 1, 2 and 3

Weeks	Treatments		
	Ration 1	Ration 2	Ration 3
1	4.50	5.01	4.98
2	6.50	5.08	5.00
3	6.00	5.83	5.86
4	6.50	5.86	5.84
5	6.60	6.47	6.52
6	6.00	4.75	4.51
7	6.32	5.33	4.79
8	7.53	5.32	5.33
9	6.94	5.74	5.76
10	7.92	6.73	6.65
11	8.00	6.86	6.84
12	8.10	7.02	7.05
13	7.50	6.24	6.54
	6.80 ± 0.26a	5.86 ± 0.13b	5.82 ± 0.17b

a, b means of the same row with different superscript differ

Table 10. Analysis of variance – Average daily dry matter intake

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	7.879	3.939	7.005**	0.0027
Error	36	20.245	0.562		

** Significant at 1 per cent level

Table 11. Average daily dry matter intake (g) of male/female kids in the three groups

Weeks	Group 1		Group 2		Group 3	
	Males	Females	Males	Females	Males	Females
1	460.10	439.90	505.32	496.68	504.28	491.72
2	646.38	653.62	515.25	500.75	500.86	499.14
3	592.10	607.90	590.00	582.57	590.00	576.00
4	645.14	654.88	577.14	590.00	575.71	595.43
5	649.15	670.89	683.43	621.14	653.71	640.29
6	594.55	605.43	444.57	456.57	468.00	481.71
7	626.15	637.90	484.00	474.00	539.71	525.43
8	746.57	759.43	537.71	527.43	519.43	544.86
9	689.14	699.43	575.71	575.71	570.29	578.00
10	779.14	804.87	684.86	645.43	692.57	654.00
11	801.15	798.89	690.71	681.29	686.28	681.74
12	807.84	812.16	703.44	700.56	706.25	703.75
13	746.35	753.68	647.14	660.57	627.14	621.43
Mean ± S.E.	675.67 ± 26.55	684.54 ± 27.80	587.63 ± 23.35	577.90 ± 21.73	587.25 ± 21.33	584.12 ± 19.57

Table 12. Average daily gain (g) of animals maintained on rations 1, 2 and 3

Weeks	Treatments		
	Ration 1	Ration 2	Ration 3
1	151.42	215.71	194.29
2	142.86	141.43	127.14
3	195.71	198.57	95.71
4	260.00	300.00	240.00
5	204.29	248.57	175.71
6	111.43	158.57	52.86
7	68.57	140.00	98.57
8	124.29	157.14	168.57
9	94.29	137.14	117.14
10	168.57	107.14	168.57
11	158.57	68.57	74.29
12	118.57	57.14	40.00
13	161.43	64.28	27.14
Mean ± S.E.	150.76 ± 13.46	153.40 ± 19.40	121.53 ± 17.28

Table 13. Analysis of variance – Average daily gain

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	8133.473	4066.737	1.012 NS	0.3736
Error	36	144683.855	4018.996		

NS - Non significant

Table 14. Average daily gain (g) of male/female kids in the three groups

Weeks	Group 1		Group 2		Group 3	
	Males	Females	Males	Females	Males	Females
1	145.71	157.14	217.14	214.29	260.00	128.57
2	142.86	142.86	91.43	191.43	134.29	120.00
3	200.00	191.43	165.71	231.43	97.14	94.29
4	242.86	277.14	282.86	317.14	260.00	220.00
5	191.43	217.14	265.71	231.43	165.71	185.71
6	97.14	125.71	74.29	242.86	57.14	48.57
7	65.71	71.43	148.57	131.43	117.14	80.00
8	105.71	142.86	225.71	88.57	125.71	211.43
9	77.14	111.43	151.43	122.86	160.00	74.29
10	157.14	180.00	140.00	74.29	191.43	145.71
11	165.71	151.43	80.00	57.14	51.43	97.14
12	114.29	122.86	74.29	40.00	37.14	42.86
13	160.00	162.86	94.29	34.29	28.57	25.71
Mean ± S.E.	143.52 ± 13.59	158.02 ± 13.71	154.73 ± 19.50	152.10 ± 24.36	129.67 ± 20.56	113.41 ± 16.79

Table 15. Average weekly feed conversion efficiency and cumulative feed efficiency of animals maintained on rations 1, 2 and 3

Weeks	Treatments		
	Ration 1	Ration 2	Ration 3
1	2.97	2.32	2.56
2	4.55	3.59	3.93
3	3.07	2.94	6.13
4	2.50	1.95	2.43
5	3.23	2.60	3.71
6	5.38	2.99	8.52
7	9.22	3.80	4.86
8	6.06	3.39	3.16
9	7.36	4.19	4.91
10	4.70	6.28	3.95
11	5.05	10.00	9.21
12	6.83	12.29	17.63
13	4.65	9.71	24.09
Mean ± S.E.	5.04 ± 0.52	5.08 ± 0.91	7.31 ± 1.73
Cumulative feed efficiency	4.51	3.67	4.79

Table 16. Analysis of variance – Feed conversion efficiency

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	43.403	21.702	1.350 NS	0.2721
Error	36	578.848	16.079		

NS - Non significant

Table 17. Cumulative feed efficiency of male/female kids in the three groups

	Group 1		Group 2		Group 3	
	Males	Females	Males	Females	Males	Females
Cumulative feed efficiency	4.66	4.36	3.49	3.84	4.54	5.10

Table 18. Body length (cm) of kids recorded at weekly intervals (Group 1)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	50	47	34	37	34	45	45	35	35	46	40.8 ± 1.90
1	51	48	36	37	35	46	47	35	35	46	41.6 ± 1.95
2	54	48	36	38	36	46	47	36	36	48	42.5 ± 2.03
3	54	49	38	38	36	48	49	37	37	50	43.16 ± 2.08
4	57	51	39	39	36	49	49	37	38	52	44.7 ± 2.29
5	58	51	40	39	38	50	50	38	38	54	45.6 ± 2.32
6	58	54	40	39	40	50	52	38	39	55	46.5 ± 2.39
7	60	54	43	40	40	50	53	39	41	56	47.6 ± 2.35
8	62	54	44	40	42	52	55	41	43	57	49.0 ± 2.36
9	62	55	46	42	43	54	56	42	45	59	50.4 ± 2.27
10	63	57	46	43	45	55	57	42	46	59	51.3 ± 2.29
11	64	58	48	43	46	56	57	43	46	60	52.1 ± 2.31
12	66	59	49	45	46	56	59	44	47	60	53.1 ± 2.33
13	66	60	50	46	47	58	60	45	48	61	54.1 ± 2.30
Cumulative increase in length = 13.3 ± 0.71											

Table 19. Chest girth (cm) of kids recorded at weekly intervals (Group – 1)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	53	51	45	46	43	45	48	45	47	43	46.6 ± 0.98
1	57	55	46	47	46	47	50	48	47	48	49.1 ± 1.15
2	59	57	49	49	49	50	52	51	48	51	51.5 ± 1.10
3	60	59	52	52	52	52	55	54	50	53	53.9 ± 0.97
4	61	61	55	55	54	54	56	57	51	54	55.6 ± 0.92
5	62	62	58	57	57	57	58	60	52	55	57.8 ± 0.91
6	62	62	61	59	58	58	58	60	54	56	58.8 ± 0.77
7	63	63	63	62	59	61	59	60	56	57	60.3 ± 0.76
8	65	65	65	64	60	62	59	61	58	58	61.0 ± 0.85
9	66	67	67	66	61	63	61	61	61	59	63.2 ± 0.90
10	67	69	67	67	62	64	63	61	64	60	64.4 ± 0.89
11	68	70	68	68	63	65	65	62	66	61	65.6 ± 0.89
12	69	71	68	69	65	67	66	62	68	62	66.7 ± 0.89
13	70	71	68	69	66	67	66	62	70	63	67.2 ± 0.90
Cumulative increase in chest girth = 20.6 ± 0.76											

Table 20. Height at withers (cm) of kids recorded at weekly intervals (Group – 1)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	50	53	46	47	45	47	50	43	48	45	47.4 ± 0.89
1	53	57	47	48	48	49	53	48	48	47	49.8 ± 1.01
2	55	61	50	51	51	51	55	50	51	49	52.9 ± 1.20
3	58	63	53	54	54	54	56	51	54	51	54.8 ± 1.07
4	61	64	54	56	55	56	57	52	57	53	56.5 ± 1.09
5	63	65	56	58	56	58	58	53	60	55	58.2 ± 1.09
6	65	66	59	60	57	60	59	55	62	57	60.0 ± 1.05
7	66	67	60	62	58	61	60	56	64	58	61.2 ± 1.08
8	67	68	61	64	59	63	61	57	66	59	62.5 ± 1.12
9	68	69	62	65	60	63	62	58	68	60	63.5 ± 1.15
10	69	70	64	66	61	64	63	59	69	61	64.6 ± 1.14
11	70	71	66	68	63	64	64	60	71	62	65.9 ± 1.18
12	71	72	69	70	65	66	65	62	71	63	67.4 ± 1.09
13	72	73	69	70	66	67	66	62	71	63	67.9 ± 1.12
Cumulative increase in height = 20.5 ± 0.77											

Table 21. Body length (cm) of kids recorded at weekly intervals (Group – 2)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	48	48	40	35	34	36	33	34	45	37	39.0 ± 1.77
1	49	49	40	35	36	37	36	36	48	37	40.3 ± 1.78
2	51	50	40	35	39	40	37	38	50	37	41.7 ± 1.84
3	53	52	41	38	41	42	38	39	52	40	42.7 ± 1.87
4	56	54	42	39	43	44	40	41	54	42	45.5 ± 1.95
5	58	56	44	41	44	46	42	43	56	43	46.4 ± 1.99
6	61	58	46	43	46	48	44	45	58	45	47.4 ± 2.06
7	62	60	48	45	48	51	46	46	59	47	48.3 ± 2.08
8	63	61	50	47	50	52	48	48	59	49	49.1 ± 2.10
9	65	63	52	49	51	53	50	50	60	51	54.4 ± 1.78
10	66	63	54	51	53	54	52	50	60	53	55.6 ± 1.63
11	67	64	56	53	54	55	54	51	61	55	56.3 ± 1.61
12	68	64	58	55	55	57	55	52	62	58	57.0 ± 1.60
13	68	64	60	56	56	57	56	52	62	60	59.1 ± 1.40
Cumulative increase in length = 20.1 ± 0.73											

Table 22. Chest girth (cm) of kids recorded at weekly intervals (Group – 2)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	55	55	45	45	46	48	42	39	47	41	46.3 ± 1.61
1	57	55	47	45	46	52	42	41	50	46	48.1 ± 1.60
2	59	57	49	45	48	53	43	43	53	49	49.9 ± 1.66
3	60	59	51	46	50	55	46	45	54	51	51.7 ± 1.59
4	62	61	53	47	52	57	49	46	56	53	53.6 ± 1.64
5	64	63	54	50	53	60	51	48	58	55	55.6 ± 1.64
6	65	64	55	54	55	61	53	50	60	57	57.4 ± 1.47
7	67	66	58	56	57	62	55	52	62	59	59.4 ± 1.44
8	68	68	60	58	58	63	57	54	64	60	61.0 ± 1.40
9	69	68	62	60	60	64	58	56	65	61	62.3 ± 1.26
10	69	69	64	62	62	65	60	58	67	62	63.8 ± 1.11
11	70	69	66	64	64	66	62	60	68	63	65.2 ± 0.95
12	71	69	67	66	66	66	65	62	69	64	66.5 ± 0.79
13	72	71	67	68	68	66	65	62	70	64	67.3 ± 0.95
Cumulative increase in chest girth = 21.0 ± 0.84											

Table 23. Height at withers (cm) of kids recorded at weekly intervals (Group – 2)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	50	49	43	45	44	48	37	39	49	45	44.9 ± 1.31
1	53	52	45	45	45	51	39	42	50	48	47.0 ± 1.37
2	56	55	47	45	47	53	42	44	52	50	49.1 ± 1.44
3	57	58	49	46	49	55	43	46	55	52	51.0 ± 1.55
4	58	61	51	46	51	57	45	48	58	54	52.9 ± 1.66
5	60	62	53	47	54	59	47	50	60	56	54.8 ± 1.65
6	62	63	55	50	56	60	49	52	62	57	56.6 ± 1.54
7	64	63	57	53	58	61	50	53	64	58	58.1 ± 1.49
8	66	65	59	56	61	62	52	55	66	59	60.1 ± 1.45
9	67	66	61	58	63	63	54	57	68	59	61.6 ± 1.38
10	69	67	63	60	65	64	56	59	70	59	63.2 ± 1.40
11	71	68	64	63	66	64	58	61	70	60	64.5 ± 1.28
12	72	69	66	66	67	64	60	62	70	60	65.6 ± 1.23
13	72	70	66	68	67	64	60	62	70	61	66.0 ± 1.24
Cumulative increase in height = 21.1 ± 1.77											

Table 24. Body length (cm) of kids recorded at weekly intervals (Group – 3)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	42	44	38	39	35	37	38	32	39	35	37.9 ± 1.04
1	47	50	38	39	35	41	43	34	39	36	40.2 ± 1.55
2	51	55	41	41	39	44	47	37	41	38	43.4 ± 1.77
3	53	57	44	44	41	46	50	40	44	40	45.9 ± 1.72
4	55	59	47	46	44	48	51	43	46	42	48.1 ± 1.63
5	57	60	50	48	47	50	51	45	48	44	50.0 ± 1.51
6	59	61	52	50	50	52	52	47	50	46	51.9 ± 1.42
7	60	61	54	52	52	54	52	49	52	48	52.7 ± 1.36
8	61	61	56	55	54	56	53	50	54	49	53.4 ± 1.35
9	62	62	58	57	55	58	53	52	56	50	54.1 ± 1.37
10	63	62	60	59	56	60	54	53	58	51	57.5 ± 1.19
11	64	63	61	60	57	60	55	55	60	52	58.7 ± 1.15
12	64	64	61	60	57	60	56	55	62	53	59.2 ± 1.14
13	64	65	61	62	58	60	57	55	62	54	59.8 ± 1.11
Cumulative increase in length = 21.9 ± 0.49											

Table 25. Chest girth (cm) of kids recorded at weekly intervals (Group – 3)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	53	53	45	41	45	50	50	43	46	50	47.6 ± 1.25
1	54	55	45	44	46	52	51	44	47	52	49.0 ± 1.27
2	56	55	48	44	47	54	52	46	49	52	50.3 ± 1.23
3	57	57	51	45	48	54	52	47	51	53	51.5 ± 1.20
4	59	59	51	45	49	56	53	48	53	54	52.7 ± 1.38
5	61	60	51	45	50	56	54	49	53	54	53.3 ± 1.47
6	61	60	52	46	51	58	55	50	53	54	54.0 ± 1.40
7	61	61	52	48	52	59	56	51	54	55	54.9 ± 1.31
8	62	61	54	51	53	61	56	52	54	58	56.2 ± 1.21
9	65	61	56	53	54	61	58	53	54	61	57.6 ±1.27
10	66	63	58	53	55	61	59	53	55	62	58.5 ± 1.34
11	66	64	58	53	55	62	62	54	57	63	59.4 ± 1.37
12	66	65	58	54	55	63	64	54	58	64	60.1 ± 1.44
13	68	66	60	55	57	64	65	54	58	65	61.2 ± 1.50
Cumulative increase in chest girth = 13.6 ± 0.45											

Table 26. Height at withers (cm) of kids recorded at weekly intervals (Group – 3)

Weeks	Replicate										Mean ± S.E.
	Males					Females					
	1	2	3	4	5	6	7	8	9	10	
0	53	54	43	39	40	51	48	41	44	50	46.3 ± 1.67
1	57	59	48	43	44	56	52	45	49	54	50.7 ± 1.72
2	59	61	49	44	44	57	54	45	49	56	51.3 ± 1.83
3	61	62	50	44	44	57	56	46	52	56	52.8 ± 1.99
4	64	63	51	46	47	57	57	46	52	57	54.0 ± 1.99
5	66	64	52	47	47	57	57	48	53	58	54.9 ± 2.02
6	66	66	52	49	50	60	57	50	54	59	56.3 ± 1.91
7	66	66	53	51	50	61	59	52	54	60	57.2 ± 1.80
8	67	68	54	51	50	61	60	53	56	61	58.1 ± 1.90
9	67	68	55	53	51	63	61	54	57	61	59.0 ± 1.77
10	67	68	56	55	51	64	62	55	58	61	59.7 ± 1.69
11	68	69	57	57	52	65	63	56	59	62	60.8 ± 1.66
12	68	69	58	57	53	66	64	56	60	62	61.3 ± 1.62
13	69	69	59	57	53	66	65	57	60	64	61.6 ± 1.64
Cumulative increase in height at withers = 15.6 ± 0.43											

Table 27. Combined data on body length (cm) and cumulative increase in length (cm) of kids in the three groups

Weeks	Average body length		
	Group 1	Group 2	Group 3
0	40.8 ± 1.90	39.0 ± 1.77	37.9 ± 1.04
1	41.6 ± 1.95	40.3 ± 1.78	40.2 ± 1.55
2	42.5 ± 2.03	41.7 ± 1.84	43.4 ± 1.77
3	43.6 ± 2.08	42.7 ± 1.87	45.9 ± 1.72
4	44.7 ± 2.29	45.5 ± 1.95	48.1 ± 1.63
5	45.6 ± 2.32	46.5 ± 1.99	50.0 ± 1.51
6	46.4 ± 2.39^{b}	47.4 ± 2.06^{a}	51.9 ± 1.42^{a}
7	47.6 ± 2.35^{b}	48.3 ± 2.08^{a}	52.7 ± 1.36^{a}
8	49.0 ±2.36^{b}	49.1 ± 2.10^{a}	53.4 ± 1.35^{a}
9	50.4 ± 2.27^{b}	54.4 ± 1.78^{a}	54.1 ± 1.37^{a}
10	51.3 ± 2.29^{b}	55.6 ± 1.63^{a}	57.6± 1.19^{a}
11	52.1 ± 2.31^{b}	56.3 ± 1.61^{a}	58.7 ± 1.15^{a}
12	53.1 ± 2.33^{b}	57.0 ± 1.60^{a}	59.2 ± 1.14^{a}
13	54.1 ± 2.30^{b}	59.1 ± 1.40^{a}	59.8 ± 1.11^{a}
Cumulative increase in length	13.3 ± 0.71^{b}	20.1 ± 0.73^{a}	21.9 ± 0.49^{a}

a, b Means of the same row with different superscript differ

Table 28. Combined data on chest girth (cm) and cumulative increase in girth (cm) of kids in the three groups

Weeks	Average chest girth		
	Group 1	Group 2	Group 3
0	46.6 ± 0.98	46.2 ± 1.61	47.6 ± 1.25
1	49.1 ± 1.15	48.1 ± 1.60	49.0 ± 1.27
2	51.5 ± 1.10	49.9 ± 1.66	50.3 ± 1.23
3	53.9 ± 0.97	51.7 ± 1.59	51.5 ± 1.20
4	55.6 ± 0.92	53.6 ± 1.64	52.7 ± 1.38
5	57.8 ± 0.91 ^{a}	55.6 ± 1.64 ^{a}	53.3 ± 1.47 ^{b}
6	58.8 ± 0.77 ^{a}	57.4 ± 1.47 ^{a}	54.0 ± 1.40 ^{b}
7	60.3 ± 0.76 ^{a}	59.4 ± 1.44 ^{a}	54.9 ± 1.31 ^{b}
8	61.0 ± 0.85 ^{a}	61.0 ± 1.40 ^{a}	56.2 ± 1.21 ^{b}
9	63.2 ± 0.90 ^{a}	62.3 ± 1.26 ^{a}	57.7 ± 1.27 ^{b}
10	64.4 ± 0.89 ^{a}	63.8 ± 1.11 ^{a}	58.5 ± 1.34 ^{b}
11	65.6 ± 0.89 ^{a}	65.2 ± 0.95 ^{a}	59.4 ± 1.37 ^{b}
12	66.7 ± 0.89 ^{a}	66.5 ± 0.79 ^{a}	60.1 ± 1.44 ^{b}
13	67.2 ± 0.90 ^{a}	67.3 ± 0.95 ^{a}	61.2 ± 1.50 ^{b}
Cumulative increase in girth	20.6 ± 0.76 ^{a}	21.0 ± 0.84 ^{a}	13.6 ± 0.45 ^{b}

a, b Means of the same row with different superscript differ

Table 29. Combined data on height at withers (cm) and cumulative increase in height (cm) of kids in the three groups

Weeks	Average height at withers		
	Group 1	Group 2	Group 3
0	47.4 ± 0.89	44.9 ± 1.30	46.3 ± 1.67
1	49.8 ± 1.01	47.0 ± 1.37	50.7 ± 1.72
2	52.9 ± 1.20	49.1 ± 1.44	51.3 ± 1.83
3	54.8 ± 1.07	51.0 ± 1.55	52.8 ± 1.99
4	56.5 ± 1.09	52.9 ± 1.66	54.0 ± 1.99
5	58.2 ± 1.09	54.8 ± 1.65	54.9 ± 2.02
6	60.0 ± 1.05^{a}	56.6 ± 1.54^{a}	56.3 ± 1.91^{b}
7	61.2 ± 1.08^{a}	58.1 ± 1.49^{a}	57.2 ± 1.80^{b}
8	62.5 ± 1.12^{a}	60.1 ± 1.45^{a}	58.1 ± 1.90^{b}
9	63.5 ± 1.15^{a}	61.6 ± 1.38^{a}	59.0 ± 1.77^{b}
10	64.6 ± 1.14^{a}	63.2 ± 1.40^{a}	59.7 ± 1.69^{b}
11	65.9 ± 1.18^{a}	64.5 ± 1.28^{a}	60.8 ± 1.66^{b}
12	67.4 ± 1.09^{a}	65.6 ± 1.23^{a}	61.3 ± 1.62^{b}
13	67.9 ± 1.12^{a}	66.0 ± 1.24^{a}	61.6 ± 1.64^{b}
Cumulative increase in height	20.5 ± 0.71^{a}	21.1 ± 1.77^{a}	15.6 ± 0.43^{b}

a, b Means of the same row with different superscript differ

Table 30. Analysis of covariance – weekly body length (cm) and cumulative increase in length (cm)

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	1.153	9.646	275.009	0.525
2	1.346	34.692	296.132	1.259
3	1.527	66.092	320.867	1.600
4	1.331	94.649*	317.962	3.108
5	2.769	128.637**	332.313	4.111
6	2.685	162.502**	307.571	5.786
7	3.692	166.259**	240.054	7.714
8	4.694	162.755**	209.339	9.698
9	4.700	161.281**	192.046	11.013
10	6.266	163.176**	145.240	12.519
11	6.546	173.380**	127.300	13.402
12	7.267	158.056**	105.774	12.966
13	7.733	142.749**	103.515	13.170
Cumulative increase in length	5.751	135.415**	13.524	16.565

* Significant at 5 per cent level
** Significant at 1 per cent level

Table 31. Analysis of covariance – weekly chest girth (cm) and cumulative increase in girth (cm)

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	0.275	2.645	168.640	0.578
2	0.671	9.924	127.274	0.615
3	0.775	23.803	100.100	1.147
4	1.277	35.458*	89.876	3.211
5	1.972	67.482**	80.160	5.485
6	2.627	78.483**	55.817	6.489
7	3.811	103.410**	50.805	6.066
8	5.773	107.756**	43.028	5.669
9	6.927	106.106**	36.071	6.023
10	7.625	117.053**	23.642	5.892
11	6.818	131.419**	22.047	6.578
12	8.371	142.758**	8.085	7.768
13	10.670	123.041**	6.643	8.743
Cumulative increase in girth	7.401	118.149**	71.449	8.715

* Significant at 5 per cent level
** Significant at 1 per cent level

Table 32. Analysis of covariance – weekly height at withers (cm) and cumulative increase in height

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	0.322	6.979	180.873	0.737
2	0.796	20.633	182.297	1.677
3	1.979	41.985	169.329	3.134
4	4.036	48.369*	147.326	3.573
5	6.045	62.197**	127.579	4.719
6	6.663	65.107**	96.360	4.422
7	7.614	74.681**	105.021	5.465
8	8.833	85.505**	96.495	7.163
9	10.141	89.058**	89.152	7.222
10	12.207	103.249**	83.646	7.625
11	14.132	101.762**	65.738	8.553
12	15.076	125.195**	54.093	8.908
13	15.289	127.198**	58.713	9.484
Cumulative increase in height	14.228	123.384**	80.556	8.895

* Significant at 5 per cent level
** Significant at 1 per cent level

Table 33 Digestibility coefficients of nutrients in animals maintained on Ration 1 (Group 1)

Nutrients	Replicate				Mean ± S.E.
	1	2	3	4	
Dry matter	68.56	71.00	74.43	76.85	72.71 ± 1.59
Organic matter	79.60	80.20	83.38	85.58	82.19 ± 1.21
Crude protein	82.12	80.48	85.61	87.61	83.96 ± 1.40
Ether extract	52.58	63.28	65.91	66.01	61.95 ± 2.76
Crude fibre	48.43	40.72	56.33	63.30	52.20 ± 4.23
Nitrogen free extract	75.87	76.69	78.41	79.18	77.54 ± 0.66

Table 34. Digestibility coefficients of nutrients in animals maintained on Ration 2 (Group 2)

Nutrients	Replicate				Mean ± S.E.
	1	2	3	4	
Dry matter	73.19	77.28	71.14	69.96	72.89 ± 1.39
Organic matter	82.41	84.71	81.05	80.63	82.20 ± 0.80
Crude protein	79.83	80.75	84.40	84.59	82.39 ± 1.06
Ether extract	56.42	60.82	60.12	55.10	58.12 ± 1.21
Crude fibre	37.10	43.69	50.34	43.37	43.63 ± 2.34
Nitrogen free extract	80.38	81.40	82.44	73.96	79.55 ± 1.65

Table 35. Digestibility coefficients of nutrients in animals maintained on Ration 3 (Group 3)

Nutrients	Replicate				Mean ± S.E.
	1	2	3	4	
Dry matter	70.38	69.45	70.59	69.61	70.01 ± 0.24
Organic matter	74.73	75.56	76.13	75.01	75.36 ± 0.27
Crude protein	82.55	80.83	83.95	79.54	81.72 ± 0.83
Ether extract	54.26	61.96	63.74	66.07	61.51 ± 2.22
Crude fibre	48.82	46.18	51.83	47.53	48.59 ± 0.66
Nitrogen free extract	75.01	78.67	76.06	72.92	75.67 ± 1.04

Table 36. Consolidated data on digestibility coefficients of nutrients in animals maintained on rations 1, 2 and 3

Nutrients	Treatments		
	Ration 1	Ration 2	Ration 3
Dry matter	72.71 ± 1.59	72.89 ± 1.39	70.01 ± 0.24
Organic matter	82.19 ± 1.21	82.20 ± 0.80	75.36 ± 0.27
Crude protein	83.96 ± 1.40	82.39 ± 1.06	81.72 ± 0.83
Ether extract	61.95 ± 2.76	58.12 ± 1.21	61.51 ± 2.22
Crude fibre	52.20 ± 4.23	43.63 ± 2.34	48.59 ± 0.66
Nitrogen free extract	77.54 ± 0.66	79.55 ± 1.65	75.67 ± 1.04

Table 37. Analysis of variance – Digestibility coefficients of dry matter

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	83.047	41.524	3.986 NS	0.0576
Error	9	93.761	10.418		

NS - Non significant

Table 38. Analysis of variance – Digestibility coefficients of organic matter

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	105.048	52.524	4.102NS	0.0084
Error	9	55.590	6.177		

NS – Non significant

Table 39. Analysis of variance – Digestibility coefficients of crude protein

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	9.443	4.721	0.677 NS	
Error	9	62.785	6.976		

NS – Non significant

Table 40. Analysis of variance – Digestibility coefficients of ether extract

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	35.159	17.580	0.708 NS	
Error	9	223.563	24.840		

NS – Non significant

Table 41. Analysis of variance – Digestibility coefficients of crude fibre

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	148.123	74.061	1.703 NS	0.2360
Error	9	391.488	43.499		

NS – Non significant

Table 42. Analysis of variance – Digestibility coefficients of nitrogen free extract

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	30.121	15.060	1.999 NS	0.1913
Error	9	67.819	7.535		

NS – Non significant

Table 43. Nitrogen balance (Group 1)

Replication	Nitrogen intake (g/day)	Nitrogen outgo in dung (g/day)	Nitrogen outgo in urine (g/day)	Total outgo (g/day)	Nitrogen balance (g/day)	Per cent retention of nitrogen
1	13.57	2.41	5.16	7.57	6.00	44.22
2	14.22	2.76	6.22	8.98	5.24	36.85
3	12.63	1.80	4.71	6.51	6.12	48.46
4	12.95	1.59	4.57	6.16	6.79	52.43
Mean ± S.E.	13.34 ± 0.30	2.14 ± 0.23	5.05 ± 0.31	7.31 ± 0.55	6.04 ± 0.28	45.49 ± 2.89

Table 44. Nitrogen balance (Group 2)

Replication	Nitrogen intake (g/day)	Nitrogen outgo in dung (g/day)	Nitrogen outgo in urine (g/day)	Total outgo (g/day)	Nitrogen balance (g/day)	Per cent retention of nitrogen
1	16.08	3.24	7.22	10.46	5.62	34.95
2	12.97	2.49	3.28	5.77	7.20	55.51
3	13.82	2.16	5.07	7.23	6.59	47.68
4	19.08	2.92	8.99	11.91	7.17	37.57
Mean ± S.E.	15.49 ± 1.18	2.70 ± 0.21	6.14 ± 1.08	8.84 ± 1.23	6.65 ± 0.32	43.92 ± 4.10

Table 45. Nitrogen balance (Group 3)

Replication	Nitrogen intake (g/day)	Nitrogen outgo in dung (g/day)	Nitrogen outgo in urine (g/day)	Total outgo (g/day)	Nitrogen balance (g/day)	Per cent retention of nitrogen
1	13.75	2.37	6.11	8.48	5.27	38.32
2	13.78	2.64	5.88	8.52	5.26	38.17
3	12.68	2.04	5.63	7.67	5.01	39.51
4	12.89	2.63	4.95	7.58	5.31	41.19
Mean ± S.E.	13.37 ± 0.24	2.42 ± 0.12	5.64 ± 0.22	8.06 ± 0.22	5.21 ± 0.06	39.29 ± 0.60

Table 46. Analysis of variance – Per cent retention of nitrogen

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	82.967	41.484	0.914 NS	0.3470
Error	9	408.349	45.372		

NS – Non significant

Table 47. Digestible crude protein (DCP) and total digestible nutrient (TDN) intake per 100 g dry matter intake

Treatment	Intake in grams per 100 g dry matter intake	
	DCP	TDN
Group 1	13.66	74.88
Group 2	13.83	74.20
Group 3	13.49	72.60

Table 48. Dressing percentage of animals slaughtered from the three groups

Replication	Group 1			Group 2			Group 3		
	Live weight (kg)	Carcass weight (kg)	Dressing percentage	Live weight (kg)	Carcass weight (kg)	Dressing percentage	Live weight (kg)	Carcass weight (kg)	Dressing percentage
1	21	11.05	52.62	21	10.8	51.40	22	12.35	56.14
2	21	10.30	49.05	25	12.2	48.80	18	8.70	48.33
3	20	9.30	46.50	23	11.2	48.69	20	10.00	50.00
Mean ± S.E.	20.66 ± 0.27	10.20 ± 0.41	49.39 ± 1.45	23.00 ± 0.94	11.40 ± 0.34	49.63± 0.72	20.00 ± 0.94	10.35 ± 0.87	51.49 ± 1.93

Table 49. Analysis of variance – Dressing percentage

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	7.927	3.964	0.414 NS	
Error	6	57.434	9.572		

NS – Non significant

Table 50. Economics – Expenditure of rearing kids on three diet treatments

	Ration 1		Ration 2		Ration 3	
	Male	Female	Male	Female	Male	Female
1. Initial cost of animals @ Rs.450/animal x 5	Rs.2250	Rs.2250	Rs.2250	Rs.2250	Rs.2250	Rs.2250
2. Cost of feed @ Rs.6.81/kg for ration 1, Rs. 7.08/kg for ration 2, Rs.6.86/kg for ration 3	Rs.2338.40	Rs.2407.49	Rs.2141.09	Rs.2085.20	Rs.1888.85	Rs.2048.40
3. Miscellaneous (feeder, waterer, medicines, electricity etc.) @ Rs.50/animal x 5	Rs.250	Rs.250	Rs.250	Rs.250	Rs.250	Rs.250
4. Slaughter charges @ Rs.50/animal x 5	Rs.250	Rs.250	Rs.250	Rs.250	Rs.250	Rs.250
Total (Rs.)	5088.40	5157.49	4891.09	4835.20	4638.85	4798.40
Total expenditure for each group	Rs.10245.89		Rs.9726.29		Rs.9437.25	

Table 51. Cost of production per kg gain (Rs.) of the animals maintained on rations 1, 2 and 3

	Treatments					
	Ration 1		Ration 2		Ration 3	
	Males	Females	Males	Females	Males	Females
Total weight gain (kg)	65.30	71	70.40	69.20	59.00	51.60
Total feed intake on fresh basis (kg)	343.55	353.70	302.24	294.35	275.38	298.64
Total feed cost (Rs.)	2338.40	2407.49	2141.09	2085.20	1888.85	2048.40
Cost per kg gain (Rs.)	35.81	33.48	30.56	30.13	32.01	39.70
Total cost per kg gain (Rs.)	34.59		30.27		35.59	

Cost of rations

Ration 1 - Rs.680.66 per 100 kg
Ration 2 - Rs.708.41 per 100 kg
Ration 3 - Rs.685.91 per 100 kg

Table 52. Revenue from each diet treatment calculated on the basis of three animals slaughtered from each group at the rates prevailing in the open market

	Ration 1	Ration 2	Ration 3
1. Average weight of animals	22.71 kg	22.88 kg	20.1 kg
2. Dressing percentage	49.39%	49.63%	51.49%
3. Sale proceeds of meat @ Rs.100/kg	Rs.1121.65	Rs.1135.53	Rs.1034.95
4. Sale proceeds of skin @ Rs.120/skin	Rs.120	Rs.120	Rs.120
5. Sale proceeds of head @ Rs.35/head	Rs.35	Rs.35	Rs.35
6. Sale proceeds of offals @ Rs.15/offal	Rs.15	Rs.15	Rs.15
7. Sale proceeds of legs @ Rs.25/set of four legs	Rs.25	Rs.25	Rs.25
Total	Rs.1316.65	Rs.1330.53	Rs.1229.95
Gross profit per animal for 13 weeks	Rs.292.06	Rs.357.90	Rs.286.20
Calculated gross profit for 10 animals in 13 weeks	Rs.2920.61	Rs.3579.00	Rs.2862.00

Fig.1 AVERAGE WEEKLY BODYWEIGHT(Kg) OF KIDS IN THE THREE GROUPS

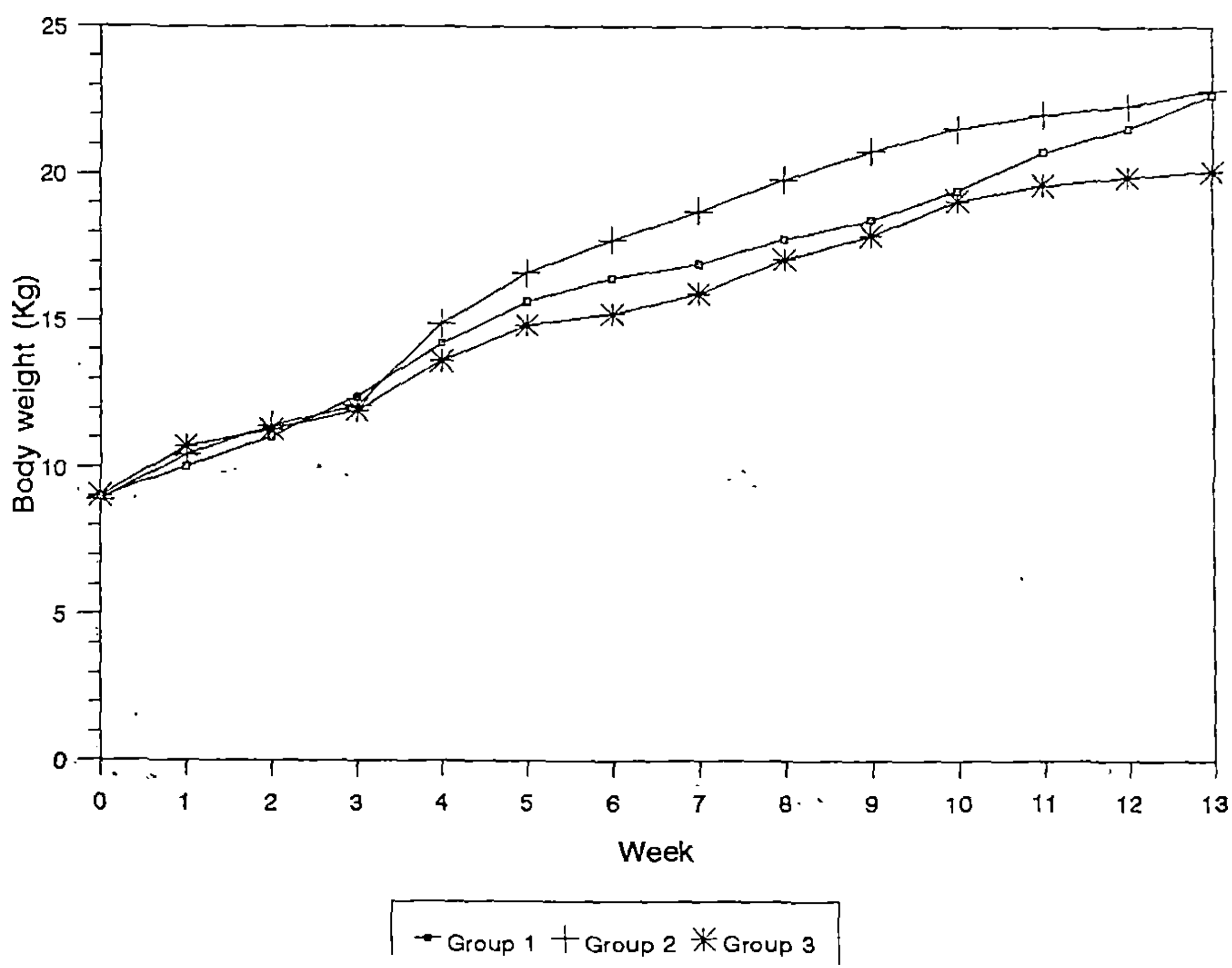


Fig.2 AVERAGE WEEKLY BODYWEIGHT(Kg) OF MALE/FEMALE KIDS IN THE THREE GROUPS

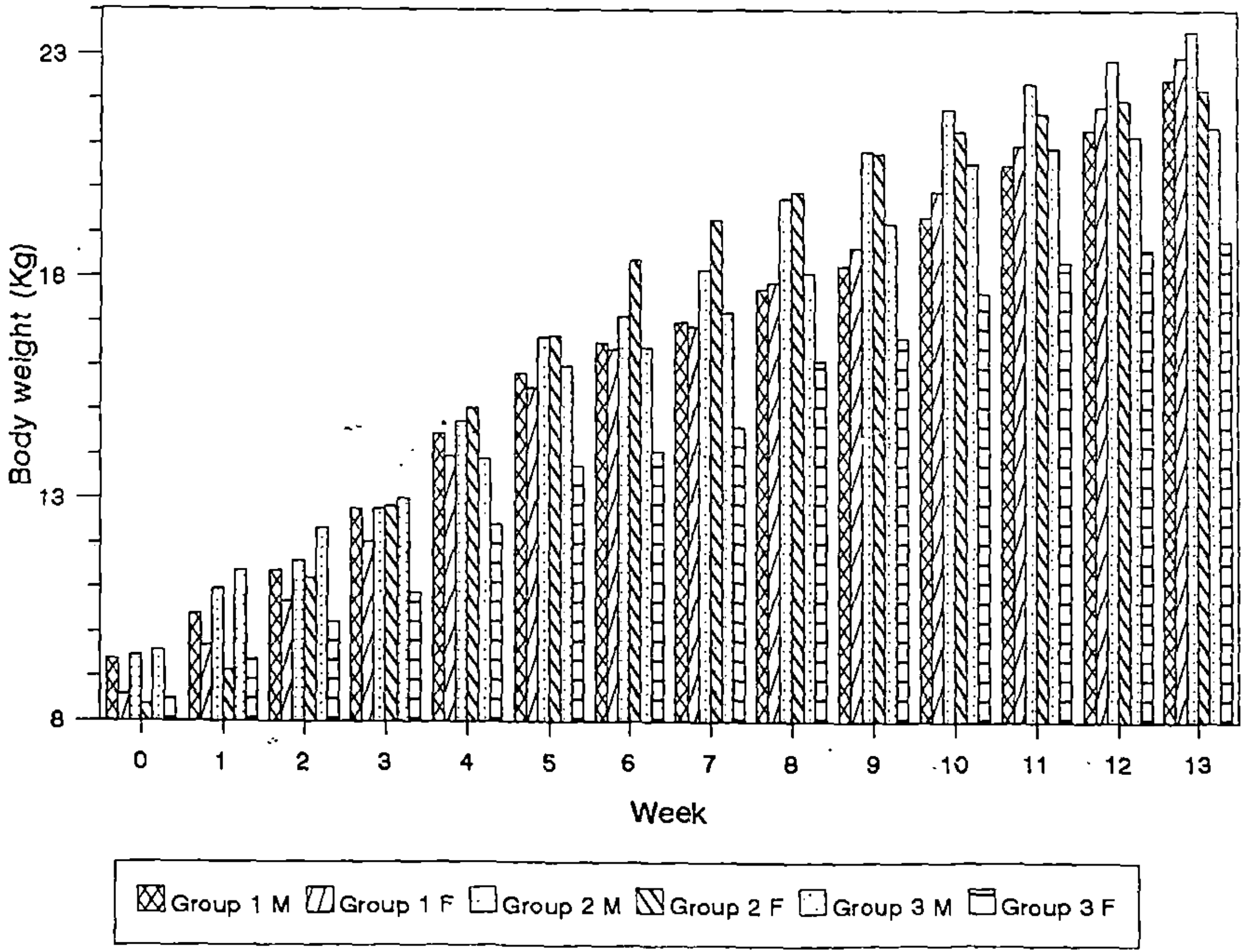


Fig.3 AVERAGE BODY MEASUREMENTS(cm)OF KIDS IN THE THREE GROUPS

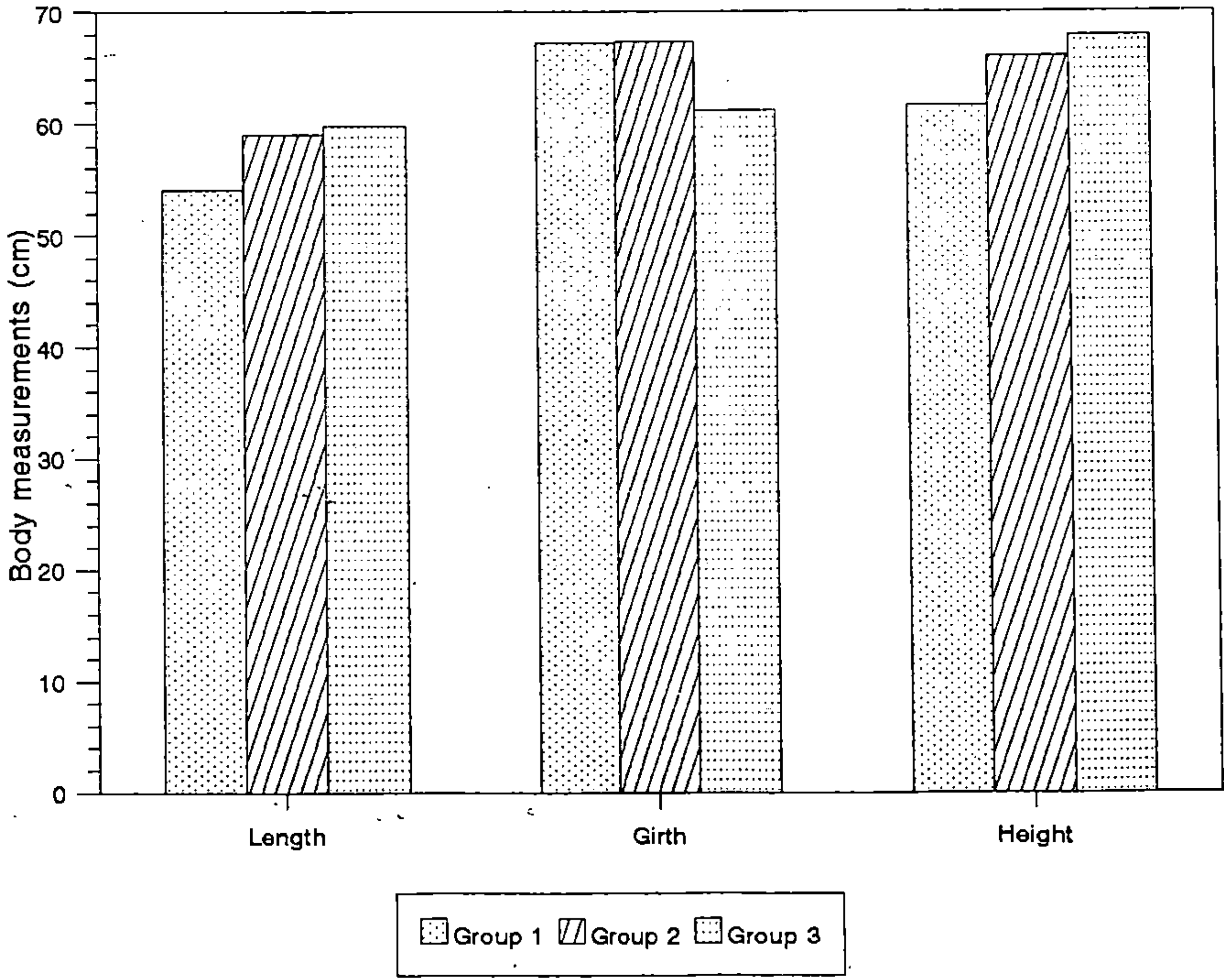


Fig.4 AVERAGE DAILY DRY MATTER INTAKE (kg)OF KIDS IN THE THREE GROUPS

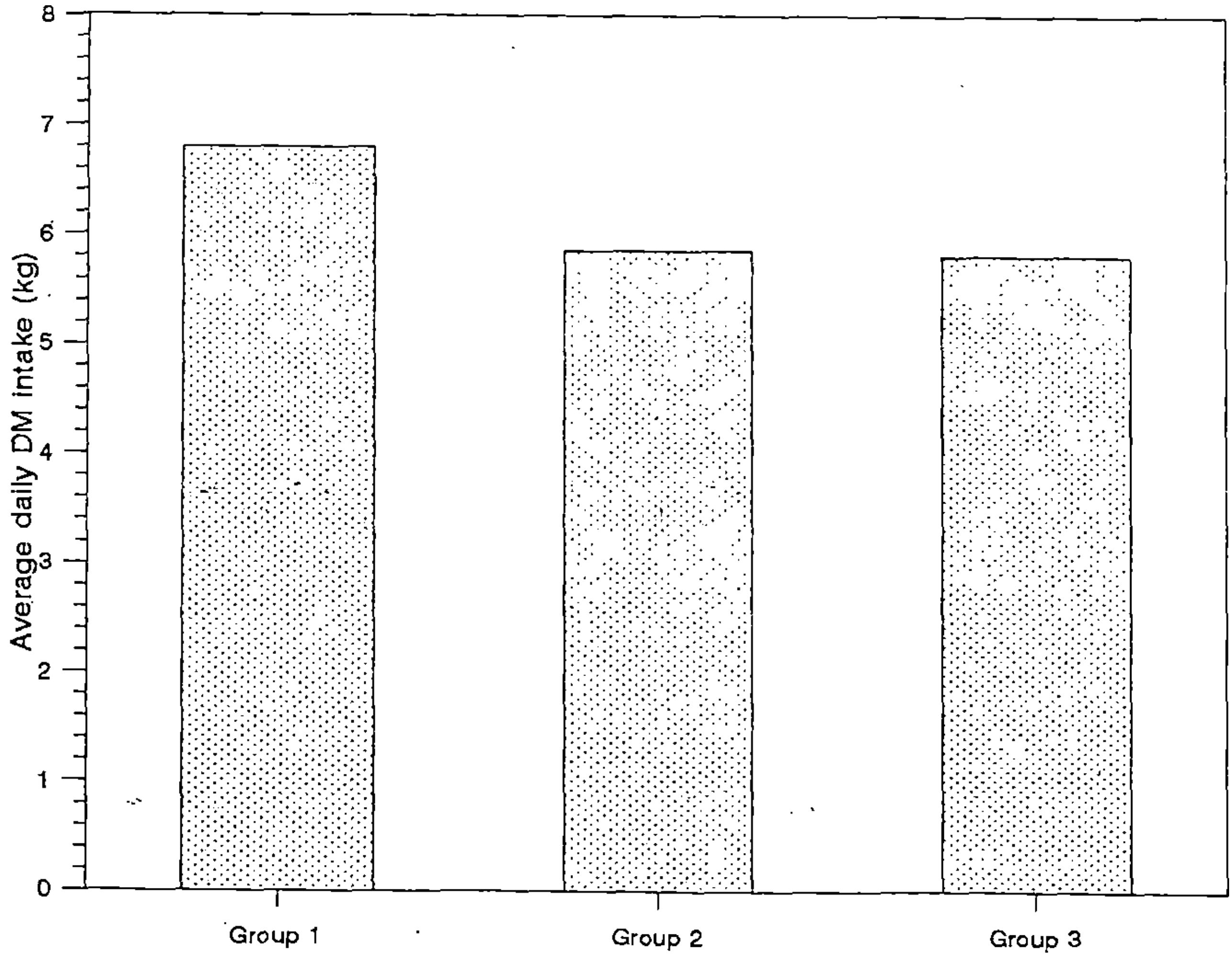


Fig.5 AVERAGE DAILY DRY MATTER INTAKE (kg)OF MALE/FEMALE KIDS IN THE THREE GROUPS

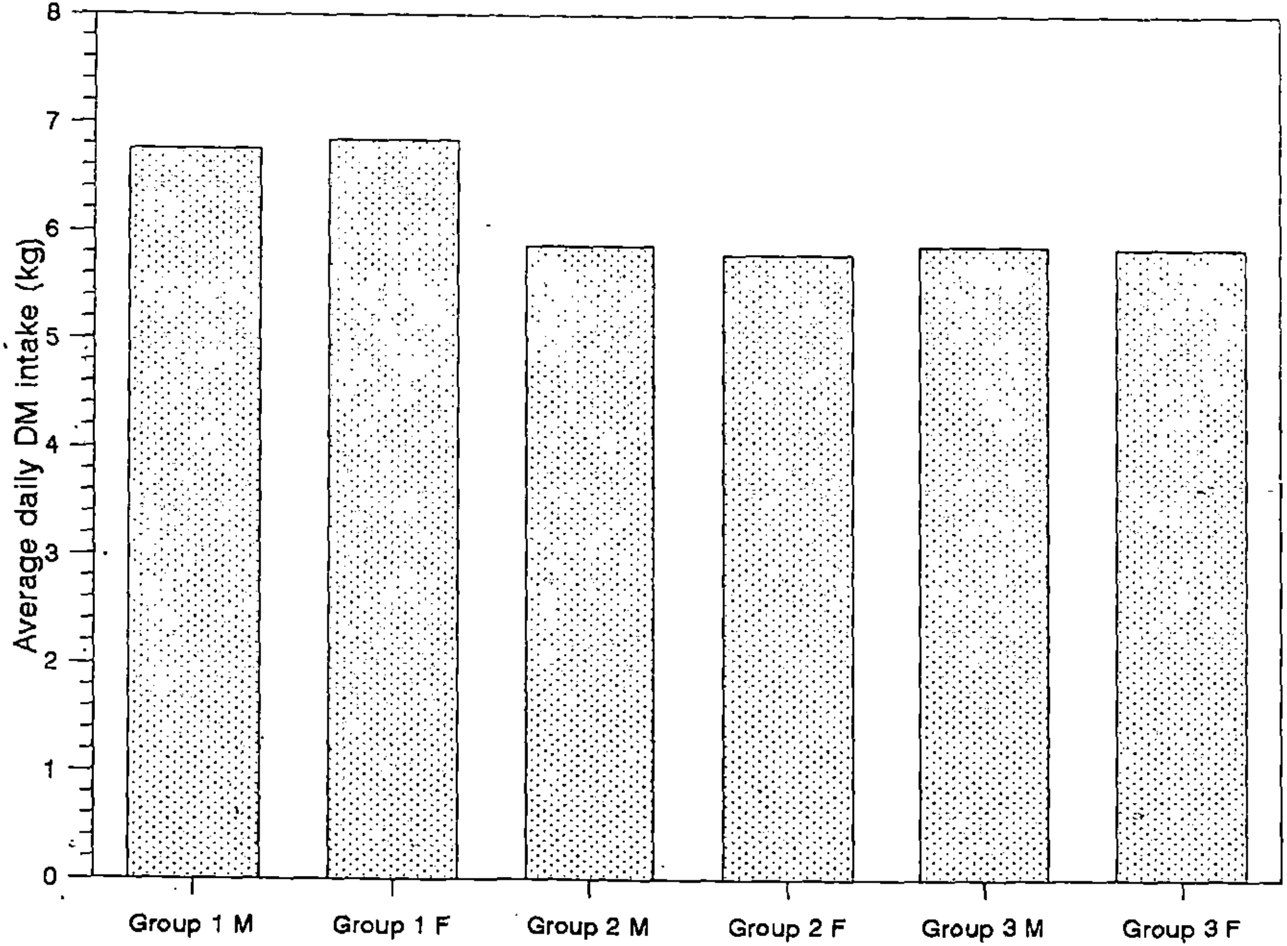


Fig.6 AVERAGE DAILY BODY WEIGHT GAIN(g) OF KIDS IN THE THREE GROUPS

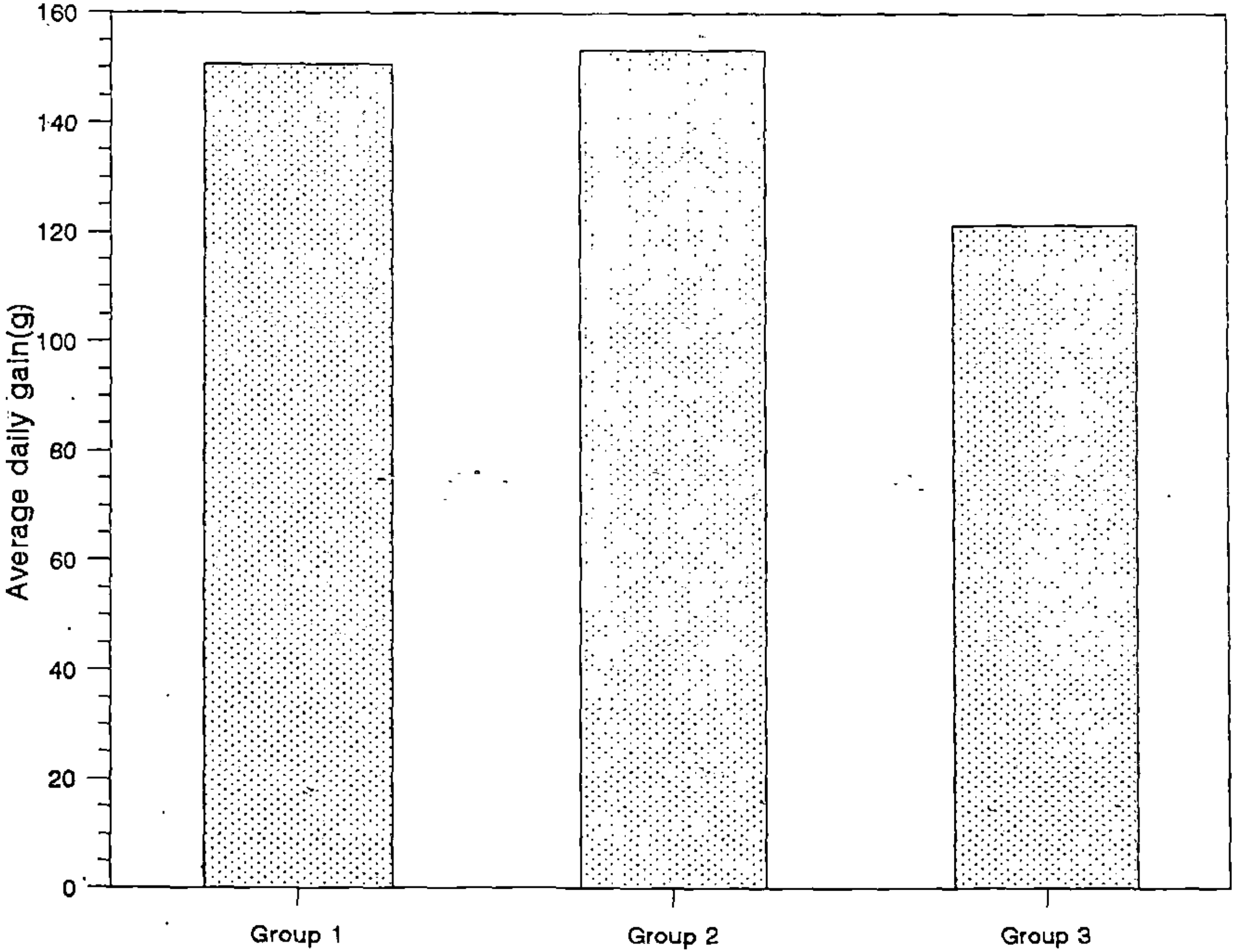


Fig.7 AVERAGE DAILY BODY WEIGHT GAIN(g) OF MALE/FEMALE KIDS IN THE THREE GROUPS

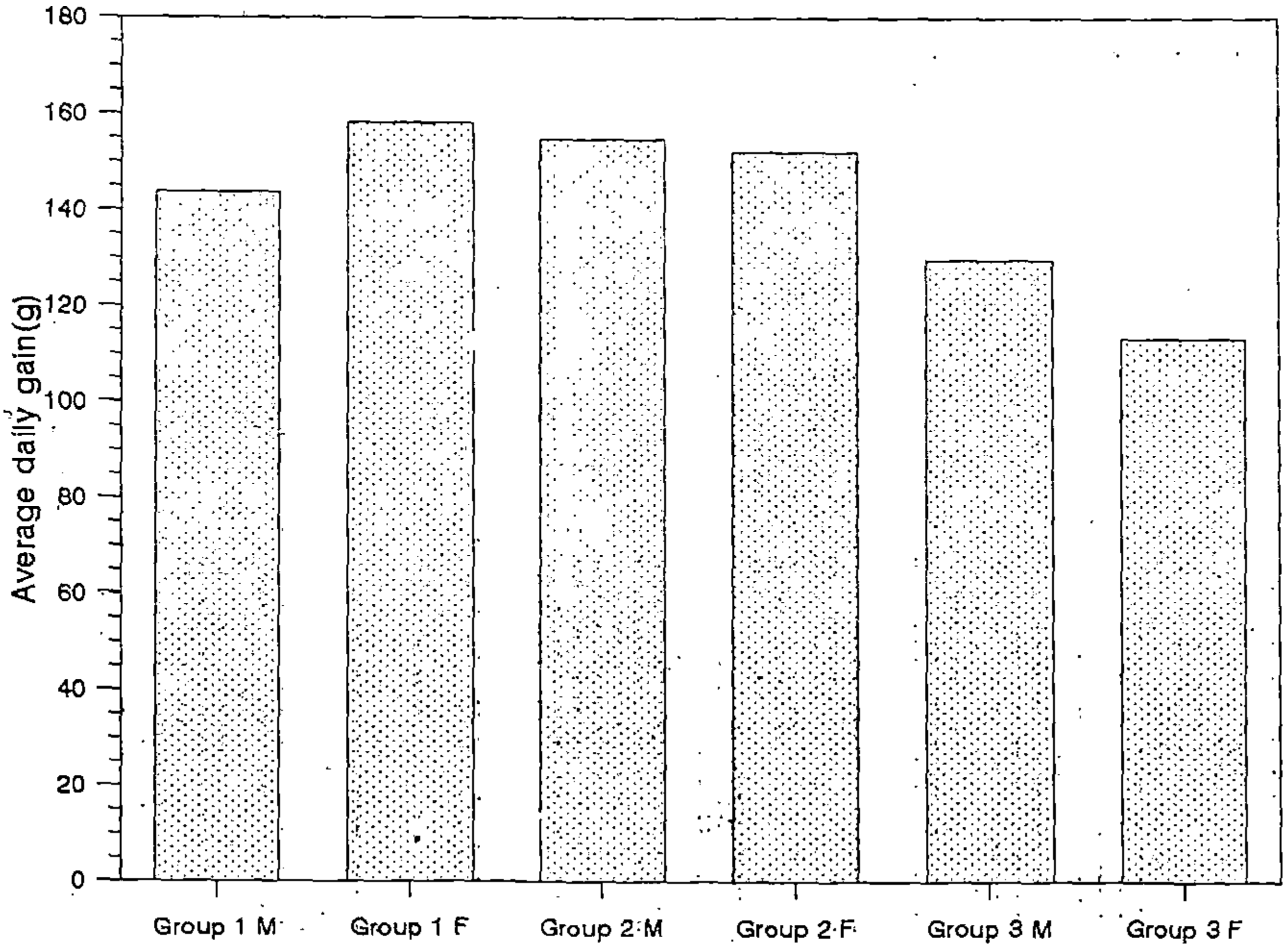


Fig.8 CUMULATIVE FEED CONVERSION EFFICIENCY OF KIDS IN THE THREE GROUPS

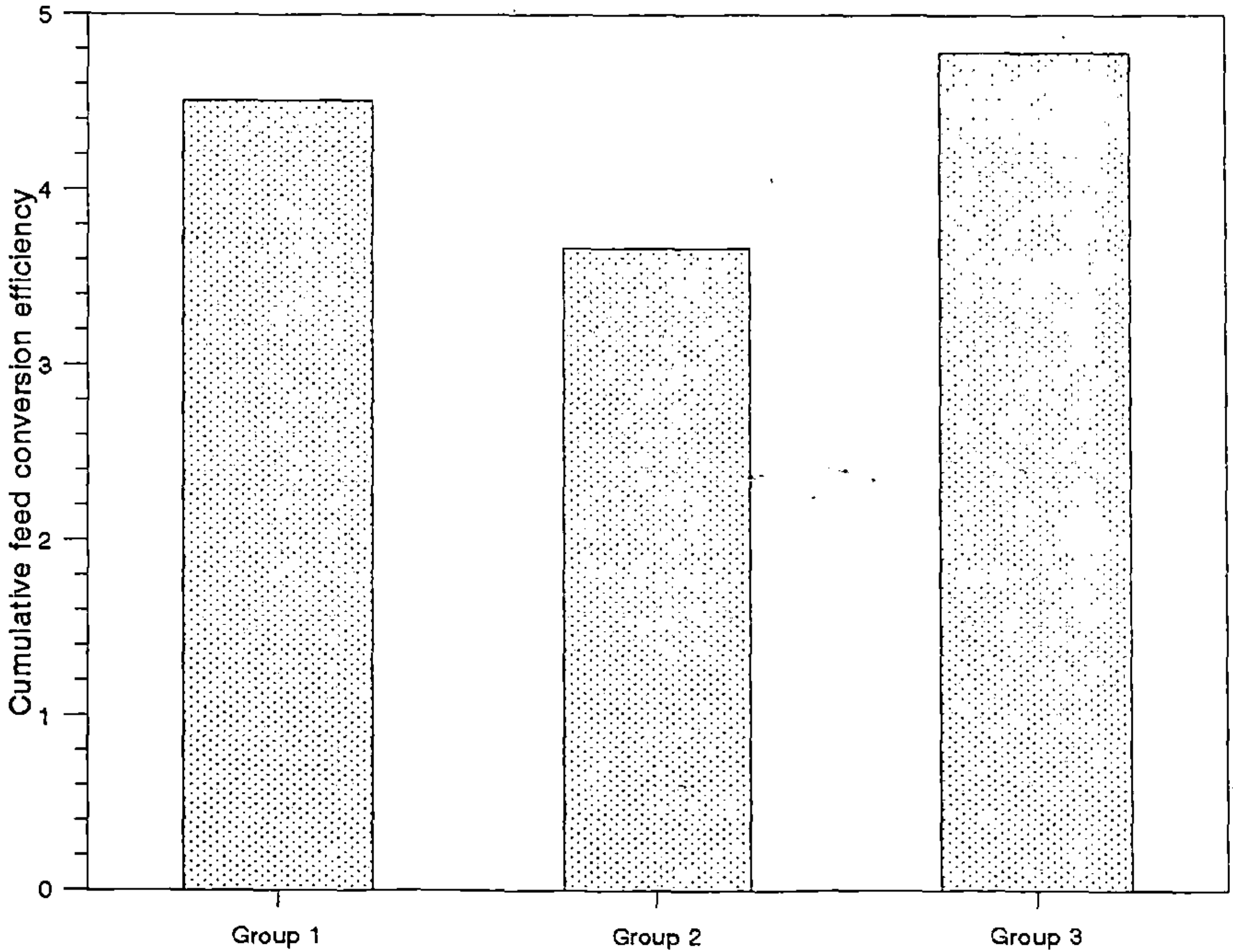


Fig.9 CUMULATIVE FEED CONVERSION EFFICIENCY OF MALE/FEMALE KIDS IN THE THREE GROUPS

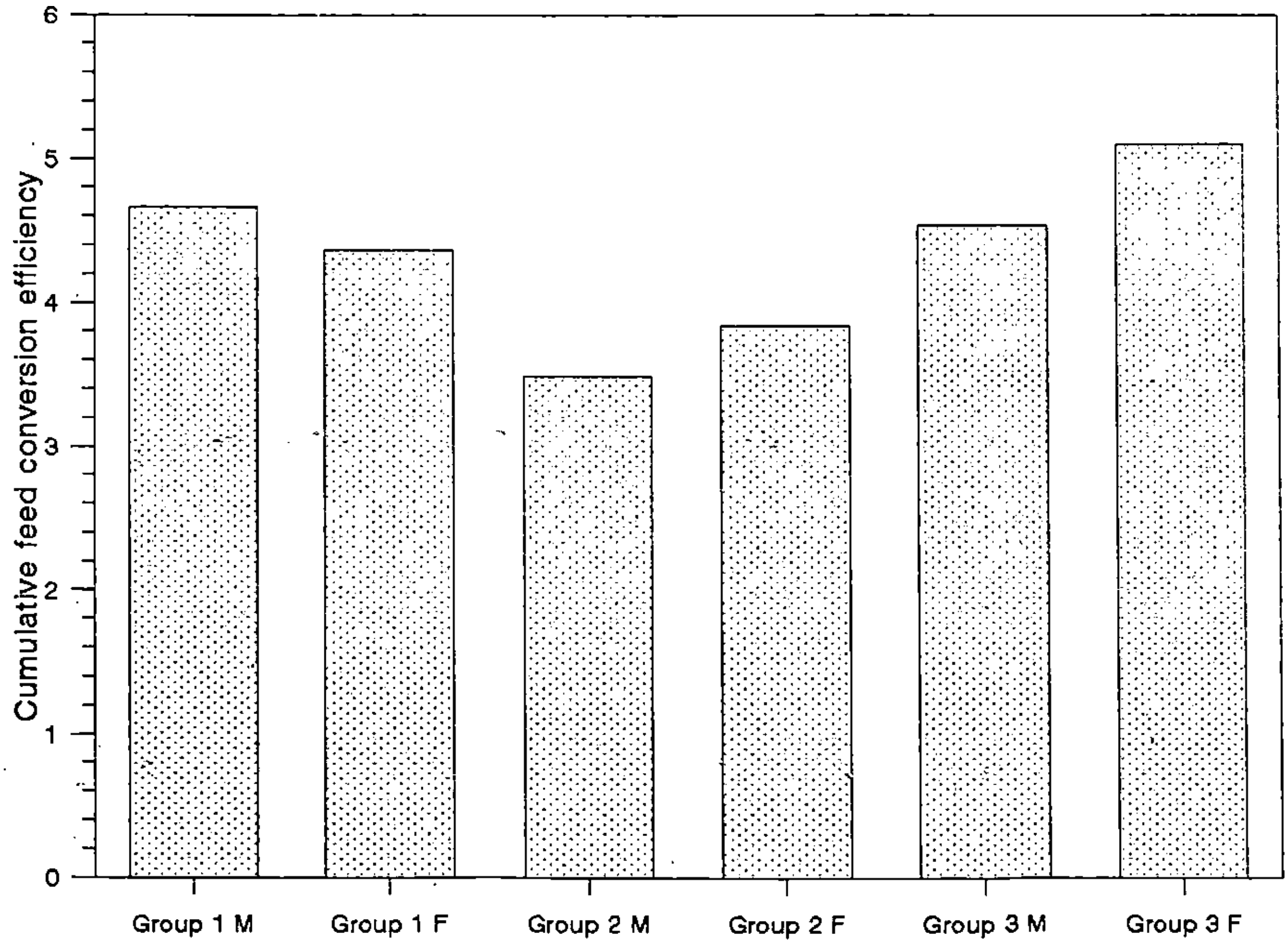


Fig.10 AVERAGE DIGESTIBILITY COEFFICIENTS OF DRY MATTER IN THE THREE GROUPS

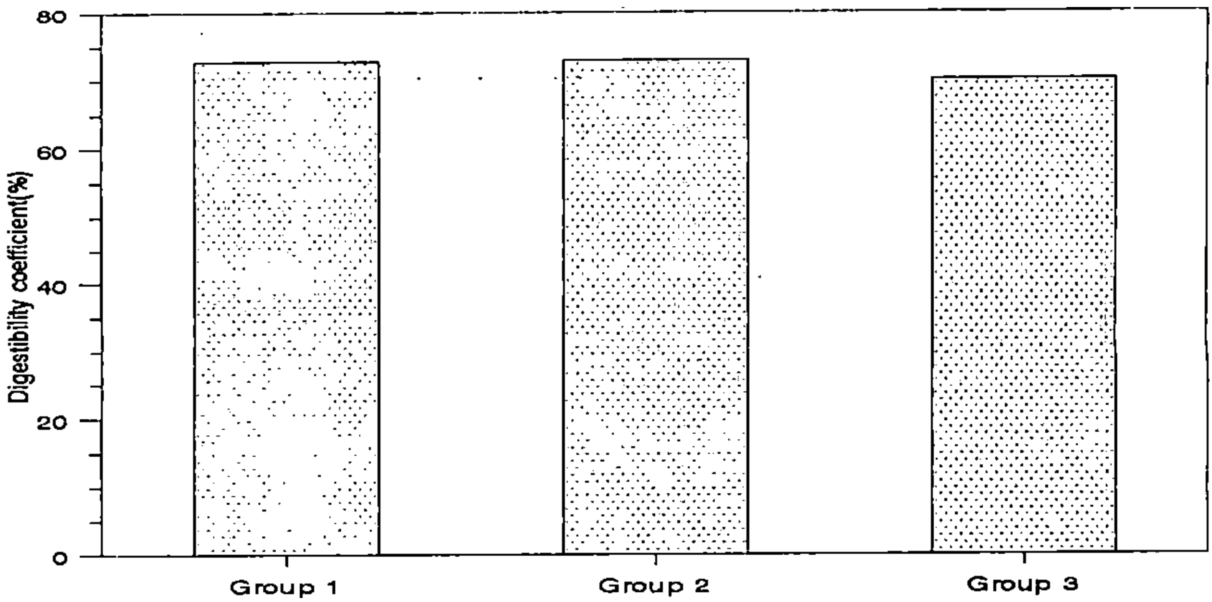


Fig.11 AVERAGE DIGESTIBILITY COEFFICIENTS OF ORGANIC MATTER IN THE THREE GROUPS

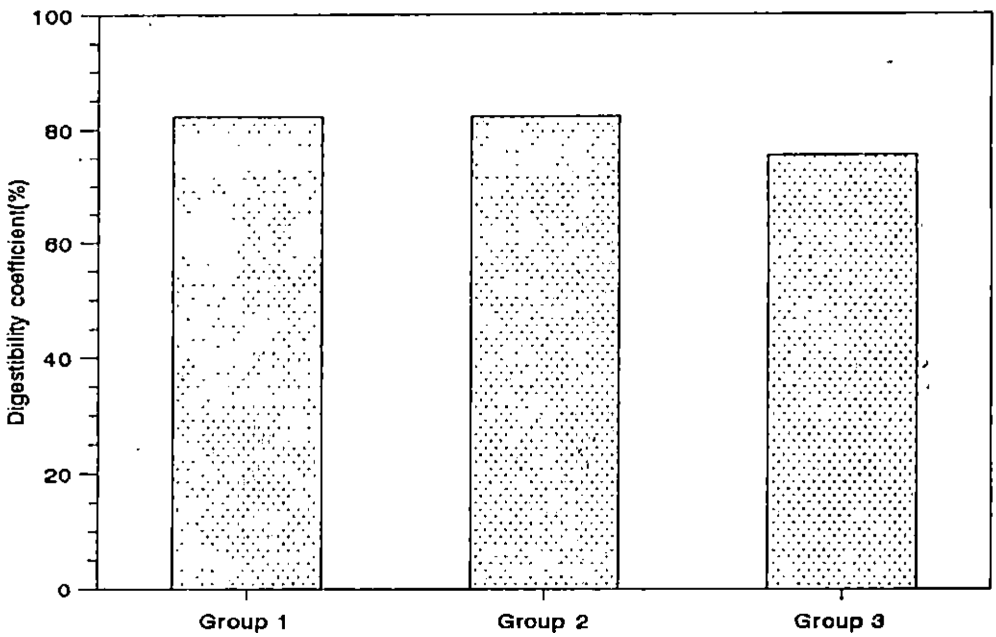


Fig. 12 AVERAGE DIGESTIBILITY COEFFICIENTS OF CRUDE PROTEIN IN THE THREE GROUPS

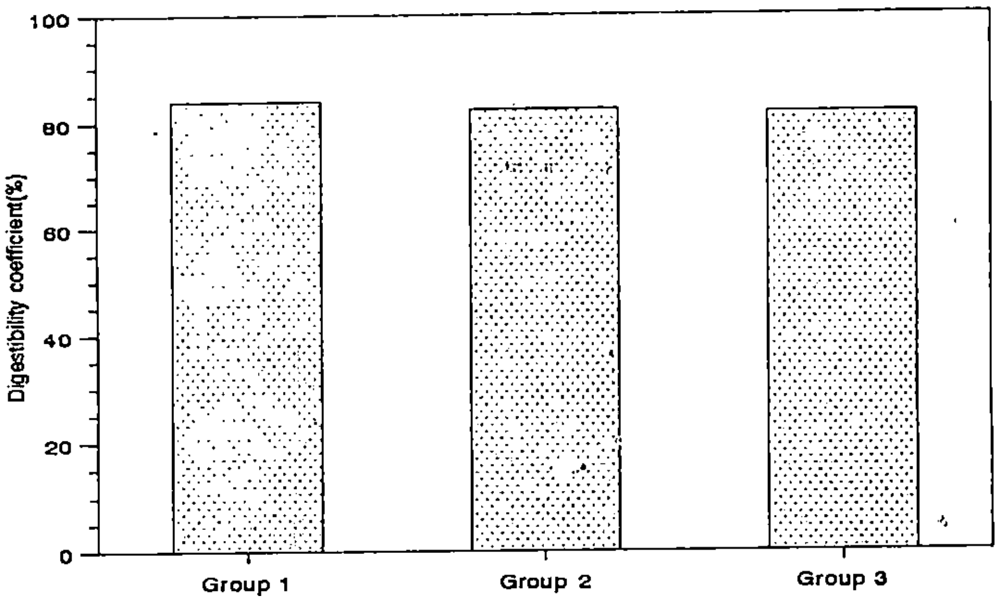


Fig. 13 AVERAGE DIGESTIBILITY COEFFICIENTS OF ETHER EXTRACT IN THE THREE GROUPS

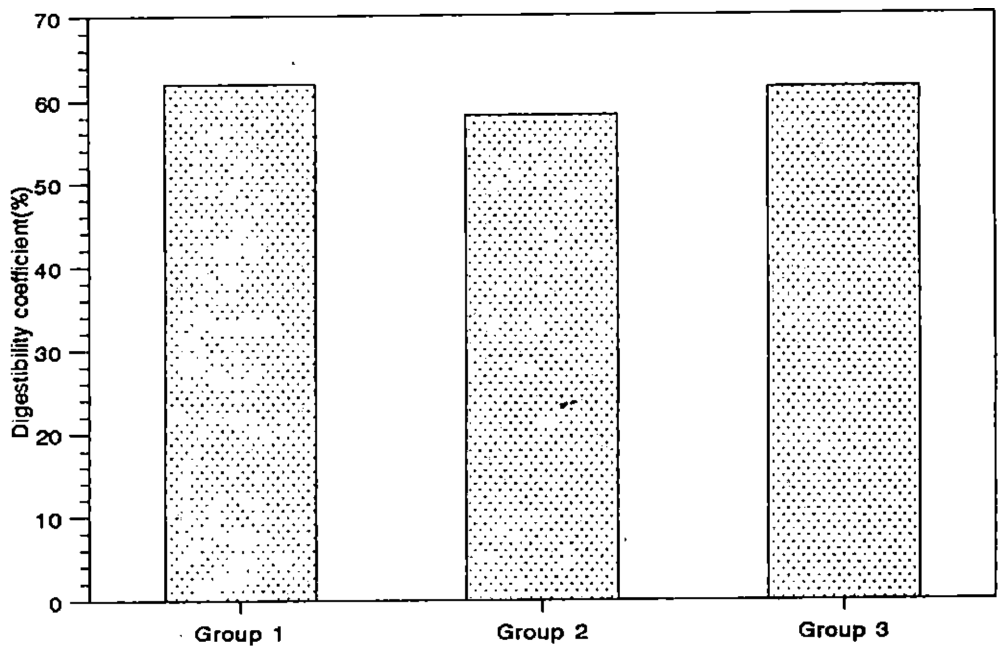


Fig.14 AVERAGE DIGESTIBILITY COEFFICIENTS OF CRUDE FIBRE IN THE THREE GROUPS

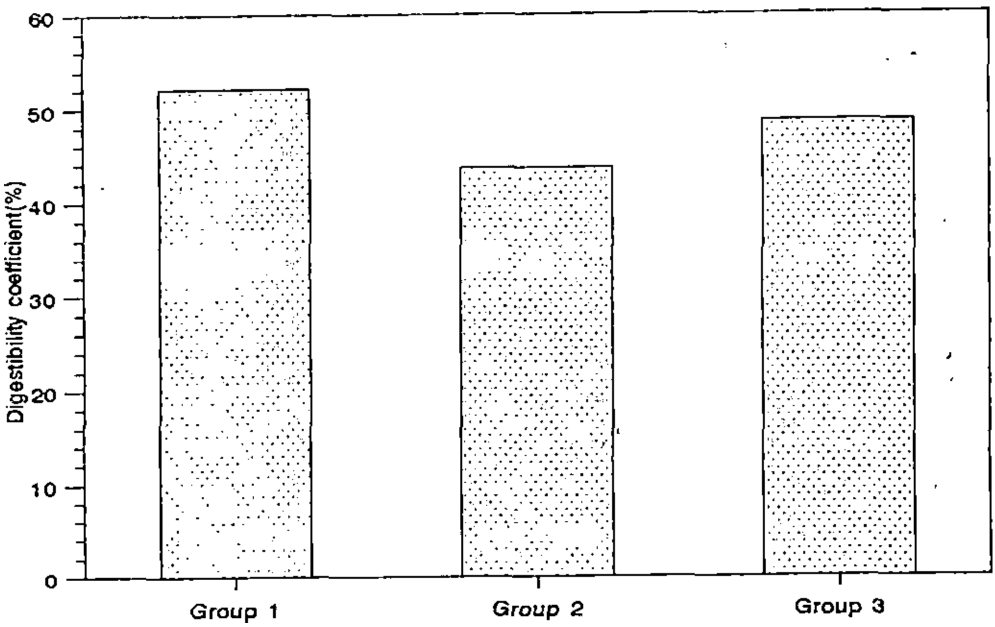


Fig.15 AVERAGE DIGESTIBILITY COEFFICIENTS OF NITROGEN FREE EXTRACT IN THE THREE GROUPS

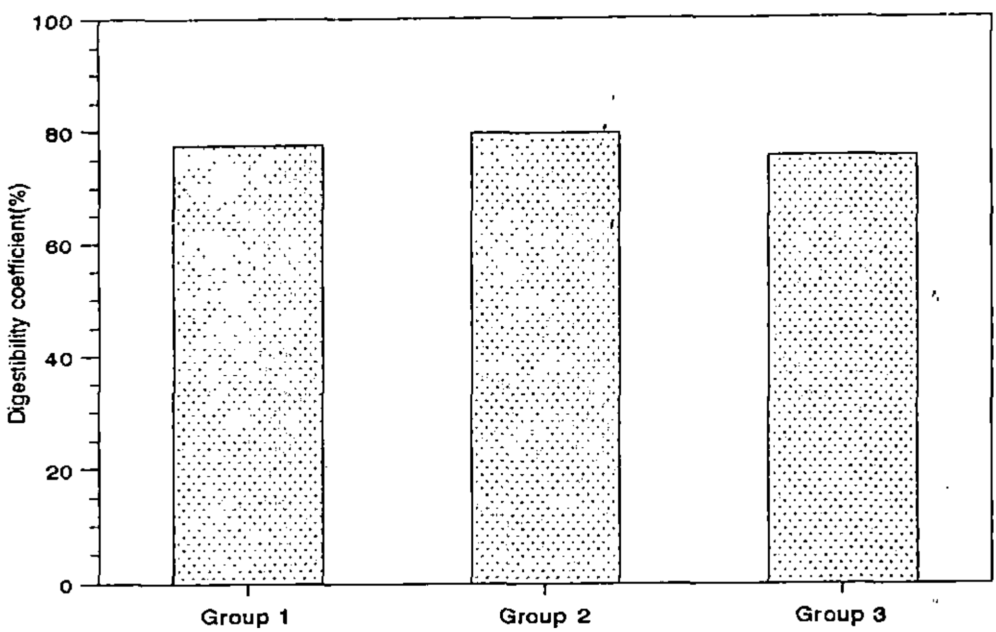


Fig.16 AVERAGE DRESSING PERCENTAGE OF KIDS SLAUGHTERED FROM THE THREE GROUPS

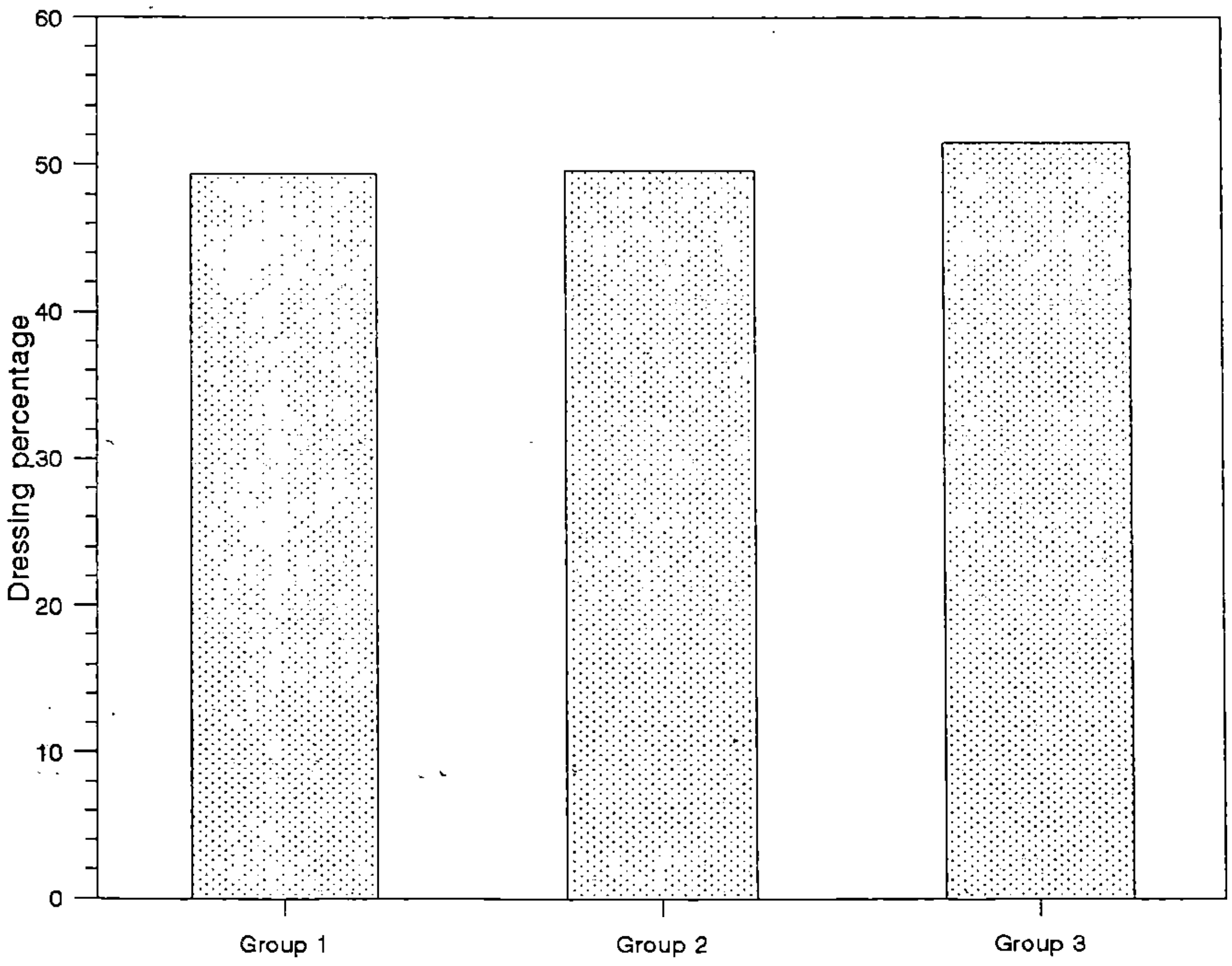


Fig.17 COST OF PRODUCTION PER KILOGRAM GAIN (Rs) OF KIDS IN THE THREE GROUPS

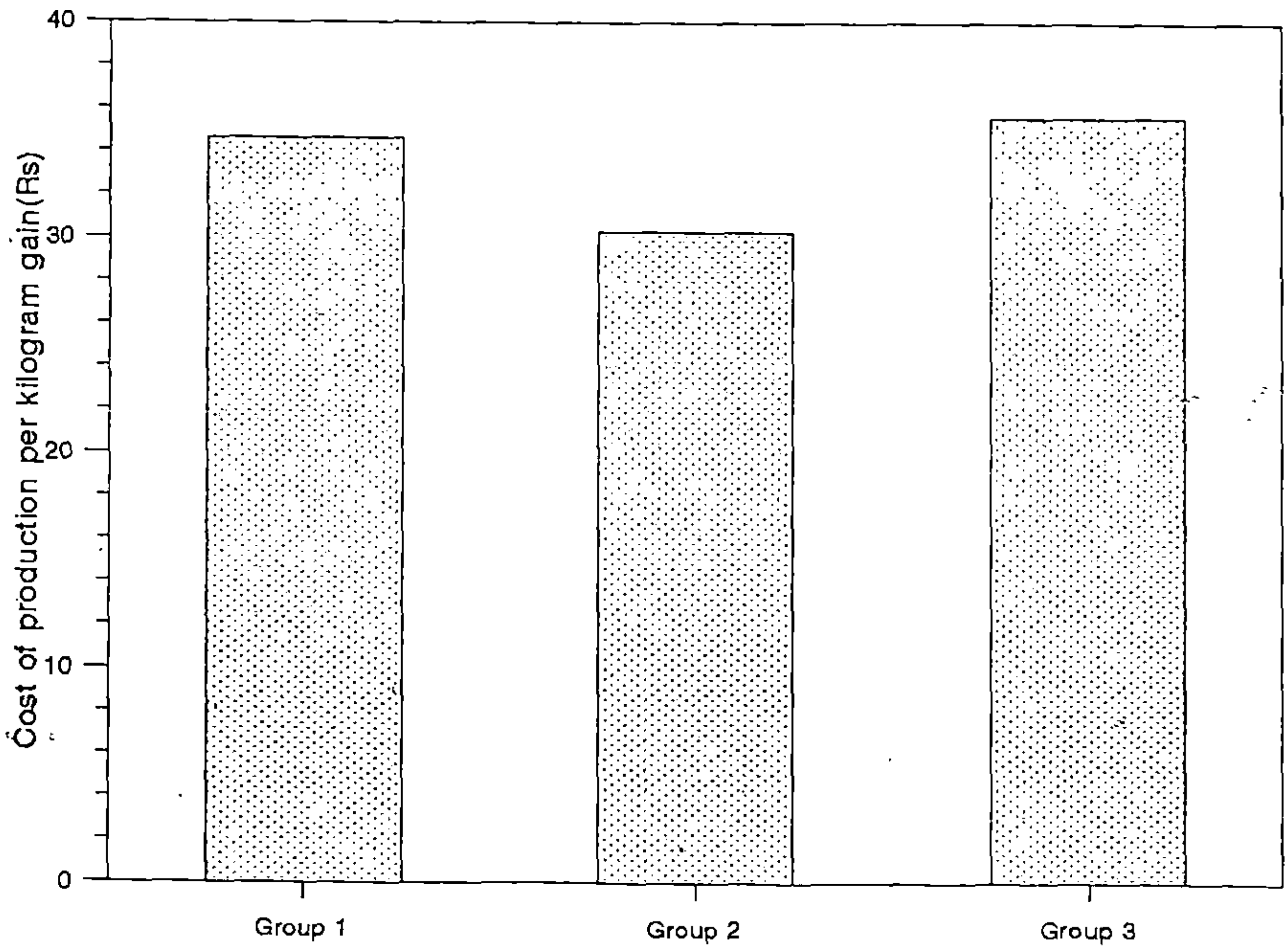


Fig.18 GROSS PROFIT (Rs) FOR TEN ANIMALS IN EACH GROUP FOR 3 MONTH

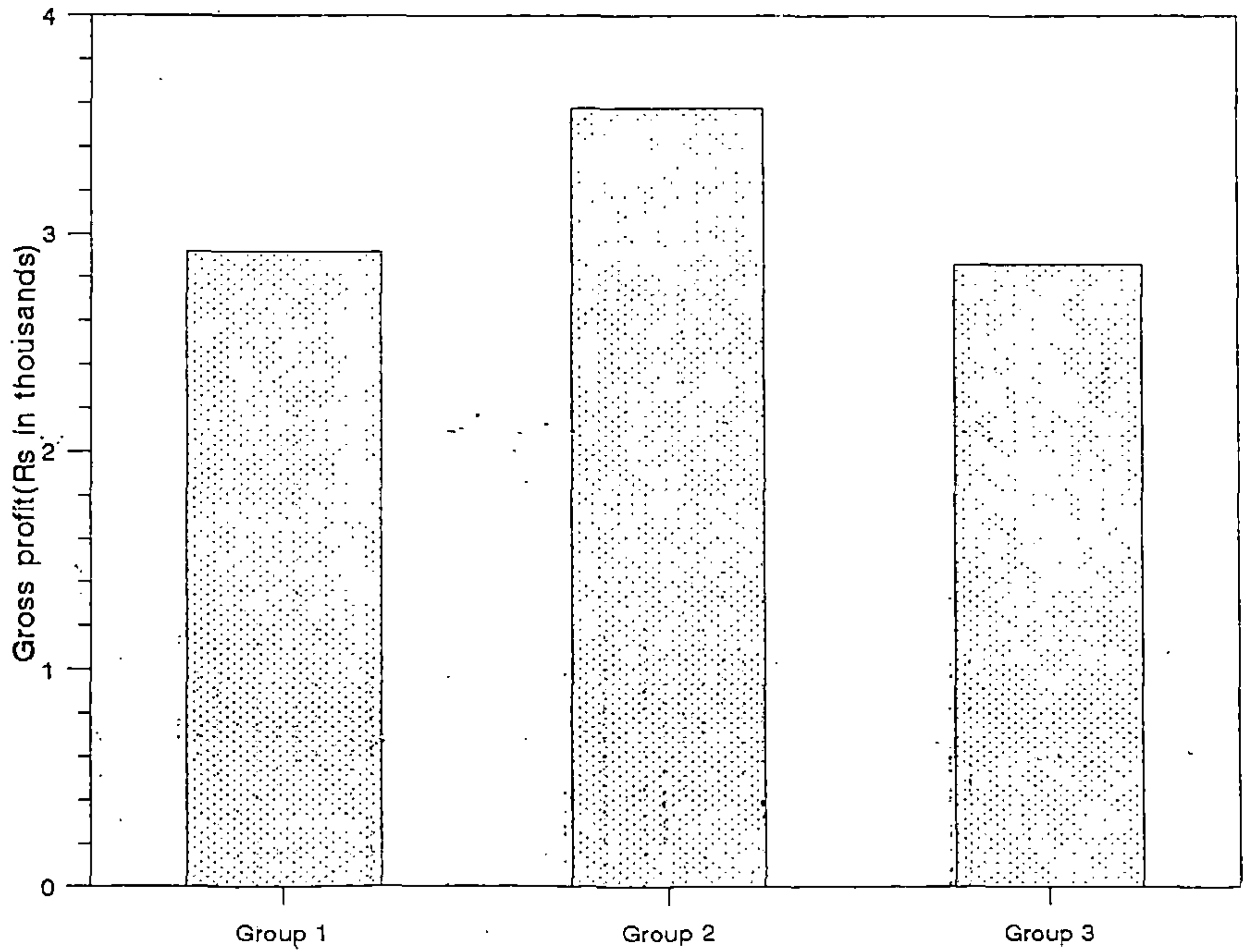


Plate 1. Section of rumen from group 1 showing rumen papillae that are long and thickened with sparsely distributed keratin deposition indicating distinct parakeratosis. H&E x 100

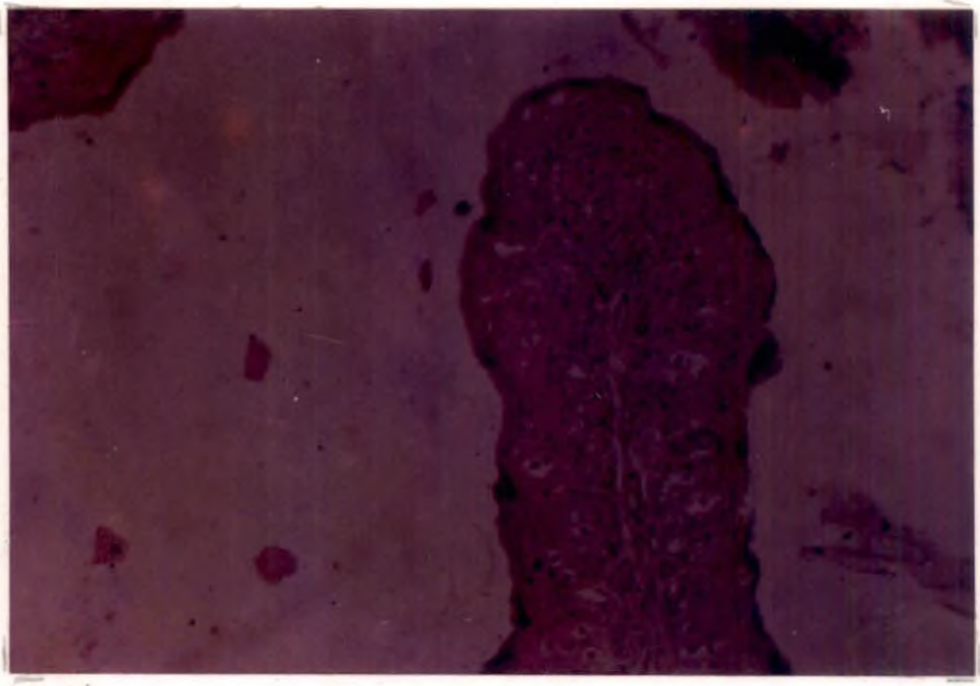


Plate 2. Section of rumen from group 2 showing rumen papillae that are long and thickened with sparsely distributed keratin deposition indicating distinct parakeratosis. H&E x 100

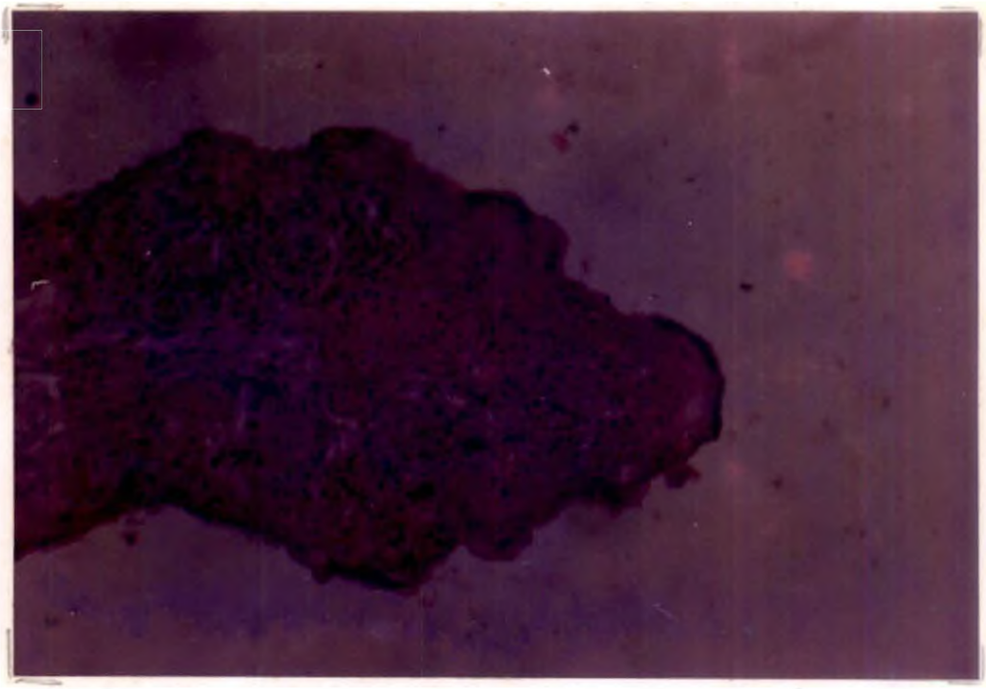
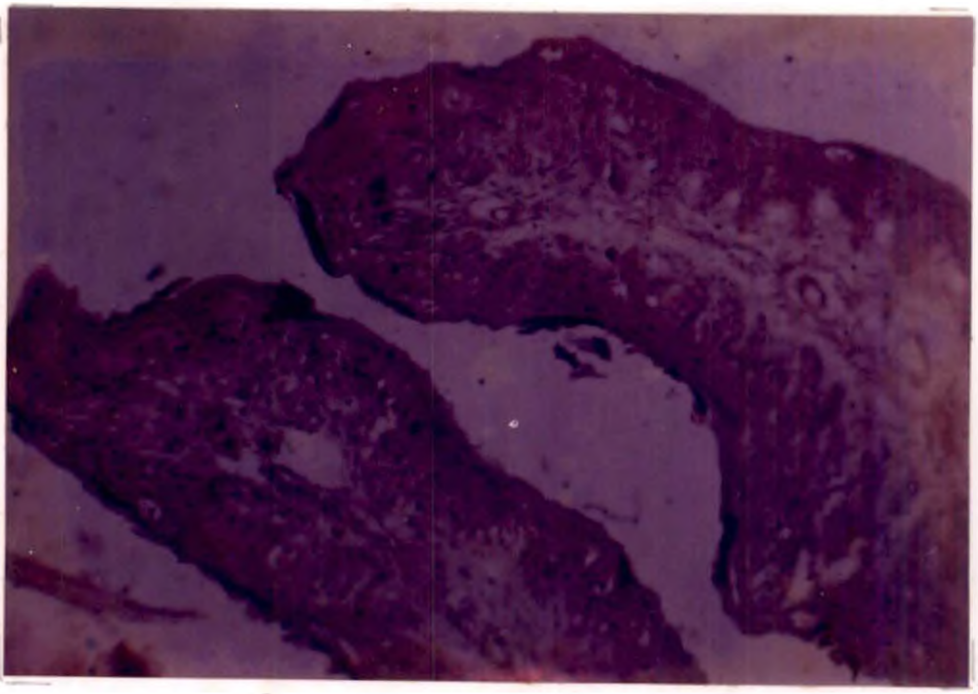


Plate 3. Section of rumen from group 3 showing rumen papillae that are long and thickened with sparsely distributed keratin deposition indicating distinct parakeratosis. H&E x 100



Discussion

DISCUSSION

5.1 Growth

5.1.1 Body weight

The average final body weight recorded in animals of the three groups namely 1, 2 and 3 were 22.71 ± 0.41, 22.88 ± 0.88 and 20.1 ± 0.73 kg respectively (Table 6).

The cumulative weight gain (kg) of kids in groups 1, 2 and 3 were 13.72 ± 0.36, 13.96 ± 0.32 and 11.06 ± 0.49 respectively (Table 6).

Statistical analysis of the data (Table 7) on body weights using analysis of covariance technique and critical difference test indicated no significant growth difference between animals of group 1 and group 2 but the cumulative weight gain of group 3 fed on fish meal containing complete ration was significantly lesser ($P<0.05$) when compared to groups 1 and 2. Animals in group 3 had occasional diarrhoea which explains the reason for lower gains.

From the results presented on weekly body weights of individual animals in each group (Tables 3, 4 and 5) and the average weekly body weights of the group (Table 6), it can be deducted that animals in group 2 fed on diet containing meat cum bone meal had better growth as indicated by higher final body weights and better average daily gains, compared to animals in the other two groups (Group 1 and Group 3) fed on control diet and fish meal containing diet respectively.

Average daily gain (g) of animals in group 1, 2 and 3 were 150.76 ± 13.46, 153.40 ± 19.40 and 121.53 ± 17.28 respectively (Table 12).

Statistical analysis of the data using ANOVA technique indicated no significant difference in daily gain between the groups (Table 13).

The data on average daily gain as presented in Table 12 indicate a better gain in animals of group 2 fed on complete diet containing meat cum bone meal.

The final body weight attained by kids in the present study were considerably higher than the values reported by Ralston (1997) and Deepa (1998) in Malabari kids of similar age fed on complete rations. Inclusion of animal protein did not show any significant influence on the growth of kids. This is contrary to the findings of Vipond *et al.* (1989), Hag and Shargi (1996) and Smith *et al.* (1985) but is in agreement to that reported by Thonney *et al.* (1987). One of the reasons for better weight gains in the present study compared to the values reported in Malabari kids may be due to the influence of monensin. This is in accordance to that reported by Joyner *et al.* (1979) and Patel and Honmonde (1994).

Better growth obtained in all the three groups of animals in the present study could also be attributed to separation of male and female animals of each group, frequent human contact with the animals such as brushing of the coat and frequent feeding, which might have stimulated the animals to eat more and grow better. The diets also contained one per cent sodium bicarbonate and this might have helped the animals to perform better as reported by Kellaway *et al.* (1977).

Slightly better growth response though non significant observed in animals in group 2 compared to those in group 1 and 3 could be attributed to the combination of animal protein and monensin used in the rations in accordance to that reported by Gibb and Baker (1992). Eventhough animal protein plus monensin was used in group 3, comparatively lesser growth was observed, probably due to the occasional diarrhoea which was present in group 3 animals.

5.1.2 Body measurements

5.1.2.1 Body length

The body length at the end of the experimental period of 13 weeks were 54.1. ± 2.30, 59.1 ± 1.40 and 59.8 ± 1.11 cm for animals in groups 1, 2 and 3 respectively (Table 27).

The average difference between the initial and final body length observed in the three groups were 13.3 ± 0.71, 20.1 ± 0.73 and and 21.9 ± 0.49 cm respectively for groups 1,2 and 3 (Table 27).

The analysis of covariance on increase in length (cm) (Table 30) taking initial body length (cm) as covariate indicate that there was significant difference ($P<0.01$) between animals of group 1 and the other two groups. Although the increase in body length was lesser in group 1, the higher chest girth values obtained in group 1 explains the higher body weight in group 1 compared to group 3 animals.

The results of the present investigation are in agreement with those reported by Gangadevi (1981), Ralston (1997) and Biju (1998), though slightly higher values are obtained for animals in group 2 and group 3. Monensin does not seem to have any influence on body measurements and this observation is in agreement with Biju (1998). Animal protein inclusion was found to influence on the cumulative increase in body length of kids.

5.1.2.2 Chest girth

The final chest girth at the end of the experimental period of 13 weeks were 67.2 ± 0.90 cm, 67.3 ± 0.95 cm and 61.2 ± 1.50 cm respectively for group 1, 2 and 3 respectively (Table 28).

The cumulative increase in chest girth (cm) observed in the 3 groups were 20.6 ± 0.76, 21 ± 0.84 and 13.6 ± 0.45 (Table 28).

The analysis of covariance on cumulative increase in chest girth (cm) taking initial chest girth as covariate indicated that there was significant difference ($P<0.05$) between animals of group 3 and the other two groups (Table 31).

The results of the present study were slightly higher than the values reported by Gangadevi (1981) and Biju (1998) evidently due to the higher weights of animals in the present study. Animal protein inclusion was found to have no influence on the cumulative increase in chest girth of kids.

5.1.2.3 Height at withers

The final height at withers (cm) at the end of experimental period of 13 weeks were 67.9 ± 1.12, 66.0 ± 1.24 and 61.60 ± 1.64 respectively for animals in group 1, 2 and 3 (Table 29).

The cumulative increase in height at withers (cm) observed in the 3 groups were 20.5 ± 0.71, 21.1 ± 1.77 and 15.6 ± 0.43 respectively for group 1, 2 and 3 (Table 29).

The analysis of covariance on cumulative increase in height at withers taking initial height as covariate (Table 32) indicated that the values were significantly lesser ($P<0.05$) in group 3 compared to other two groups probably due to lesser weight gain observed in group 3 compared to other twogroups.

The values obtained in the present investigation are higher than those reported by Gangadevi (1981) and Biju (1998) evidently due to the higher body weights of the kids. Animal protein inclusion was found to have no influence on the cumulative increase in height at withers of kids.

5.2 Daily dry matter intake

The average daily dry matter intake of animals (males + females) in group 1,2 and 3 were 680 ± 0.26 g, 586 ± 0.13 (g) and 582 ± 0.17 (g) respectively (Table 9), which works out to be 4.06, 3.29 and 3.64 kg/100 kg body weight respectively.

The average daily dry matter intake (g) of males and females (separately) in group 1,2 and 3 were 669.73 ± 29.60, 689.67 ± 25.85; 589.80 ± 18.81, 574.42 ± 15.66 and 587.80 ± 15.66, 585.14 ± 12.54 respectively (Table 11).

It was observed that there was only a marginal difference between male and female animals of the same groups (Table 11).

The data on average daily dry matter intake of different groups presented in Table 9 indicate a higher dry matter intake in group 1 animals compared to those in group 2 and group 3. The difference ($P<0.01$) is also statistically significant (Table 10). Dry matter intake in groups 2 and 3 were lower than group 1 and this may be due to the problems in palatability in animal protein containing diets as reported by Oldham *et al.* (1985) and Mantysaari *et al.* (1989b).

Dry matter intakes observed in the present study were similar to that reported by Gangadevi (1981) but were higher when compared to those obtained by Deepa (1998) and Biju (1998), evidently due to the better growth rate in the present study.

5.3 Feed conversion efficiency

The average weekly feed conversion efficiency values obtained were 5.04, 5.08 and 7.31 and the cumulative feed conversion efficiency were 4.51, 3.67 and 4.79 for group 1,2 and 3 respectively (Table 15).

Higher weekly feed conversion values obtained are due to the fluctuations in rate of growth which is normal with growing animals. Cumulative feed conversion values are usually considered to assess the efficiency of a feed.

Statistical analysis of the data indicated no significant difference between the groups (Table 16). Feed conversion efficiency values obtained in the present study was almost similar to that obtained by Biju (1998), but better than the values reported by Wadhwani and Patel (1992) and Deepa (1998) in studies using complete rations. Better feed conversion efficiency obtained in the present study may be due to the effect of monensin supplemented at 20 ppm and is in conformity with Joyner *et al.* (1979) and Biju (1998).

Inclusion of animal protein was reported to improve feed efficiency in ruminants as reported by Mantysaari *et al.* (1989b) and it holds true with animals of group 2. The decreased feed efficiency of animals of group 3 may be due to occasional diarrhoea observed in these animals.

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

The DCP intake per 100 g DM consumed was 13.66, 13.83 and 13.49 g respectively for groups 1, 2 and 3 (Table 47). The average DCP intake per animal per day were 92.89, 81.04 and 78.51 g for the experimental groups 1, 2 and 3 respectively (calculated on the basis of average daily DM intake).

The TDN intake per 100 g DM consumed were 74.88, 74.20 and 72.60 g respectively for groups 1, 2 and 3 (Table 47). The average TDN intake per animal per day were 509.18, 434.81 and 422.53 g for the experimental groups 1, 2 and 3 respectively (calculated on the basis of average daily DM intake).

5.5 Digestibility coefficients

5.5.1 Dry matter

The average dry matter digestibility coefficients calculated for rations fed to group 1, 2 and 3 were 72.71 ± 1.59, 72.89 ± 1.39 and 70.01 ± 0.24 per cent respectively (Table 36). No statistical difference was observed between the rations in this regard (Table 37).

Digestibility figures for DM obtained in the present study are slightly higher than the values reported by Rao *et al.* (1995) and Chahal and Sharma (1992). Higher digestibility values may be due to the influence of monensin as reported by Beede *et al.* (1985) and Lee *et al.* (1992).

Slightly lower DM digestibility in the present study in comparison to the values obtained in similar complete rations supplemented with monensin as reported by Biju (1998) may be due to the effect of pelleting in accordance with that reported by Singhal and Mudgal (1983).

The results of the present study indicates that animal protein inclusion does not have any influence on dry matter digestibility which is contrary to that reported by Andrighetto and Bailoni (1994).

5.5.2 Organic matter

The average organic matter digestibility coefficient in the rations fed to groups 1, 2 and 3 were 82.19 ± 1.21, 82.20 ± 0.80 and 75.36 ± 0.27 per cent respectively (Table 36).

Statistical analysis of the data using ANOVA technique indicated no significant differences between the rations in this regard (Table 38).

The values obtained in the present study agree with the values reported by Biju (1998). The results of the present study are higher than the values reported by Rao *et al.* (1995) and Chahal and Sharma (1992) and is in confirmation with the reports of Beede *et al.* (1985) and Faulkner *et al.* (1985). The results indicate that animal protein inclusion does not have any influence on organic matter digestibility.

5.5.3 Crude protein

The average digestibility coefficients for crude protein in the rations fed to groups 1, 2 and 3 were 83.96 ± 1.40, 82.39 ± 1.06 and 81.72 ± 0.83 per cent respectively (Table 36).

Statistical analysis of the data using ANOVA technique indicated no significant differences between the rations (Table 39).

The digestibility of CP obtained in the present study was more than that reported by Rao *et al.* (1995), Ram *et al.* (1990) and Biju (1998). The possible reason is that the feed protein of the present study was mainly from concentrate fraction of ingredients, which is of higher digestibility. The results of the present study indicates that animal protein inclusion does not have any influence on crude protein digestibility which is in contrary to that reported by Andrighetto and Bailoni (1994).

5.5.4 Ether extract

The average ether extract digestibility coefficient in the ration fed to groups 1, 2 and 3 were 61.95 ± 2.76, 58.12 ± 1.21 and 61.51 ± 2.22 per cent respectively (Table 36).

Statistical analysis of the data using ANOVA technique indicated no significant differences between the rations (Table 40).

The results of the present study are similar to that obtained by Biju (1998). Inclusion of animal protein was found to have no influence on the ether extract digestibility.

5.5.5 Crude fibre

The average digestibility coefficients for crude fibre in the rations fed to groups 1, 2 and 3 were 52.20 ± 4.23, 43.63 ± 2.34 and 48.59 ± 0.66 per cent respectively (Table 36).

Statistical analysis of the data using ANOVA technique indicated no significant differences between the groups (Table 41).

The values obtained in the present study are in agreement with the data obtained with complete feeds fed to goats by Biju (1998), Rao *et al.* (1995) and Chahal and Sharma (1992). Animal protein inclusion was found to have no influence on crude fibre digestibility in the present study which is contrary to that reported by Andrighetto and Bailoni (1994).

5.5.6 Nitrogen free extract

The average digestibility coefficients for nitrogen free extract in rations fed to groups 1, 2 and 3 were 77.54 ± 0.66, 79.55 ± 1.65, 75.67 ± 1.04 per cent respectively (Table 36).

Statistical analysis of the data using ANOVA technique indicated no significant differences between the groups (Table 42).

The values obtained in the present study are lesser than those reported by Biju (1998) but are higher when compared to values reported by Ram *et al.* (1990), Rao *et al.* (1995) and Chahal and Sharma (1992). Animal protein inclusion does not seem to have any influence on NFE digestibility.

5.6 Nitrogen balance

The average nitrogen balance (g/d) in animals of groups 1, 2 and 3 were 6.04 ± 0.28, 6.65 ± 0.32 and 5.21 ± 0.06 respectively (Tables 43, 44 and 45).

Statistical analysis of the data using ANOVA technique indicated no significant differences between the groups (Table 46).

Rao *et al.* (1995) recorded a nitrogen balance of 1.83, 1.08, 1.50 and 0.91 in 4 groups of 12 Nellore rams fed on fourcomplete rations while Chahal and Sharma (1992) obtained values of 7.63 ± 0.39, 2.74 ± 0.22, 5.35 ± 0.21 and 2.07 ± 0.07 g/d in twenty male crossbred (Alpine x Beetal) kids fed on four complete rations.

Ram *et al.* (1990) obtained nitrogen balance values (g/d) of 3.23 ± 0.30, 5.62 ± 0.50 and 5.35 ± 0.70 g/d.

Biju (1998) recorded a nitrogen balance of 4.25 ± 0.65, 5.09 ± 0.41 and 6.37 ± 0.17 in three groups of Malabari kids fed on monensin supplemented complete rations.

The nitrogen balance values obtained in the present study were higher than the reported values evidently due to the higher average daily gains observed in the present study. Inclusion of animal protein supplement, meat cum bone meal was found to slightly improve nitrogen balances in group 2. Slightly lesser nitrogen balance in group 3 is due to the poor growth observed in the animals of the group. Animal protein inclusion was found to have no influence on the nitrogen balance values.

5.7 Dressing percentage

The average dressing percentage obtained in the male animals slaughtered from groups 1, 2 and 3 were 49.39 ± 1.45, 49.63 ± 0.72 and 51.49 ± 1.93 (Table 48).

Statistical analysis of the data using ANOVA technique revealed no significant difference between the three groups (Table 49).

Literature on the influence of animal protein supplementation on the dressing percentage in kids slaughtered at six months of age are scanty.

The results obtained in the present study are in agreement with those obtained by Ralston (1997) and Biju (1998) in Malabari kids of six to seven months age. It can be concluded that animal protein inclusion has no influence on the dressing percentage of kids slaughtered at six months of age.

5.8 Economics

The feed cost/kg live weight gain (Rs) for animals in groups 1, 2 and 3 were 34.59, 30.27 and 35.59 respectively (Table 51).

The feed cost/kg live weight gain values reported in the present study were higher than those reported by Chahal and Sharma (1992) and Reddy and Reddy (1985). But the values are comparable to that of Biju (1998) and are lesser compared to Deepa (1998).

Although cost of feed of ration 2 containing meat cum bone meal was higher than the other two rations, cost of production per kilogram live weight gain was lower in animals of group 2 due to their better feed conversion rate.

Gross profit calculated from the study per each animal for the period of 13 weeks for groups 1, 2 and 3 were Rs.292.06, Rs.357.90 and Rs.286.20 respectively (Table 52).

Biju (1998) reported a gross profit of Rs.254.67, Rs.198.70 and Rs.75.08 respectively by feeding three groups of Malabari kids on monensin supplemented complete rations for a period of 13 weeks.

The gross profit obtained in the present study was higher than the values reported and it can be attributed to the better daily weight gain and higher final weights attained in the study. Higher body weights in the animals of group 2 fed on meat cum bone meal containing diet has reflected on its better feed conversion efficiency and higher gross profit.

5.9 Histopathological study of rumen epithelium

Microscopical examination of the rumen tissues of animals of all the three groups showed rumen papillae that were long and thickened with sparsely distributed keratin deposition indicating parakeratosis. Cytoplasmic vacuolation of the epithelial cells was clearly visible in the basal layers, but not so distinct in the superficial layers of the rumen epithelium (Microphotographs presented in Plates 1, 2 and 3).

High concentrate diets fed to ruminants for prolonged periods have been found to induce lactic acidosis (Wheeler *et al.*, 1980) as well as morphological changes in rumen epithelium (Ensminger *et al.*, 1990). Problems with lactic acidosis can be reduced by supplementing monensin (Nagaraja *et al.*, 1981) or sodium bicarbonate (Kromann *et al.*, 1972).

In parakeratosis rumen papillae become excessively thickened, branched and paddle shaped and are seen loosely attached to rumen wall (Block and Shellenberger, 1980a and Biju (1998).

The results are in agreement with Block and Shellenberger (1980a) and Biju (1998). No external symptoms of lactic acidosis could be observed and this may be due to supplementation of monensin and sodium bicarbonate in the diets and is in accordance with reports of Kromann (1972) and Nagaraja (1981).

From the overall results, it can be concluded that inclusion of animal protein in the rations of kids of three to four months of age did not have any positive influence on growth. It is possible to maintain kids profitably on concentrate like complete rations containing 20 ppm monensin and 1 per cent sodium bicarbonate, for a period not exceeding 91 days, maintaining high rate of growth and with no apparent ill effects.

Summary

SUMMARY

An investigation was carried out in 30 Malabari kids of three to four months of age to evaluate pelleted complete rations incorporating animal protein and monensin, on growth of animals. The kids selected from Goat and Sheep Farm of Kerala Agricultural University were divided randomly into three equal groups (1, 2 and 3). The male and female animals in each group were housed in separate but adjacent identical pens.

Three complete pelleted rations containing 20 ppm monensin and 1% sodium bicarbonate namely 1, 2 and 3, isoproteimic and isocaloric, containing 16% CP and 70% TDN were fed to the animals on *ad libitum* basis for 13 weeks (91 days). Ration 2 contained 5 per cent meat cum bone meal and ration 3 contained 5 per cent fish meal.

Parameters of the study were: weekly body weight gain, weekly body measurements, daily dry matter intake, feed conversion efficiency, digestibility coefficients of nutrients, nitrogen balance and dressing percentage of carcass, at the termination of the study.

Salient observations and inferences drawn from the study were,

The average final body weight (kg) in animals of the groups 1, 2 and 3 were 22.71, 22.88 and 20.10 and cumulative weight gains (kg) were 13.72, 13.96 and 11.06 respectively. No significant growth difference was observed between animals of group 1 and group 2, but the cumulative weight gain of

group 3 fed on fish meal containing complete ration was significantly lesser ($P<0.05$). Inclusion of animal proteins did not show any significant positive influence on the growth of kids.

No significant growth difference between the male and female animals of the three groups were observed.

The final body length of the three groups of animals were 54.1, 59.1 and 59.8 cm and cumulative increase in length (cm) were 13.3, 20.1 and 21.9 respectively.

There was significant increase ($P<0.01$) in body length of group 2 and group 3 fed on animal protein containing diets. The difference in body length noticed was not in accordance with gain in body weight as animals in group 3 had lesser body weight compared to other groups.

The final chest girth were 67.2, 67.3 and 61.2 cm and cumulative increase in chest girth (cm) were 20.6, 21.0 and 13.6 for the groups 1, 2 and 3 respectively. The increase in chest girth were in accordance with body weight gains in different groups.

The final height at withers were 67.9, 66.0 and 61.6 cm and cumulative increase in height at withers (cm) were 20.5, 21.1 and 15.6 for the groups 1, 2 and 3 respectively.

The increase in height at withers were in accordance with body weight gain in different groups. Animal protein inclusion was found to have no influence on the cumulative increase in height at withers of kids as well as chest girth of kids.

The average daily dry matter intake (g) of animals in groups 1, 2 and 3 were 680, 586 and 582 respectively. Lower dry matter intakes observed in animal protein containing diets can be attributed to the palatability problems.

The cumulative feed conversion efficiency of the three groups were 4.51, 3.67 and 4.79 respectively. No significant influence of animal protein inclusion on feed conversion efficiency was observed.

The average digestibility coefficients of nutrients in rations fed to group 1, 2 and 3 did not differ significantly . Animal protein inclusion was found to have no influence on digestibility of nutrients.

The average nitrogen balance (g/d) in animals of groups 1, 2 and 3 were 6.04, 6.65 and 5.21 respectively. This corresponds with respective body weights of the three groups of animals.

The average dressing percentage obtained in the male animals slaughtered from groups 1, 2 and 3 were 49.39, 49.63 and 51.49 respectively.

Supplementing animal protein in the diets of kids reared for meat production does not have any effect on dressing percentage of carcasses.

Microscopical examination of the rumen tissues of all the 3 groups showed rumen papillae that were long and thickened with sparsely distributed keratin deposition indicating parakeratosis.

Clinical symptoms of lactic acidosis were not observed during the study possibly due to the influence of monensin and sodium bicarbonate added to the rations.

From the overall results it can be concluded that inclusion of animal proteins in complete pelleted concentrate type diets, containing monensin, for kids of three to four months of age did not have any significant effect on growth rate compared to diet supplemented with vegetable protein.

The feed cost per kilogram live weight gain (Rs) for animals in groups 1, 2 and 3 were 34.59, 30.27 and 35.59 respectively. Inclusion of meat cum bone meal improved the feed efficiency (though non significant) and weight gains leading to reduction in cost of production. The DM intake of animals on ration containing animal protein were significantly lower compared to the control ration and reduced feed intake did not reflect on weight gain and this feature can be taken advantage in commercial chevon production.

The gross profit that can be expected from animals of group 2 worked out to be Rs. 357.90 compared to Rs. 292.06 and Rs. 286.20 in group 1 and group 3 respectively during the period of 13 weeks.

It is possible to maintain kids of three to four months of age profitably on concentrate like complete rations containing 20 ppm monensin and 1% sodium bicarbonate, for a period not exceeding 91 days, maintaining high rate of growth with no apparent clinical ill effects.

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EVALUATION OF COMPLETE RATIONS FOR KIDS FOR MEAT PRODUCTION

By

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ABSTRACT OF A THESIS

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ABSTRACT

An investigation was carried out in Malabari kids of three to four months of age to study the influence of animal protein and monensin incorporated in complete pelleted concentrate type diet on the growth of animals. Thirty kids were divided into three equal groups, 1, 2 and 3, and fed on three pelleted complete rations, isocaloric and isoproteimic. Ration 2 incorporated meat cum bone meal and ration 3, fish meal at 5 percentage level replacing gingelly oil cake of ration 1 and fed to respective groups for a period of 91 days.

Animal protein inclusion did not show any significant positive influence on the growth of kids. No significant growth difference between the male and female animals of the three groups were observed.

There was significant increase ($P<0.01$) in body length of kids fed on animal protein, but had no positive influence on other body measurements.

Significantly lower ($P<0.05$) dry matter intakes were observed in kids fed animal protein containing diets, which can be attributed to palatability problems.

The feed conversion efficiency and nitrogen balance values of kids were not influenced by animal protein inclusion. It also had no influence on digestibility of dry matter, organic matter, crude protein, ether extract, crude fibre and nitrogen free extract of the diets.

Dressing percentage of kids slaughtered at six months of age in the three groups were almost similar.

The gross profit that can be expected from animals of group 2 worked out to be Rs.357.90 compared to Rs.292.06 and Rs.286.20 per animal in group 1 and group 3 respectively for a period of 13 weeks.

Histopathological study of the rumen tissues of all the three groups showed rumen papillae that were long and thickened with sparsely distributed keratin deposition indicating distinct parakeratosis, but no clinical symptoms of lactic acidosis were observed.

It is possible to maintain kids of three to four months of age profitably on concentrate like complete feeds, supplemented with monensin and sodium bicarbonate for a period not exceeding 91 days.