MONENSIN SUPPLEMENTATION IN COMPLETE RATIONS FOR KIDS

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THESIS

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Department of Animal Nutrition
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1998

DECLARATION

I hereby declare that the thesis entitled **"MONENSIN SUPPLEMENTATION IN COMPLETE RATIONS FOR KIDS"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that the thesis entitled "**MONENSIN SUPPLEMENTATION IN COMPLETE RATIONS FOR KIDS**" is a record of research work done independently by **Sri. Biju Chacko**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Dedicated to my

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Introduction

INTRODUCTION

Goats are one of the earliest animals to be domesticated by man. They are an important source of income and occupation to sizable population, especially of the weaker sections of society in India.

India claims the biggest share in the goat population map of the world. Its share works out to 21 per cent of the world stock and has the richest germplasm. Twenty per cent of the goat population of India can be described in twenty distinct breeds and the rest of the population belongs to non descript breeds (Misra, 1992).

Milk, meat and fibre are the important products of goats, skin and manure being the byproducts. There is no breed exclusively used for milk and most of the breeds in India are used for both milk and meat.

Out of the 118 million goats in India (FAO, 1993) about 46 per cent is slaughtered every year for meat purpose, contributing about 41 per cent of total meat production in the country (Patnayak *et al.*, 1995). Goat meat is accepted by all religious sects as a source of animal protein. The meat is low in fat and calories and is known as lean meat. High meat production from goat is due to the prolificacy, disease resistance and free legal slaughter of these animals anywhere in India. As per 1987 figures, about 378 million kilogram of chevon is produced per year in India contributing a revenue of Rs.10,800 million to our economy. India is the third in chevon export and Indian chevon accounts to 16 per cent of total chevon production in the world (Tony, 1996).

Goats prefer drier areas where soil is light and sandy with an annual rainfall of about 250-400 mm. Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Maharashtra, Orissa and Andhra Pradesh hold 78 per cent of the total goat population in India (Prakash and Balain, 1992).

India has no breed classed as meat breed. Medium sized breeds especially Sihori and Marwari can attain high body weight under proper care and feeding. Small sized breeds particularly Black Bengal appear good for broiler production because of high feed conversion efficiency and rapid post weaning growth.

Goat population in Kerala registered an increase of 17.71 per cent between 1987 and 1996 (Livestock Census, 1996). Out of the 1,61,000 tonnes of meat sold in the Kerala market, goat meat constitutes 12 per cent (Swiss Agency for Development and Co-operation, 1998). Chevon is in great demand in Kerala and is priced at Rs.120/kg.

The recognised local breed of Kerala is Malabari, which is of medium size and highly prolific. The animals are maintained by farmers for milk as well as for meat.

The per capita land holding in Kerala is only 0.13 hectares and scope for rearing goats on a large scale is limited. However, there is ample scope for large number of small farms all over the state. The only problem encountered by farmers is the non availability of fodder during peak summer months.

The concept of intensive system of rearing of goats has recently evoked much interest among farmers and three commercial firms have introduced complete feed for goats in pellet form.

During the past decade, ionophore antibiotics have been recognised as an important tool in ruminant nutrition, particularly as a means of chemically improving feed efficiency through regulating end products of rumen fermentation. The common ionophore antibiotic used is monensin. Its anticoccidial action provides an added benefit since coccidial enteritis is a very common problem in young kids.

The objectives of the present study are to assess the influence of monensin on growth rate and feed conversion efficiency of kids reared for meat production fed on complete rations having different levels of fibre and also to find out the optimum fibre levels in complete rations supplemented with monensin.

Review of Literature

REVIEW OF LITERATURE

Feed additives are not nutrients, but certain compounds which act basically by stimulating the growth of rumen microbes there by altering the animal and avian metabolism. Their utility is in improving growth rate, productivity and efficiency of feed utilization in healthy livestock on an optimum plane of nutrition (Icchponani, 1991).

Products that improve the rate and efficiency of growth in livestock have been used during the last three decades and are termed "growth promotants". A feed growth promoter is defined as a substance that when added to the feed in subtherapeutic dosage produces an economic improvement, either by improving growth and feed conversion efficiency or by reducing mortality and morbidity (Anonymous, 1975).

A major feature of the increased intensification of animal production systems has been the extensive and continuous use of antibiotics as feed additives (Anonymous, 1975). Antibiotics are compounds produced by certain microorganisms that inhibit the growth of other organisms (Anonymous, 1975 and Maynard *et al.*, 1979).

2.1 Ionophore antibiotics

Bergen and Bates (1984) reported that a number of active compounds when fed, can manipulate and improve the efficiency of rumen fermentation as well as feed efficiency of growing ruminants. One such class of compounds are carboxylic polyether ionophore antibiotics (commonly referred to as ionophores) that were originally used as anticoccidial feed additives for poultry. These ionophores are produced by various strains of Streptomyces species of bacteria and include monensin, lasalocid, salinomycin and narasin.

2.1.2 Mechanism of action of ionophores

Bergen and Bates (1984) stated that the underlying mode of action of ionophores is on transmembrane ion fluxes and the dissipation of cation and proton gradients. The cation-proton exchange, mediated by the ionophore begins with the anionic form of the ionophore confined to the membrane interphase where it is stabilized by the polar environment. As an anion, the ionophore is capable of ion pairing with a metal cation either at the terminal carboxylic acid moiety or at other internal sites. The binding of a cation initiates the formation of a lipophilic, cyclic, cation - ionophore complex that can diffuse through the interior of the bimolecular membrane structure. Ultimately, the complex reaches the opposite face of the membrane where it is again subjected to a polar environment. The electrostatic forces that had stabilized the complex are no longer greater than the unfavourable ΔG (Gibbs free energy change) of cyclization and the ionophore releases its enclosed cation and reverts to the low energy acyclic conformation. There it awaits the next phase of the transport cycle. Both monensin and lasalocid fall into this category of ionophore. Monensin mediates primarily Na^+ - H^+ exchange because the affinity of monensin for Na^+ is ten times that of K^+, its nearest competitor. 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 dependent on substrate level phosphorylation for ATP cannot meet this demand and get themselves lysed. Those cells capable of at least some electron transport coupled with ATP synthesis will exhibit a higher maintenance energy requirement, but continue growth and survive. Gram positive bacteria depend on substrate level phosphorylation and are inhibited by ionophores while the gram negative organisms, many of which contain fumarate reductase, survive in the presence of ionophores and thus, the gram negative population in the rumen is enriched. The disturbances in the intracellular ion concentration explains the coccidiocidal and anti-bacterial effects of the compound.

2.2 Monensin

Monensin is an ionophore antibiotic compound produced by the fermentation of *Streptomyces cinnamonensis* (Havey and

Hoehn, 1967). Research efforts have led to widespread practical use of monensin as a means of chemically improving feed efficiency through regulating rumen fermentation end products (Rumsey, 1984).

2.2.1 Effects of monensin supplementation

Several authors (Oliver, 1975; Danner *et al.*, 1980; Ostilie *et al.*, 1981; Bergen and Bates, 1984; Galyean and Owens, 1988; Sip and Pritchard, 1991; Tyler *et al.*, 1992 and Zinn *et al.*, 1994) have reported that with diets containing high levels of readily fermentable carbohydrates, monensin generally depresses feed intake, but body weight gains are not decreased and feed conversion (feed/gain) is improved. When ruminants are fed diets containing considerable ß-linked carbohydrates (roughages) monensin does not depress feed intake and animals continue to gain in weight resulting in improved feed conversion.

Bergen and Bates (1984), after extensive studies in cattle, categorised three major areas of animal metabolism that can contribute to an improved efficiency in production when the ration was supplemented with monensin.

1. Improved efficiency in energy metabolism
2. Improved nitrogen metabolism

3. Retardation of feedlot disorders (lactic acidosis and bloat) and other incidental diseases (coccidiosis).

2.2.1.1 Effect on energy metabolism

The most consistent observation upon monensin supplementation is the increased molar proportion of propionic acid with a concomittant decline in the molar proportion of acetate and butyrate in the volatile fatty acids (VFA) produced in the rumen as evidenced by many reports (Dinius *et al.*, 1976; Raun *et al.*, 1976; Monetti *et al.*, 1977; Bartley *et al.*, 1979, Calhoun *et al.*, 1979; Chen and Wolin, 1979; Chalupa *et al.*, 1980; Kobayashi *et al.*, 1982; Vuuren and Nel, 1983; Bergen and Bates, 1984; Zinn and Borques, 1993 and Haimoud *et al.*, 1995).

Utley *et al.* (1976) conducted studies in heifers supplemented with monensin and found an increase of 60 per cent in rumen proprionate and a decrease of 12 per cent in acetate and 25 per cent in butyrate compared to controls. Maynard *et al.*, 1979) observed that the rumen propionic acid content in monensin supplemented animals reached to 50 per cent of total volatile fatty acids.

Chen and Wolin (1979) suggested that the increase in propionate, in monensin fed cattle, results from the selection for succinate producing and lactate fermenting bacteria with the simultaneous inhibition of the major lactate producing bacteria (Dennis *et al.*, 1981).

Propionic acid was thought to be more efficiently utilized by host animals due to its lower heat increment than acetate (Blaxter and Wainman, 1964). Rowe *et al.*, (1981) estimated ruminal VFA production rates in sheep using isotope dilution techniques and concluded that approximately 20 per cent more metabolizable energy (ME) was available to the host when the diet was supplemented with monensin.

Raun *et al.* (1976) observed that the shift towards more ruminal propionate production could not account for all the improvement in performance obtained in feedlot studies. These researchers suggested that the increased propionate may also lower the heat increment, spare amino acids normally used for gluconeogenesis and stimulate body protein synthesis thereby resulting in better growth. Zinn *et al.* (1994) supplemented monensin in the diets of feedlot cattle with low and high forage and found that low forage diets had 9.4 per cent higher propionate while high forage diets had 5.5 per cent lower propionate when compared with controls having no monensin supplementation.

Monensin incorporation in the rations has been found to decrease methanogenesis as reported by several workers (Bartley *et al.*, 1979; Joyner *et al.*, 1979; Chalupa *et al.*, 1980; Davies *et al.*, 1982; Bergen and Bates, 1984 and Zinn and Borques, 1993). Tyler *et al.* (1992) after extensive studies in cattle observed that the addition of ionophores reduced methane production by 10 to 26 per cent. Monensin inhibits several strains of methanogenic rumen bacteria which produce precursors of methane such as formic acid and hydrogen, resulting in net reduction of methane production. The exact mechanism of decreased methanogenesis is not known. However, methanogenic bacteria use a nickel transport enzyme system and monensin has been shown to inhibit this nickel transport system in *Methanobacterium bryantti.* Decreased methane production increased metabolizable energy availability as much as 5.2 per cent to the host.

2.2.1.2 Effect on nitrogen metabolism

Monensin has a protein sparing effect. Reports by Hanson and Klopfenstein (1979), Chalupa *et al.* (1980), Isichei and Bergen (1980), Bergen and Bates (1984), Goodrich *et al.* (1984), Beede *et al.* (1985), Patil and Honmonde (1994) and Haimoud *et al.* (1995) indicated that in the presence of monensin ruminal NH_3-N production is decreased. These findings denote a depressing effect on both protease and deaminase activity in the rumen.

Dietary monensin, decreased ruminal protozoa as much as 64 per cent (Ushida *et al.*, 1991 and Tyler *et al.*, 1992).

Additionally there were decreased numbers of cellulolytic bacteria that use ammonia as a nitrogen source (Tyler *et al.*, 1992).

Joyner *et al.* (1979) observed a nitrogen retention of 6.6 g/day in lambs supplemented with monensin at the rate of 20 mg/kg feed. Kobayashi *et al.* (1982) conducted studies on the rumen fermentation of steers and reported a decrease in the concentration of ammonia by 50 to 80 per cent during one to six hours and that of methylamine-N by 74 and 50 per cent at four and six hours respectively after feeding. Beede *et al.* (1985) observed after studies in goats that the empty body protein gain as a percentage of protein intake improved by 41 per cent with monensin and also the nitrogen retention. Patil and Honmonde (1994) observed a nitrogen retention of 8.59 g/day in Malpura lambs supplemented with monensin at the rate of 20 mg/kg feed.

Feeding monensin would increase the quantity of dietary protein escaping ruminal degradation and would therefore be available for digestion and uptake in the small intestine as reported by Bergen and Bates (1984). These researches found that protein bypass was increased from 22 to 55 per cent in five different experiments.

2.2.1.3 Retardation of feed lot disorders and other incidental diseases

2.2.1.3.1 Lactic acidosis

Studies with pure cultures of rumen microorganisms indicated that monensin inhibited growth of bacteria with gram positive cell wall characteristics (*Streptococcus bovis*) which are the primary ruminal lactate producers (Chen and Wolin, 1979). Dennis *et al.* (1981) reported that polyether ionophores like monensin and lasalocid inhibited growth of major ruminal lactate producers without inhibiting ruminal lactate utilizers such as Anaerovibrio, Megasphaera or Selenomonas. Nagaraja *et al.* (1981) tested monensin for its efficiency in preventing lactic acidosis in cattle engorged with grain or a glucose solution and found it to be effective in maintaining ruminal pH and preventing lactic acid accumulation. Decrease in lactic acid production, on feeding a diet supplemented with monensin has been reported by many workers (Kobayashi *et al.*, 1982; Kutas *et al.*, 1982; Nagaraja *et al.*, 1982 and Goodrich *et al.*, 1984).

2.2.1.3.2 Bloat

Bloat is a common disorder in ruminants and inspite of extensive research, the etiology of bloat has not been established. The causal contribution of ruminal slime to bloat seems plausible because an increase in fluid viscosity (surface tension) is a noticeable feature of rumen fluid obtained from bloating cattle (Bergen and Bates, 1984). These workers postulated that since monensin has an anticocidial effect, they may elicit a depressing effect by depressing putative slime production by *protozoa*. Monensin could also depress slime produced by the gram positive *S. bovis*. The bloat depressing effect of monensin was further confirmed by Goodrich *et al.* (1984).

2.2.1.3.3 Coccidiosis

Bergstrom and Maki (1974) studied the effect of monensin by mixing it with pelletted feed at the rate of 1.6 mg/kg body weight. These pellets were subsequently fed to three month old cross bred wethers. The treated lambs discharged few or no coccidial oocysts after ninth day and had little or no diarrhoea.

Bergstrom and Maki (1976) studied the anticoccidial effect of monensin by artificially infecting lambs with sporulated coccidial oocyst. The lambs whose diets were not supplemented with monensin developed severe coccidiosis.

Calhoun *et al.* (1979), Yazd *et al.* (1979) and Goodrich *et al.* (1984) have demonstrated anticoccidial effect of monensin.

Tyler *et al.* (1992) reported that monensin had to be included in the ration prior to, or shortly after the ingestion of infective oocysts, if they are to have any prophylactic or therapeutic benefit.

2.2.2 Optimum levels of monensin supplementation

Bergstrom and Maki (1976) studied the influence of monensin on body weight gain and feed conversion efficiency in lambs, supplementing the diet with different levels of monensin. They observed that 10 g/ton was sufficient to give maximum gain and feed conversion efficiency.

Joyner *et al.* (1979) conducted a growth trial in lambs to determine the effect of monensin fed at different levels in the diet ranging from five to thirty ppm. They concluded that 20 ppm was the optimum level of monensin for lambs.

Sharrow *et al.* (1981), Vuuren and Nel (1983), Beede *et al.* (1985), Faulkner *et al.* (1985), Ushida *et al.* (1991), Iotsev *et al.* (1989) and Lee *et al.* (1992) observed that 20 mg monensin/kg feed was superior in promoting body weight gains.

The only reported work so far on monensin supplementation in lambs in India is by Patil and Honmonde (1994). They have reported superior results in Malpura lambs, fed diets supplemented with monensin at the rate of 22 mg/kg feed than those fed diets supplemented with monensin at the rate of 11 mg/kg feed.

2.2.3 Growth

2.2.3.1 Influence on feed intake, weight gain and feed conversion efficiency

Joyner *et al.* (1979) conducted a growth trial in lambs and observed that monensin decreased feed consumption by two to eighteen per cent, did not affect average daily gain and improved feed efficiency by seven to eleven per cent when compared to control animals. Lambs registered an average daily gain of 210 g with a feed conversion efficiency of 6.78 when supplemented with 20 ppm monensin.

Yazd *et al.* (1979) obtained a feed conversion efficiency of 4.4 in the case of lambs fed monensin at the rate of 30 ppm.

Tyler *et al.* (1992) reported the effects of monensin in lambs on high concentrate diets and high forage diets. On high concentrate diets there is approximately a 10 per cent decrease in voluntary feed intake with minimal effects on rate of gain. In forage based diets the most consistent response was an increase in the rate of gain approximately 100 g/day and in some cases upto 20 per cent.

Patil and Honmonde (1994) fed varying levels of monensin ranging from zero to twenty two mg/kg concentrate mixture to lambs and found that intake from concentrate reduced linearly with increasing levels of monensin. Whereas, intake from roughage showed an increase with increasing levels of monensin. The body weight gain and feed efficiency improved linearly with increasing levels of monensin. Body measurements also increased linearly with the same increase in the level of monensin.

Zinn *et al.* (1994) conducted studies in feedlot cattle fed on grains mixed with limited quantity of roughage, supplemented with monensin at the rate of 28 mg/kg feed. They found that decreasing the forage in the diet from 20 per cent to 10 per cent increased average daily gain by 10.8 per cent and feed efficiency by 11.6 per cent.

Martini *et al.* (1996) conducted studies in Masese lambs by feeding them *ad libitum* on a diet supplemented with monensin (10 mg/kg feed from 7 to 49 days and 20 mg/kg feed from 49 to 105 days of age). Lambs were fed on reconstituted milk, weaning mix and leucern hay until weaning (49 days of age) and a finishing mix and mixed hay after weaning. Monensin - treated lambs had higher live weight than the controls throughout the trial period. Feed/gain ratio was better for monensin treated groups than for control lambs from zero to 42 days (1.58 and 1.67 respectively); however from day 43 to 105 (5.0 and 5.31 respectively) and during the whole experiment (1 to 105 days; 3.78 and 3.92 respectively) control lambs had better feed/gain ratios than treated lambs. In treated lambs, a significant reduction in growth was observed, two weeks after solid food was available (21 days of age), and again one week after switching from the weaning to the finishing diet (56 days of age).

There are reports of increased weight gain and feed conversion efficiency on feeding diets supplemented with monensin (Bergstrom and Maki, 1976, Potter *et al.*, 1976, Raun *et al.*, 1976, Utley *et al.*, 1976, Boling *et al.*, 1977, Monetti *et al.*, 1977, Mowat *et al.*, 1977, Dart *et al.*, 1978, Nockels *et al.*, 1978, Bartley *et al.*, 1979, Calhoun *et al.*, 1979, Danner *et al.*, 1980, Dvorak *et al.*, 1980, Ostilie *et al.*, 1981, Baldwin *et al.*, 1982, Shelton *et al.*, 1982, Vuuren and Nel, 1983, Goodrich *et al.*, 1984, Beede *et al.*, 1985 and Galyean and Owens, 1988).

Moseley *et al.* (1982) opined that monensin was found to be more effective in heifers with above average weaning weight.

Meinert *et al.* (1992) conducted studies in Holstein heifers and reported that monensin had no effect on height at withers, heart girth and length.

2.2.3.2 Influence on digestibility coefficients and nitrogen balance

2.2.3.2.1 Digestibility of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and nitrogen free extract (NFE).

There are conflicting reports on the effect of monensin in the digestibility of nutrients.

Vuuren and Nel (1983) and Ricke *et al.* (1984) observed that monensin had no significant effect on the apparent digestibility of DM in sheep. However, Goodrich *et al.* (1985) reported that monensin improved digestibility of DM in cattle.

Beede *et al.* (1985) 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.

Faulkner *et al.* (1985) found out that monensin brought about a significant increase in the OM digestibility in steers fed on high fibre diets.

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

Zinn and Borques (1993) observed that monensin supplemented in the diet of feedlot steers at the rate of 33 mg/kg of diet decreased rumen OM digestibility. However, differences in ruminal digestion were compensated for by increased post ruminal OM digestion to give a total tract digestibility of 81.5 per cent for OM.

Patil and Honmonde (1994) studied the influence of monensin on the digestibilities of nutrients. The digestibilities of nutrients were comparable in three groups fed on same diet with different levels of monensin. However DM digestibility was significantly higher in monensin treated groups (65.92 and 67.14% respectively) than control (63.03%).

Zinn *et al.* (1994) studied the interaction of forage level and monensin in diets for feedlot cattle and observed that ruminal digestibility of OM and NFE were not affected by forage level. However, ruminal digestibility of feed N was 20 per cent greater with the high forage diet. They also opined that increasing forage level in the diet decreased total tract digestion of OM.

2.2.3.2.2 Digestibility of crude fibre (CF)

There have been conflicting reports on the influence of monensin on the digestibility of crude fibre.

Dinius *et al.* (1976) reported that there were no significant differences in cellulose digestibility, eventhough there appeared to be a trend for increased cellulose digestibility at lower levels of monensin.

Thompson and Riley (1980) observed that monensin increased the digestibility of crude fibre from 36.9 per cent in control group to 42.3 per cent in the treatment group in steers.

Vuuren and Nel (1983) opined that monensin decreased the apparent digestibility of crude fibre in lambs.

Ricke *et al.* (1984) conducted metabolism trials in sheep and observed that monensin did not significantly affect crude fibre digestibility.

Beede *et al.* (1985) reported that monensin increased the digestibility of crude fibre along with that of all other constituents in growing goats.

Faulkner *et al.* (1985) conducted metabolism trials in steers and concluded that monensin significantly increased crude fibre digestibility in the animals fed high fibre diets.

Lee *et al.* (1990) stated that monensin supplemented in concentrate rations containing 80 per cent concentrate and

20 per cent ground orchard grass hay, increased the digestibility of crude fibre in Korean native goats.

Ushida *et al.* (1991) reported that rumen protozoa has a positive effect on hemicellulose digestion. They also reported that rumen lignocellulose digestion is enhanced by protozoa when the diet is supplemented with starch. In addition they observed that monensin depressed protozoal counts by 50 to 60 per cent. This defaunating effect of monensin supplementation was attributed to the decreased fibre digestibility observed in their studies. Mbanzamihigo *et al.* (1995) concluded on the basis of their *in vitro* and *in vivo* studies that the above mentioned protozoal inhibition by monensin was transient because prolonged antibiotic feeding resulted in a resistant protozoal population in the rumen of cattle.

Patil and Honmonde (1994) conducted studies in lambs and observed higher values of crude fibre digestibilities in monensin treated groups (34.29% and 35.25% respectively) when compared to the controls (32.13%) but these increases were not significant.

Zinn *et al.* (1994) observed that monensin did not significantly affect fibre digestibility in rations of feed lot cattle containing 10 and 20 per cent forage respectively.

Haimound *et al.* (1995) reported that the addition of monensin in the diet increased the rumen degradation of fibre in dairy cows.

Bedo (1996) reported, increased crude fibre digestibility for rations of sheep containing high crude fibre (31.9 to 32.1%) supplemented with monensin.

Haimoud *et al.* (1996) stated that monensin reduced rumen breakdown of fibre in cows. They also observed that post rumen digestion of fibre was greater for diets supplemented with monensin. Hence monensin had no influence on apparent total digestibility of crude fibre.

2.2.3.2.3 Nitrogen balance

Joyner *et al.* (1979) observed that monensin supplemented at the rate of 20 ppm significantly increased the nitrogen (N) retention (6.6 g/day) in treated lambs when compared to controls (4.8 g/day). Patil and Honmonde (1994) observed a N retention of 8.59 g/day in lambs fed on a concentrate diet supplemented with 22 ppm monensin.

Vuuren and Nel (1983) in lambs and Beede *et al.* (1985) and Lee *et al.* (1990) in goats have reported that the N retention value obtained was not significant when compared to the control when monensin supplemented diets were fed.

2.2.3.3 Influence on supplemental fat

Blaxter *et al.* (1953) observed that vitamin E requirements were increased when polyunsaturated fats were fed to calves. However, Lundin and Palmquist (1983) reported that no indication of impaired vitamin E status was observed when four per cent stabilized fat was added to the diet.

Although supplemental fat and ionophores are often used concurrently in beef cattle finishing diets, the mechanism of interaction between fat and ionophores has not been clearly documented. O'Kelly and Spiers (1990) opined that the interaction may be related to the similar effects of fat and ionophores on rumen fermentation. They found that both fat and ionophores favour increased propionate production and decreased methane production; changes that suggest increased ruminal energetic efficiency. In addition they observed that some of the improvements in animal performance resulting from ionophores may be caused by increased lipid flow to the intestine. They also proved by *in vitro* studies that ionophores increased microbial lipid synthesis. They have reported increased small intestinal lipid digestibility, by steers; fed 33 vs zero ppm of monensin.

Contrary evidence was provided by the work of Clary *et al.* (1993) who concluded that the usual positive response of finishing cattle to ionophores may be altered by fat supplementation, perhaps in part as a result of negative associative effects between these additives since ruminal distribution and/or access of ionophores to sensitive microorganisms may be altered by the uneven distribution of fat in the rumen.

2.2.3.4 Influence on mineral metabolism

Dvorak *et al.* (1980) conducted a study on the effect of monensin on mineral metabolism in fattening cattle and opined that monensin had no effect on calcium, magnesium, phosphorus, zinc, copper and iron in rumen fluid or on sodium, potassium, calcium, magnesium, zinc, copper and iron in blood plasma.

2.2.3.5 Influence on carcass characteristics

Monensin does not have any significant effect on dressing percentage, as reported in lambs by Nockels *et al.*, (1978) and Vuuren and Nel, (1983).

Sharrow *et al.* (1981) studied the effects of monensin on lamb carcass characteristics. These workers reported that live weights taken immediately before slaughter and cold carcass weights were consistently higher for lambs fed monensin. They also reported that monensin had no effect upon dressing percentage. A dressing percentage value of

47 per cent was obtained in these studies on adding monensin at the rate of 22 mg/kg in a high roughage feed.

Gotthardt and Hort (1990) reported that monensin at the rate of 19 mg/kg in the rations of young bulls improved carcass quality in terms of hot carcass weight and dressing percentage.

2.2.4 Toxicity

Collins and Mc Crea (1978) studied *monensin* toxicity in bulls by feeding them with locally available grazing nuts containing over 2000 ppm monensin. Clinical signs noticed within 24 hours included anorexia, rise of temperature, dullness, depression and initial constipation followed by diarrhoea with dark brown faeces. Post mortem lesions included a constant feature of heart failure as indicated by an enlarged heart and widespread haemorrhage of the right ventricle and oedematous lungs. Prominent microscopic lesions were degeneration, neuronophagia and gliosis affecting the cerebrum.

Potter *et al.* (1984) reported a near complete anorexia resulting from intake of sublethal amounts of monensin (30 mg/kg body weight). They observed that mortality resulted from feeding groups of cattle, large quantities of monensin in small quantities of feed. Collectively these studies indicated that the greatest risk of intoxication occur when cattle first receive a feed containing monensin. They concluded that mixing errors and misuse situations under actual use conditions have resulted in mortality of cattle.

Gill *et al.* (1988) studied monensin toxicity in crossbred calves by giving monensin at dose rates of 75, 50 and 25 mg/kg body weight respectively in a single dose. The mortality rates obtained were 100 per cent in calves receiving 75 mg monensin/kg, 70 per cent in calves receiving 50 mg/kg and 20 per cent in calves receiving 25 mg/kg.

Polyether ionophore antibiotics can be particularly toxic because of their mode of action on the membranes of animal cells by formation of complexes with one or two available cations. Due to the binding of cation with the ionophore, a disturbance in diffusion potential results. The nerve cells may lose its conductivity and muscle cells may lose their contractivity as indicated by the loss of succinate dehydrogenase, lactate dehydrogenase and NADH activity in muscles observed in the work of Gill *et al.* (1988).

2.2.5 Economics

Stuart (1990) conducted growth studies in stocker cattle with diets supplemented with monensin. He found that using ionophores increased considerably the net return per head.

Gilb and Baker (1991) reported that monensin supplementation was cost effective in winter, but marginal in summer, when steers were grazed.

Horn *et al.* (1992) reported after studies in grazing steers which had access to an energy supplement containing monensin 75 mg/lb that profits were increased by 14 to 20$/head depending on the profit potential that existed during the ten year period, 1980-90.

2.3 Complete feed

2.3.1 Definition

Owen (1979) reported that the complete diet system implies the self feeding of a uniform mixture of feed ingredients processed in such a way as to avoid differential selection by the animal. According to Owen a complete feed is one which includes roughages and concentrates given as a sole source of nutrients except water and sometimes certain minerals.

2.3.2 Optimum protein, energy and fibre levels in complete rations

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

Owen (1979) recommended specifications of complete diets for dry stock, beef cows, ewes and finishing lambs. Finishing lambs of 15 to 25 kg live weight, require 10 to 17.5 per cent crude fibre, 16 per cent crude protein (min), 0.65 per cent calcium (min) and 0.25 per cent phosphorus (min).

Saini *et al.* (1987) reported that weaned Barbari kids of three months of age when fed on a concentrate mixture containing 16 per cent DCP and 70 per cent TDN at the rate of three per cent of their body weight and fodder *ad libitum* under intensive system showed significantly higher weight gains than kids under semi-intensive and extensive systems.

Paek *et al.* (1991) formulated a complete diet for Korean native cattle containing 11.27 per cent CP, 8.06 per cent CF and 67.3 per cent TDN and concluded that the daily gain and feed efficiency in the treatment group was superior to that in the control group fed on diet of rice straw and concentrate.

Chahal and Sharma (1992) formulated a complete ration for kids with 14.96 per cent CP and 18.55 per cent CF.

Upase (1995) reported that the use of a complete feed containing 13 per cent DCP and 66 per cent TDN gave excellent results in Deccani lambs.

2.3.3 Complete diets fed *ad libitum*

Lukmanov (1978) studied the effect of *ad libitum* feeding of complete feed mixtures on fattening Hereford bulls. He found that the most efficient method of feeding was to offer feed from self-feeders, which gave the highest average daily weight gain, lowest feed cost/kg gain and greatest carcass yield.

Rickaby (1978) reported an increase of five to ten per cent in DM intake in dairy cows on *ad libitum* complete diet feeding compared to the conventional feeding system.

Block and Shellenberger (1980a and b) studied the effect of complete feeds in calves by giving them *ad libitum*, once daily in the morning.

2.3.4 Complete diets in mash form

Boucque *et al*. (1981) studied the effect of physical form of a complete diet on performance of fattening bulls and reported that highest intake of drymatter and lowest feed costs were obtained in the dry coarsely mixed concentrate.

Reddy and Reddy (1985) studied the effect of complete feed mash and complete feed pellets on growth performance and nutrient digestibility in Nellore sheep. They reported that, while significantly increased weight gains were observed in animals receiving pelletted rations, the average daily gains of animals fed mash rations and of the grazing group were comparable.

2.3.5 Complete rations with low fibre content

2.3.5.1 Influence on feed intake and weight gain

Animals fed on complete rations containing less crude fibre (approximately 8%) had higher dry matter intakes and higher daily gains as reported by Vasilev *et al.* (1975) in beef cattle, Murdock and Wallenius (1980) in calves and Aees (1993) in dairy cows.

2.3.5.2 Influence on rumen fermentation and digestibility of nutrients

Pardue *et al.* (1975) studied the influence of complete feed on rumen environment by giving *ad libitum* a diet containing 15.2 per cent CP and 75.2 per cent TDN in cows. They observed that the Total Volatile Fatty Acid (TVFA) concentration was higher in these cows when compared to the controls. The molar proportions of propionate were increased from 18 per cent in the control to 20 per cent in the complete feed, while that of acetate decreased from 66 per cent in the control to 61 per cent in the complete feed and that of butyrate showed a marginal increase from 12 per cent in control to 13 per cent in the complete feed.

Everson *et al.* (1976) observed that increasing the proportion of grain, while holding intake relatively constant, increased the digestibility of all organic nutrients except crude fibre.

Metzger *et al.* (1976) observed that feeding high concentrate and restricted roughage rations in dairy cows decreased the numbers of cellulolytic and fibre digesting bacteria and increased the number of lactic and propionic acid producing bacteria as well as proteolytic bacteria. They also observed that rumen propionate content was high in these cows.

Wheeler and Noller (1976) and Wheeler (1980) reported from results of digestion trials in cows that intakes of all concentrate rations above the maintenance could result in a depression in digestibility of starch. They attributed this effect to a reduced activity of pancreatic alpha amylase in the small intestine due to pH values below the optimal 6.9.

Pulina *et al.* (1995) found out that the digestibility of crude fibre was low in the low fibre group in dairy ewes fed on a complete pelletted feed.

2.3.5.3 Lactic acidosis

Finely ground high concentrate complete diets, when fed continuously for a period of time, may result in excess acidity in the rumen. The clinical condition produced is called lactic acidosis and is characterised by reduced feed intake and rumen motility as reported by several workers (Boshinova, 1976; Wheeler *et al.*, 1980 and Marckiewicz *et al.*, 1988).

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. The condition is called `parakeratosis'.

The phenomenon of lactic acidosis and parakeratosis produced by high concentrate complete feeds was studied in detail by Block and Shellenberger (1980a and b). The study was conducted in young dairy replacements in two stages; from birth through 18 weeks of age and from 18 through 36 weeks of age. The three rations consisted of (dry basis); (1) 11 per cent woodpulp fines and 89 per cent concentrate;

(2) 33.7 per cent corn silage and 66.3 per cent concentrate; and (3) a commercially available pelletted complete ration. Rumen tissue from male calves at both the stages fed woodpulp showed the most normal appearance in papillae colour, density and length. Calves fed silage had rumen tissue showing short, black, nodular papillae. Calves fed commercial ration showed long, branched, necrotic papillae that were keratotic and loosely attached. These workers postulated that the necrosis of the papillae could have been caused by rapid acid production around the papillae when easily fermentable materials touched the rumen wall.

2.3.6 Complete rations with high fibre content

Complete feeds which are high in crude fibre decreased the intake of feed and weight gain and increased the digestibility of crude fibre as reported by several workers (Vasilev *et al.*, 1975; Yadav *et al.*, 1990 and Rohr and Oslage, 1975). Soo (1995) reported that forage finished cattle have less carcass fat than those finished on grain, but the meat has a less desirable flavour and tenderness and a shorter shelf-life.

2.3.7 Growth

2.3.7.1 Body weight

Reddy and Reddy (1985) conducted studies in three to four month old Nellore lambs. They reported a daily weight gain of 58.00 g on a mash diet containing 46 per cent forest grass and 55.00 g on a similar diet with sorghum straw replacing the grass.

Saini *et al.* (1987) reported an average daily gain of 61.00 g in Barbari kids, weaned at three months of age and reared intensively for a period of 90 days.

Chahal and Sharma (1992) obtained an average daily gain of 92.80 g in crossbred male kids of five to six months of age, fed on a complete diet for a period of 14 weeks.

Ralston (1997) observed an average daily gain of 43.41 g in Malabari kids fed on a complete diet under intensive system for a period of four months from three months of age onwards.

Deepa (1998) reported an average daily gain of 62.77 g in the control diet which had guinea grass as the major roughage when compared to the treatment groups (59.38 and 53.21 grams respectively) which had tapioca leaves and glyricidia leaves as major roughage source in studies on complete rations for kids.

2.3.7.2 Body measurements

Body measurements of Black Bengal goats were studied by Singh *et al.* (1979) who recorded the body length, chest circumference and height at withers as 43.7 cm, 53.3 cm and 49.1 cm respectively in goats which had an average body weight of 10.8 kg.

A significant increase in the height at withers and chest circumferance was reported by Block and Shellenberger (1980a) in dairy calves fed on a commercially available pelletted ration when compared to those fed on conventional rations.

Gangadevi (1981) observed a 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) reported a length of 54.8 cm, a heart girth of 57.1 cm and a height at withers of 51.3 cm in seven to eight month old Malabari kids maintained on a complete feed under intensive system.

2.3.8 Dry matter intake

Reddy and Reddy (1985) reported an average daily dry matter intake of 747.00 g and 705.00 g in Nellore lambs fed on complete rations which worked out to 4.33 and 4.16 kg per 100 kg live weight.

Shyama (1994) observed a dry matter intake of 562.92, 574.59, 572.30 and 564.00 g per day in kids maintained on rations containing 12 per cent and 16 per cent crude protein with and without supplementation of dried spleen.

Deepa (1998) reported that the average dry matter intakes in kids maintained on complete diets containing guinea grass, tapioca leaves and glyricidia leaves as major roughage were 569.07, 554.00 and 510.00 g respectively.

2.3.9 Feed conversion efficiency

Block and Shellenberger (1980a) obtained a feed conversion efficiency of 3.30 in Holstein calves when fed on a commercially available pelletted ration, which was low in crude fibre.

Reddy and Reddy (1985) reported a feed conversion efficiency of 12.45 and 12.77 respectively in Nellore lambs fed complete feeds in mash form containing forest grass and sorghum straw as the roughage source.

The feed conversion efficiency obtained by Chahal and Sharma (1992) in their studies on complete rations in kids were 9.06 in the control and 12.77, 10.74 and 14.20 respectively in the three treatment groups.

Deepa (1998) obtained a feed conversion efficiency of 9.10 in the control group which was superior when compared to the treatment groups (9.30 and 9.70 respectively) in her studies on complete rations for kids.

2.3.10 Cost efficiency

Reddy and Reddy (1985) reported that the cost of feed/kg live weight gain was Rs.9.28 and Rs.9.45 respectively in Nellore lambs fed complete feed in mash form, with two different roughage sources.

Chahal and Sharma (1992) conducted studies in kids and observed that the feed cost/kg live weight gain in kids fed complete ration was least in the control group with a value of Rs.14.09.

Deepa (1998) reported a cost per unit gain value of Rs.69.54, 60.43 and 59.16 respectively for kids maintained on the complete rations I, II, and III containing different roughage sources.

2.3.11 Carcass characteristics-dressing percentage

Saini *et al*. (1987) reported an average slaughter weight of 17.93 kg, average dressed carcass weight of 8.47 kg and an average dressing percentage of 47.02 in Barbari kids reared under intensive system and slaughtered at 6 months of age.

Skrivanova *et al.* (1995) reported that there were no significant differences in dressing percentages of White Short-wooled goats fed three different complete rations, the values being 40.10, 43.30 and 43.80 per cent respectively.

Upase (1995) obtained a dressing percentage of 48.50 in lambs given a complete diet containing 12.4 per cent DCP and 66.7 per cent TDN.

Ralston (1997) reported a dressing percentage of 49.15 in Malabari kids fed on a complete feed under intensive system.

2.3.12 Digestion and metabolism trial

2.3.12.1 Digestibility coefficients of nutrients

Reddy and Reddy (1985) conducted studies in Nellore lambs by feeding them with complete rations in mash form. The digestion coefficients for dry matter, organic matter, crude protein, crude fibre, ether extract and nitrogen free extract were 56.11, 59.89, 58.97, 49.91, 50.39, 65.74 and 59.92, 62.87, 58.99, 52.97, 55.04 and 65.78 per cent respectively for rations containing forest grass and sorghum straw as the source of roughage.

Ram *et al.* (1990) reported the digestibility coefficients of dry matter, organic matter, crude protein, ether extract, crude fibre and nitrogen free extract as 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 respectively for three different complete rations in goats.

Chahal and Sharma (1992) observed that the digestibility coefficients in kids fed complete diets were maximum in the control group, the values in percentages being 67.76 for dry matter, 70.50 for organic matter, 67.27 for crude protein 45.20 for crude fibre, 88.10 for ether extract and 73.20 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 a complete ration containing 11.95 per cent crude protein and 23.35 per cent crude fibre.

Deepa (1998) conducted studies in Malabari kids and observed that the digestibility coefficients of dry matter, crude protein, ether extract, crude fibre and nitrogen free extract were 67.04, 65.26, 86.48, 36.36, 81.43; 60.72, 59.79, 77.53, 43.01, 74.19 and 56.37, 54.46, 68.30, 49.44 and 63.83 per cent respectively with three different complete rations in kids. She observed that the digestibility coefficients except that of crude fibre were higher in the control group when compared to the treatment groups.

2.3.12.2 Nitrogen balance

Positive nitrogen balances were reported by several workers on feeding complete feeds in different species of growing ruminants.

Reddy and Reddy (1985) conducted studies in Nellore sheep and obtained nitrogen balance values of 4.46 and 5.77 g per day on feeding complete rations in mash form, containing forest grass and sorghum straw as the source of roughage.

Ram *et al.* (1990) reported nitrogen balance values of 3.23, 5.62 and 5.35 g per day on feeding three different complete rations to goats.

Tagel *et al.* (1990) observed nitrogen balance values of 6.50, 6.30, 3.10, 2.50 and 7.60 g per day in adult rams fed five different complete diets.

Chahal and Sharma (1992) obtained a nitrogen balance value of 7.63 g per day in the control group in a study on the performance of kids fed four different complete feeds.

Dayal *et al.* (1995) conducted studies in goats and reported nitrogen balance values of 4.21, 3.54, 2.88 and 1.92 g per day with four different complete feeds.

Deepa (1998) reported nitrogen balance values of 9.73, 7.44 and 7.18 g per day in Malabari kids fed three different complete rations. The nitrogen retention expressed as a percentage of intake amounted to 53.03, 47.26 and 46.12 per cent respectively in these three groups.

2.3.13 Monensin in complete feeds

Fontenot and Huchette (1992) reported that feeding of complete feeds containing atleast one ionophore antibiotic and sorbitol, improved feed conversion efficiency in ruminants.

Materials and Methods

MATERIALS AND METHODS

The animal experiment part of the present investigation was carried out at the Goat and Sheep Farm of the Kerala Agricultural University attached to the College of Veterinary and Animal Sciences, Mannuthy.

3.1 Animals

Thirty Malabari kids of three to four months of age (fifteen males and fifteen females), born and reared in the farm, were selected for the experiment. The animals were dewormed with Albendazole Suspension (Albendazole 25 mg/ml, Wockhardt) and dipped in diluted Butox (Deltamethrin 1.25%, Hoechst) solution to eliminate ectoparasites. The animals were divided randomly into three groups (I, II and III) of 10 animals each, as uniformly as possible with regard to age, body weight and sex. The three groups of animals were housed in separate pens. Each pen was provided with feed and water troughs kept at an appropriate height. All the animals were maintained under identical conditions of feeding and management. The animals were fed on the respective experimental rations for a pre-experimental period of two weeks. The duration of the experiment was 13 weeks. During the course of the experiment the animals were dewormed once a month using Albendazole Suspension. Dung samples were examined every two weeks to make sure that the animals did not carry any worms.

3.2 Experimental rations

The experimental rations consisted of three complete rations, A, B and C containing 8, 12 and 16 per cent crude fibre respectively. The rations were isoproteimic and isocaloric.

The calculated percentage composition of the three experimental rations were

Rations	Calculated CP	Calculated CF	Calculated TDN
Ration A	15.56	8.62	65.60
Ration B	15.11	12.85	64.29
Ration C	14.93	16.37	63.50

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

Table 1. Percentage ingredient composition of complete rations

	Ingredients	A	B	C
1.	Groundnut cake (expellar)	5	10	15
2.	Gingelly oil cake	5	5	5
3.	Yellow maize	26	25	24
4.	Wheat bran	57	34	14
5.	Lucerne meal	5	5	5
6.	Hay	-	18	33
7.	Mineral mixture*	1.5	1.5	1.5
8.	Common salt	0.5	0.5	0.5
9.	Fat (Tallow)	-	1	2

To 100 kg of the above three rations 20 g of `Coban 100' (Elanco, USA) and 250 g of `Alvite-M' (Alembic) was added. Coban 100 was the monensin preparation used. It contained 10 per cent monensin sodium. Alvite-M was the vitamin mixture added. It contained Vitamin A 5,00,000 I.U., Vitamin D_3 1,02,500 I.U., Vitamin B_2 0.13 g, Vitamin E 87.5 Units and Vitamin K 0.1 g per 250 g.

* The mineral mixture added was Keyes Forte Mineral Mixture for cattle containing 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%.

Table 2. Percentage chemical composition of complete rations

Nutrients	Complete rations		
	A	B	C
1. Moisture	10.09	10.04	9.14
2. Organic matter	93.60	94.26	93.08
3. Crude protein	16.04	15.86	15.97
4. Ether extract	3.64	4.21	4.85
5. Crude fibre	8.60	12.96	16.72
6. Nitrogen free extract	65.32	61.23	55.54
7. Total ash	6.40	5.74	6.92
8. Acid insoluble ash	0.91	1.48	3.08
9. Calcium	1.22	1.34	0.98
10. Phosphorus	0.86	1.06	0.70
11. Potassium	1.19	1.14	1.20

Values of items 2 to 11 on DM basis

The feed ingredients were purchased from local sources. Hay made from congosignal grass (*Brachiaria ruziziensis*) was chaffed and then coarsely powdered in a hammer mill. Fresh beef fat (tallow) was preserved by adding Butylated Hydroxy Toluene (BHT) at 0.2 per cent level. The fat was mixed thoroughly with coarsely powdered hay before mixing with rations B and C. To ensure thorough mixing, monensin was premixed with wheat bran before the final mixing in a horizontal mixer. The three experimental rations were processed in the feed plant attached to the Small Animals Breeding Station. Representative samples of the rations were analysed for proximate principles as per standard procedure (AOAC, 1990). The minerals, calcium and potassium in feed were estimated using atomic absorption spectrophotometer (Perkin-Elmer model 3110) and phosphorus by colorimetry (Ward and Johnston, 1962).

3.3 Methods

The animals were offered respective rations thrice a day at the scheduled timings on *ad libitum* basis. The left over feed was collected before every feeding and quantified. Records of daily feed intake by each experimental group was maintained. Individual records of weekly body weights and body measurements such as body length from the point of shoulder to pin bone, chest girth and height at withers of all the experimental animals were maintained.

3.4 Feed conversion efficiency

The weekly feed conversion efficiency of each group was calculated by dividing the respective quantities of feed consumed by each group, by gain in weight of the group.

3.5 Digestion-cum-metabolism trial

Towards the end of the feeding experiment, a digestion-cum-metabolism trial was carried out using four animals from each of the three groups. The animals were maintained in the metabolism cages for seven days and the dung and urine were collected during the last five days.

Measured quantity of feed was offered three times a day and the left over feed was quantified. Representative samples of complete feed of each group was taken every day during the trial for proximate analysis.

Total collection method was employed for collection of dung. All precautions were taken to ensure the collection of dung quantitatively uncontaminated by urine or any feed residue or dirt. The dung was collected manually as and when it was voided and stored in an airtight plastic container kept separately for each animal.

Total collection method was also employed for collection of urine. The entire urine voided by the animal was collected in a `Winchester bottle' containing 20 ml of 25 per cent sulphuric acid as preservative.

At 7.30 am every day the dung and urine collected during the previous 24 hours were weighed accurately, mixed thoroughly and representative samples at the rate of 10 per cent of the total voided quantity were taken and stored in a deep freezer. The process of collection, weighing and sampling of dung and urine was continued till the end of the trial.

Dung and urine samples of each animal collected during the metabolism trial period were pooled, mixed and samples taken for proximate analysis. Proximate analysis of feed and dung were carried out as per standard procedure (AOAC, 1990). The urine samples collected during the metabolism trial were subjected to determination of nitrogen as per standard procedure (AOAC, 1990). Digestibility coefficients of nutrients and nitrogen balance were calculated from the above data.

3.6 Dressing percentage

At the termination of the feeding experiment three male animals from each group were slaughtered at the Kerala Agricultural University Meat Technology Unit to assess the dressing percentage.

3.7 Histopathology

Two samples of rumen wall of 10x10 cm size were collected from each animal slaughtered for histopathological examination. Samples of the tissues were preserved in 10 per cent neutral buffered formalin. They were processed by routine paraffin embedding techniques (Armed Forces Institute of Pathology, 1968). Paraffin sections cut at five to six micron thickness from the 18 samples of tissue collected were stained with Haematoxylin and Eosin (H&E) method of Haris as described by Disbrey and Rack (1970).

3.8 Economics

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

3.9 Statistical analysis

Statistical analysis of the data was carried out using the statistical software `MStat' at the Department of Statistics, College of Veterinary and Animal Sciences, Mannuthy. A one factor randomized complete block design was adopted to study the effect of monensin supplementation at 20 mg/kg level in complete feeds with different levels of fibre (8%, 12% and 16% respectively) on body weight and body measurements using Analysis of Covariance (ANOCOVA) technique. The significantly different treatment means were compared using Critical Difference (CD) test (Snedecor and Cochran, 1980). A one factor completely randomized design was adopted to study the effect of monensin supplementation on the other parameters, viz. dry matter intake, feed conversion efficiency, average daily body weight gain, digestibility coefficients of nutrients and nitrogen balance using Analysis of Variance (ANOVA) technique, with the significantly different treatment means being compared by Least Significant Difference (LSD) test (Snedecor and Cochran, 1980).

Results

RESULTS

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

4.1 Body weight

The body weight records of the animals at weekly intervals are presented in Tables 3 to 5 and represented in Fig.1. Their consolidated data are presented in Table 7. The statistical analysis of the data on weekly body weights and cumulative weight gain are given in Table 6.

4.2 Body measurements

The data on body length, girth and height recorded every week are presented in Tables 8 to 10, 13 to 15 and 18 to 20 respectively and represented in Fig.2. Their consolidated data are presented in Tables 12, 17 and 22 respectively. The statistical analysis of the data on body length, girth and height along with their cumulative increases are presented in Tables 11, 16 and 21 respectively.

4.3 Dry matter intake

The average daily dry matter consumption per week during the period of 13 weeks of study is presented in Table 23 and represented in Fig.3. Its statistical analysis is presented in Table 24.

4.4 Average daily body weight gain

The average daily gain in weights of the three experimental groups for 13 weeks of study are presented in Table 25, represented in Fig.4 and its statistical analysis given in Table 26.

4.5 Feed conversion efficiency

Feed conversion efficiency values of the three experimental groups are tabulated in Table 27 and their statistical analysis in Table 28. The cumulative feed conversion efficiency of animals in the three groups are represented in Fig.5.

4.6 Cost per unit gain

Data on cost per unit gain are tabulated in Table 29 and represented in Fig.6.

Summarised data on body weight changes, dry matter intake, feed efficiency and cost efficiency of animals in the three groups are given in Table 30.

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 animals belonging to the three groups are presented in Tables 31 to 33 and represented in Fig.7 to 12. The consolidated data on the above are given in Table 34 and their analysis of variance in Tables 35 to 40.

Summarised data on average daily intake of dry matter, digestible crude protein and total digestible nutrient per 100 kg body weight are given in Table 41 and their statistical analysis in Tables 42 to 44.

The data on digestible crude protein (DCP) and total digestible nutrient (TDN) intake per 100 g dry matter intake are presented in Table 45.

4.8 Nitrogen balance

The summarised data on nitrogen balance and per cent retention of nitrogen in kids belonging to the three experimental groups are given in Table 46 and statistical analysis of per cent retention of nitrogen in Table 47.

4.9 Dressing percentage

The data on dressing percentage of animals slaughtered from the three experimental groups are presented in Table 48, represented in Fig.13 and their statistical analysis given in Table 49.

4.10 Histopathology of the rumen epithelium

Representative microphotographs of the rumen tissue of one animal from each of the three experimental groups are presented in Fig.15 to 17.

4.11 Economics

The economics of the study are tabulated in Table 50 and the gross profit for ten animals in each group for three months is represented in Fig.14.

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

Weeks	Replicate 1	2	3	4	5	6	7	8	9	10	Average with S.E.
0	8.9	7.5	8.8	7.4	9.0	7.9	7.8	6.8	7.3	7.0	7.8±0.26
1	10.2	8.7	10.4	8.5	10.0	7.8	10.0	7.4	8.3	9.8	9.1±0.35
2	10.3	8.8	9.7	9.0	10.7	7.9	10.1	7.5	8.5	8.5	9.1±0.34
3	11.0	10.5	9.9	9.2	10.2	7.9	10.4	7.7	8.9	8.6	9.4±0.36
4	11.8	10.0	11.2	10.8	11.5	9.1	11.0	8.8	9.4	9.2	10.3±0.35
5	13.0	10.3	12.9	10.7	12.9	9.6	11.6	9.4	9.8	9.7	11.0±0.47
6	13.5	11.1	13.9	11.0	14.0	10.7	12.2	9.9	10.1	10.4	11.7±0.51
7	14.7	11.7	15.2	11.4	14.6	11.2	13.4	10.5	10.9	10.7	12.4±0.58
8	16.3	13.0	16.1	12.5	15.4	12.4	14.1	11.2	11.7	12.0	13.5±0.59
9	16.8	14.0	17.2	13.7	17.2	13.4	14.9	12.1	12.2	12.5	14.4±0.64
10	17.9	15.0	18.3	14.6	18.8	14.3	15.7	12.5	12.6	13.9	15.4±0.72
11	18.7	15.9	19.0	15.6	20.2	15.5	16.8	12.9	13.6	14.5	16.3±0.76
12	19.0	16.5	19.3	15.8	20.8	15.8	17.4	13.4	13.7	14.8	16.5±0.78
13	19.5	16.5	19.7	16.4	21.7	17.8	18.8	13.8	14.4	15.5	17.4±0.80

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

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	10.0	8.7	8.2	7.2	7.1	8.7	8.7	7.2	6.2	6.0	7.8±0.40
1	10.8	9.7	8.0	7.4	8.4	9.9	9.4	7.9	9.0	7.5	8.8±0.36
2	11.7	9.8	8.9	7.7	8.6	10.7	9.4	8.3	9.5	8.0	9.3±0.40
3	12.5	11.0	9.2	6.9	9.3	11.1	10.2	8.8	9.7	9.0	9.8±0.49
4	13.4	11.7	10.0	7.1	10.6	11.6	11.0	9.4	10.0	9.5	10.4±0.53
5	14.6	12.5	10.7	7.6	11.1	12.3	11.7	10.1	11.3	10.0	11.2±0.58
6	15.1	13.1	11.2	8.5	11.7	12.7	12.2	11.1	12.2	10.9	11.9±0.54
7	15.7	13.8	12.0	8.8	12.8	13.4	12.4	10.8	12.9	11.0	12.4±0.60
8	16.8	14.3	11.4	9.5	13.3	13.8	12.5	11.5	13.1	11.5	12.8±0.63
9	17.8	15.9	12.5	9.4	14.8	14.5	13.5	11.9	13.8	11.8	13.6±0.75
10	18.8	16.1	13.2	10.7	15.6	15.2	13.7	12.5	14.8	12.8	14.3±0.72
11	19.5	16.5	13.7	11.1	16.0	15.4	14.2	12.8	15.6	12.8	14.8±0.75
12	19.7	17.5	14.4	11.4	16.1	16.0	14.5	13.4	16.4	13.1	15.3±0.76
13	20.9	18.8	15.5	12.0	17.5	17.0	15.8	13.7	18.0	13.4	16.3±0.86

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

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	9.5	9.3	8.9	7.5	6.8	6.8	7.6	8.2	7.2	6.7	7.8±0.34
1	9.9	10.4	10.9	8.2	7.2	7.4	8.3	8.5	8.1	9.0	8.8±0.39
2	10.3	10.5	11.3	8.2	6.7	7.8	8.7	7.6	8.4	8.9	8.8±0.46
3	11.0	11.3	11.1	8.5	6.8	8.1	9.3	8.3	8.6	9.1	9.2±0.47
4	11.8	12.3	11.6	8.3	7.1	8.8	9.4	9.4	8.0	9.7	9.6±0.55
5	12.7	12.8	12.7	8.9	7.7	9.5	10.6	9.5	8.9	10.5	10.4±0.58
6	13.2	13.3	13.1	9.4	7.8	10.1	11.4	9.6	9.0	10.9	10.8±0.61
7	13.8	13.1	13.3	9.7	7.9	10.3	11.3	9.9	9.0	11.1	10.9±0.62
8	14.7	13.1	13.9	10.1	8.2	10.4	12.4	10.1	8.6	11.3	11.3±0.69
9	16.1	13.6	14.1	10.9	8.7	11.3	12.8	10.3	8.9	12.2	11.9±0.74
10	17.0	13.6	14.8	11.1	8.9	12.1	13.4	10.3	8.5	12.7	12.2±0.84
11	17.4	13.4	14.6	11.6	8.5	12.7	13.0	10.5	8.4	12.7	12.3±0.86
12	18.0	13.6	15.5	12.2	9.2	13.0	13.8	11.0	8.6	12.8	12.8±0.88
13	19.5	13.7	16.7	13.8	10.3	12.9	15.4	12.3	9.6	14.0	13.8±0.92

Table 6. Analysis of covariance - Weekly body weight (kg) and cumulative weight gain (kg)

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	0.697	0.292	10.679	0.523
2	0.592	0.531	9.887	0.690
3	1.142	0.908	6.846	0.749
4	0.652	1.926	11.650	1.036
5	1.035	1.959	12.962	1.201
6	1.074	3.582	11.942	1.419
7	1.411	7.307*	10.667	1.612
8	1.665	12.674**	9.373	1.894
9	2.002	16.611**	11.008	2.486
10	2.916	25.534**	9.497	3.016
11	2.812	40.816**	10.938	3.527
12	2.688	38.877**	9.908	3.843
13	3.039	34.108**	13.758	4.643
Cumulative weight gain	2.716	29.109**	0.195	3.412

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

Table 7. Consolidated data on body weight (kg) and cumulative weight gain (kg) of kids in the three groups

Weeks	Average body weight		
	Group I	Group II	Group III
0	7.8 ± 0.26	7.8 ± 0.4	7.8 ± 0.34
1	9.1 ± 0.35	8.8 ± 0.36	8.8 ± 0.39
2	9.1 ± 0.34	9.3 ± 0.39	8.8 ± 0.46
3	9.4 ± 0.36	9.8 ± 0.49	9.2 ± 0.47
4	10.3 ± 0.35	10.4 ± 0.53	9.6 ± 0.55
5	11.0 ± 0.47	11.2 ± 0.58	10.4 ± 0.58
6	11.7 ± 0.51	11.9 ± 0.54	10.8 ± 0.61
7	12.4 ± 0.58[a]	12.4 ± 0.60[a]	10.9 ± 0.62[b]
8	13.5 ± 0.59[a]	12.8 ± 0.63[a]	11.3 ± 0.69[b]
9	14.4 ± 0.64[a]	13.6 ± 0.75[a]	11.9 ± 0.74[b]
10	15.4 ± 0.72[a]	14.3 ± 0.72[a]	12.2 ± 0.84[b]
11	16.3 ± 0.76[a]	14.8 ± 0.75[a]	12.3 ± 0.86[b]
12	16.5 ± 0.78[a]	15.3 ± 0.76[a]	12.8 ± 0.88[b]
13	17.4 ± 0.80[a]	16.3 ± 0.86[a]	13.8 ± 0.92[b]
Cumulative weight gain	9.6 ± 0.57[a]	8.5 ± 0.71[a]	6.0 ± 0.74[b]

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

Fig.1 AVERAGE WEEKLY BODY WEIGHT (kg) OF KIDS IN THE THREE GROUPS

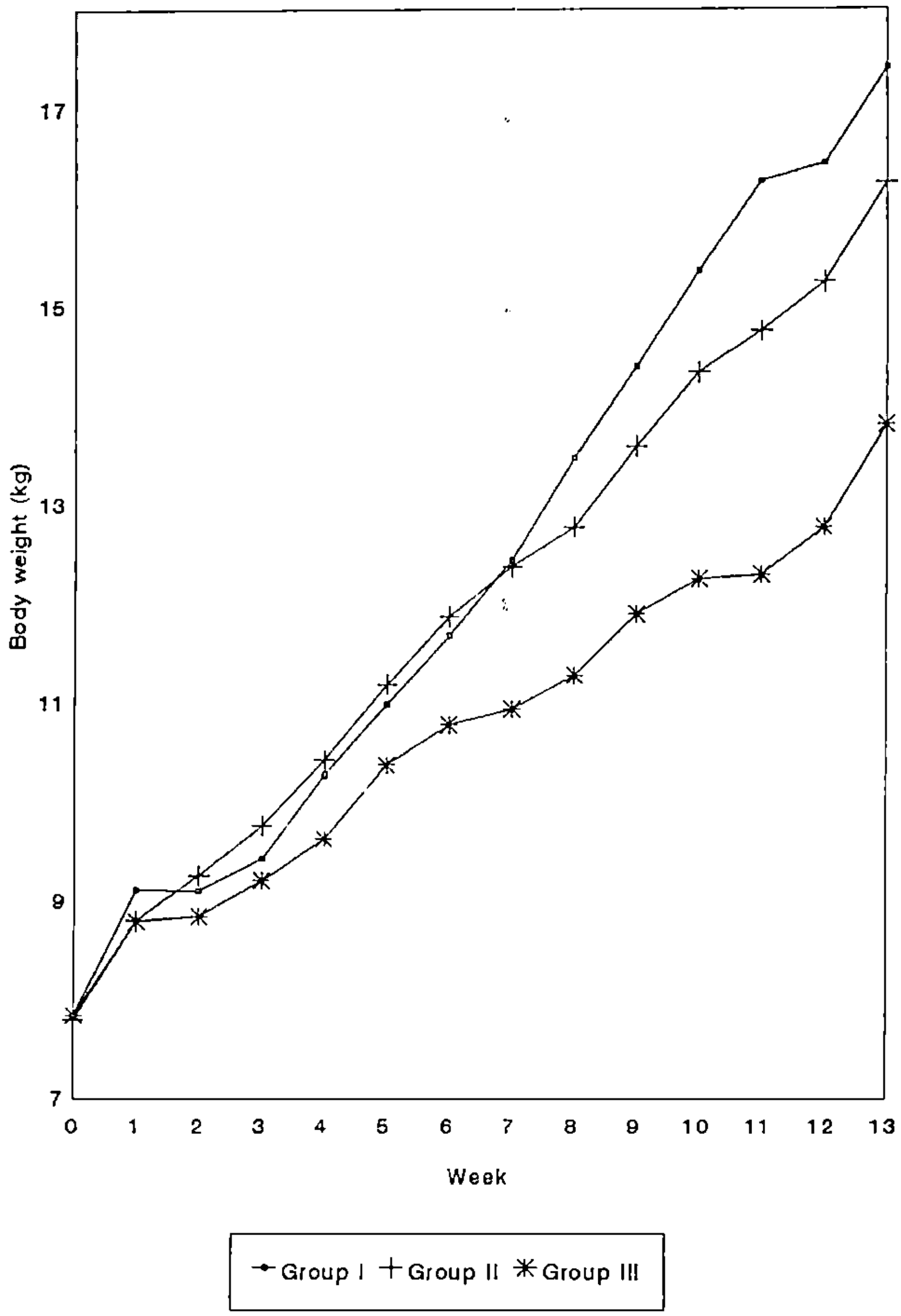


Table 8. Body length (cm) of kids recorded at weekly intervals (Group I)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	39	37	35	32	39	35	38	35	39	40	36.9±0.81
1	39	38	39	37	39	40	42	35	40	41	39.0±0.63
2	42	39	41	40	43	40	42	37	41	42	40.7±0.56
3	42	43	42	42	44	43	44	42	44	43	42.9±0.28
4	45	44	46	45	44	45	45	42	44	45	44.5±0.34
5	46	45	47	46	47	45	47	43	45	45	45.6±0.40
6	48	46	48	46	48	46	47	44	46	45	46.4±0.43
7	48	46	50	46	49	48	48	46	48	47	47.6±0.43
8	50	48	52	48	50	48	49	46	49	49	48.9±0.50
9	53	49	52	48	52	48	49	46	49	50	49.6±0.69
10	53	50	53	51	57	49	50	48	50	50	51.1±0.82
11	54	51	55	51	57	49	50	49	51	52	51.9±0.84
12	55	52	56	53	57	51	51	49	51	53	52.8±0.81
13	56	53	57	54	57	52	51	49	51	53	53.9±1.03

Table 9. Body length (cm) of kids recorded at weekly intervals (Group II)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	42	40	39	35	38	38	42	37	37	38	38.6±0.70
1	43	43	40	37	40	40	42	39	38	39	40.1±0.64
2	44	43	41	37	42	42	42	41	42	40	41.7±0.60
3	44	46	44	39	43	44	45	42	42	40	42.9±0.69
4	45	48	47	42	44	46	45	42	45	43	44.7±0.63
5	51	48	47	42	46	47	47	44	47	43	46.2±0.83
6	52	48	51	44	46	48	48	44	47	43	47.1±0.94
7	53	50	52	44	47	49	48	45	48	44	48.0±0.99
8	53	52	52	46	48	49	50	46	50	45	49.1±0.87
9	54	53	52	47	48	49	50	46	51	46	49.6±0.91
10	54	54	53	48	50	49	52	48	52	47	50.7±0.83
11	57	55	53	49	52	49	52	48	55	47	51.7±1.07
12	59	56	53	49	53	53	54	51	57	49	53.4±1.04
13	59	57	53	49	56	53	54	52	57	50	54.0±1.05

Table 10. Body length (cm) of kids recorded at weekly intervals (Group III)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	41	37	40	37	35	37	38	38	37	40	38.0±0.58
1	42	41	40	38	39	37	41	38	38	41	39.5±0.54
2	44	42	40	40	40	38	41	38	39	41	40.3±0.58
3	44	44	44	43	40	43	43	39	40	44	42.4±0.62
4	46	46	45	44	41	44	44	41	42	45	43.8±0.59
5	49	46	47	44	41	44	46	41	43	46	44.7±0.82
6	49	48	48	44	42	46	46	41	44	47	45.5±0.85
7	50	51	48	46	42	47	48	44	44	47	46.7±0.88
8	50	51	48	46	44	47	48	44	44	47	46.9±0.78
9	51	51	49	49	44	47	48	44	45	49	47.7±0.85
10	55	52	50	50	44	49	48	44	45	50	48.7±1.13
11	56	54	53	50	46	50	48	46	46	50	49.9±1.12
12	57	55	53	51	47	50	50	48	46	54	51.1±1.12
13	58	55	54	51	48	50	50	49	46	54	51.5±1.18

Table 11. Analysis of covariance - Weekly body length (cm) and cumulative increase in length (cm)

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	3.690	0.837	6.792	1.832
2	2.924	1.904	3.136	2.196
3	2.983	1.771	17.142	1.992
4	4.767	1.938	2.150	1.493
5	5.736	4.357	5.052	3.071
6	8.998	4.769	5.751	2.552
7	8.063	3.571	5.649	4.087
8	7.906	13.756*	3.187	2.853
9	8.935	11.959	9.306	3.214
10	8.888	18.659	20.873	5.926
11	11.750	12.985	19.950	5.948
12	7.981	12.367	12.417	7.792
13	13.928	19.729	8.400	7.672
Cumulative increase in length	11.619	22.378	0.085	8.580

* Significant at 5 per cent level

Table 12. Consolidated data on body length (cm) and cumulative increase in length (cm) of kids in the three groups

Weeks	Average body length		
	Group I	Group II	Group III
0	36.9 ± 0.81	38.6 ± 0.70	38.0 ± 0.58
1	39.0 ± 0.63	40.1 ± 0.64	39.5 ± 0.54
2	40.7 ± 0.56	41.7 ± 0.60	40.3 ± 0.58
3	42.9 ± 0.28	42.9 ± 0.69	42.4 ± 0.62
4	44.5 ± 0.34	44.7 ± 0.63	43.8 ± 0.59
5	45.6 ± 0.40	46.2 ± 0.83	44.7 ± 0.82
6	46.4 ± 0.43	47.1 ± 0.94	45.5 ± 0.85
7	47.6 ± 0.43	48.0 ± 0.99	46.7 ± 0.88
8	48.9 ± 0.50[a]	49.1 ± 0.87[a]	46.9 ± 0.78[b]
9	49.6 ± 0.69	49.6 ± 0.91	47.7 ± 0.85
10	51.1 ± 0.82	50.7 ± 0.83	48.7 ± 1.13
11	51.9 ± 0.84	51.7 ± 1.07	49.9 ± 1.12
12	52.8 ± 0.81	53.4 ± 1.04	51.1 ± 1.12
13	53.9 ± 1.03	54.0 ± 1.05	51.5 ± 1.18
Cumulative increase in length	17.0 ± 1.26	15.4 ± 0.84	13.5 ± 0.89

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

Table 13. Chest girth (cm) of kids recorded at weekly intervals (Group I)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	48	46	48	45	46	44	49	42	40	41	44.9±0.98
1	50	47	48	46	47	44	50	43	42	42	45.9±0.96
2	50	47	48	46	47	45	50	43	44	42	46.2±0.87
3	51	47	49	48	48	45	52	44	46	44	47.4±0.87
4	51	48	51	48	49	45	52	45	46	49	48.4±0.79
5	53	48	53	49	51	47	55	47	47	49	49.9±0.92
6	55	49	55	49	53	48	55	47	49	50	51.0±1.00
7	55	51	55	51	54	48	56	48	49	50	51.7±0.96
8	56	53	55	52	55	50	57	49	50	51	52.8±0.91
9	57	54	57	52	57	51	57	50	50	52	53.7±0.97
10	58	56	58	55	58	52	59	51	51	54	55.2±1.00
11	58	56	58	56	60	53	59	52	52	54	55.8±0.93
12	60	56	59	58	61	53	62	52	53	55	56.9±1.12
13	61	57	61	58	63	55	62	54	54	56	58.1±1.09

Table 14. Chest girth (cm) of kids recorded at weekly intervals (Group II)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	50	47	46	42	44	48	47	45	45	44	45.8±0.73
1	50	47	46	43	45	48	48	46	46	45	46.4±0.62
2	51	48	46	43	46	49	48	46	47	46	47.0±0.68
3	52	48	48	43	49	51	49	48	48	46	48.2±0.79
4	54	50	50	44	50	51	49	50	49	46	49.3±0.86
5	54	51	50	45	52	52	50	50	52	47	50.3±1.15
6	55	53	50	45	55	53	51	50	53	48	51.3±0.99
7	55	55	52	46	55	53	51	51	53	50	52.1±0.89
8	56	55	52	46	55	53	51	52	54	51	52.5±0.95
9	56	56	52	47	55	55	52	52	56	51	53.2±0.93
10	58	57	52	48	56	55	53	53	56	51	53.9±0.98
11	59	57	53	48	56	55	53	53	56	51	54.1±0.98
12	59	57	55	48	58	57	54	53	57	52	54.9±1.04
13	59	59	55	50	59	57	54	56	60	53	56.2±1.02

Table 15. Chest girth (cm) of kids recorded at weekly intervals (Group III)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	48	48	49	43	42	44	46	46	43	42	45.1±0.84
1	48	52	50	43	42	45	46	46	44	45	46.1±0.98
2	50	53	51	45	43	45	46	47	44	46	47.0±1.03
3	50	53	52	45	43	45	46	48	44	46	47.2±1.08
4	52	53	52	46	43	46	46	48	44	46	47.6±1.12
5	53	53	54	46	45	46	47	48	45	49	48.6±1.13
6	53	54	55	47	45	47	51	49	45	49	49.4±1.14
7	53	54	56	47	45	48	51	49	45	49	49.7±1.18
8	54	54	56	48	46	49	51	49	45	50	50.2±1.14
9	55	54	56	48	46	49	52	50	45	50	50.5±1.17
10	56	54	56	49	46	49	52	50	45	51	50.8±1.20
11	56	55	57	51	46	52	53	50	45	52	51.7±1.23
12	57	55	58	52	47	52	54	50	46	52	52.2±1.24
13	57	55	58	52	50	54	55	52	47	52	53.2±1.04

Table 16. Analysis of covariance - Weekly chest girth (cm) and cumulative increase in girth (cm)

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	0.723	0.584	63.903	1.029
2	1.266	1.489	64.740	1.313
3	0.972	0.462	77.936	2.616
4	2.041	3.348	56.230	3.253
5	4.320	8.565	83.517	4.108
6	4.169	8.360	69.581	4.408
7	3.291	12.771	68.894	3.611
8	3.625	19.875*	70.162	3.247
9	3.431	30.431**	81.465	3.595
10	3.486	52.550**	86.481	3.969
11	2.518	48.578**	75.689	5.460
12	3.921	61.041**	93.233	5.870
13	3.821	64.747**	82.330	5.844
Cumulative increase in girth	4.205	64.304**	1.166	6.487

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

Table 17. Consolidated data on chest girth (cm) and cumulative increase in girth (cm) of kids in the three groups

Weeks	Average chest girth		
	Group I	Group II	Group III
0	44.9 ± 0.98	45.8 ± 0.73	45.1 ± 0.84
1	45.9 ± 0.96	46.4 ± 0.62	46.1 ± 0.98
2	46.2 ± 0.87	47.0 ± 0.68	47.0 ± 1.03
3	47.4 ± 0.87	48.2 ± 0.79	47.2 ± 1.08
4	48.4 ± 0.79	49.3 ± 0.86	47.6 ± 1.12
5	49.9 ± 0.92	50.3 ± 1.15	48.6 ± 1.13
6	51.0 ± 1.00	51.3 ± 0.99	49.4 ± 1.14
7	51.7 ± 0.96	52.1 ± 0.89	49.7 ± 1.18
8	52.8 ± 0.91[a]	52.5 ± 0.91[ab]	50.2 ± 1.14[b]
9	53.7 ± 0.97[a]	53.2 ± 0.93[a]	50.5 ± 1.17[b]
10	55.2 ± 1.00[a]	53.9 ± 0.98[b]	50.8 ± 1.20[c]
11	55.8 ± 0.93[a]	54.1 ± 0.98[b]	51.7 ± 1.23[b]
12	56.9 ± 1.12[a]	54.9 ± 1.04[b]	52.2 ± 1.24[b]
13	58.1 ± 1.09[a]	56.2 ± 1.02[b]	53.2 ± 1.04[b]
Cumulative increase in girth	13.2 ± 0.60[a]	10.4 ± 0.88[a]	8.1 ± 0.61[b]

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

Table 18. Height at withers (cm) of kids recorded at weekly intervals (Group I)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	45	47	45	46	44	45	42	47	44	45	45.0±0.47
1	47	47	47	46	45	45	43	47	46	46	45.9±0.41
2	49	49	48	47	51	47	44	48	48	49	48.0±0.58
3	49	50	49	49	53	49	45	48	48	50	49.0±0.63
4	52	52	49	52	53	50	46	50	49	50	50.3±0.65
5	53	53	53	52	55	50	47	52	49	51	51.5±0.73
6	54	53	54	52	56	52	50	52	50	52	52.5±0.57
7	55	53	54	53	58	52	51	54	52	52	53.4±0.64
8	55	54	55	55	59	52	51	55	52	53	54.1±0.72
9	55	55	55	56	60	54	53	55	53	53	54.9±0.66
10	56	58	56	56	62	54	54	55	55	54	56.0±0.78
11	57	58	58	57	62	55	56	56	56	55	56.9±0.68
12	59	60	60	60	63	56	56	56	58	57	58.5±0.70
13	60	63	60	60	64	57	58	57	58	57	59.4±0.79

Table 19. Height at withers (cm) of kids recorded at weekly intervals (Group II)

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	52	45	46	45	42	48	46	46	50	42	46.2±1.00
1	52	45	47	46	43	49	46	46	51	44	46.9±0.92
2	53	46	48	46	45	50	49	48	52	44	48.1±0.94
3	53	50	49	46	48	51	50	48	53	44	49.2±0.90
4	55	52	50	46	50	52	52	50	54	46	50.7±0.94
5	55	53	52	47	51	53	52	52	55	47	51.7±0.88
6	55	55	52	48	51	53	53	52	55	49	52.3±0.77
7	57	57	54	50	51	55	53	53	56	49	53.5±0.99
8	59	57	54	50	52	56	53	53	56	49	53.9±0.99
9	60	57	54	50	54	57	54	53	57	50	54.6±1.02
10	60	58	55	51	55	58	55	54	58	50	55.3±1.03
11	62	59	57	51	56	59	55	55	59	51	56.3±1.15
12	62	59	59	54	58	59	56	55	61	52	57.5±1.00
13	62	59	59	54	59	59	58	57	61	52	58.0±0.96

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

Weeks	Replicate										Average with S.E.
	1	2	3	4	5	6	7	8	9	10	
0	44	49	50	48	43	40	47	45	42	46	45.4±1.01
1	47	50	50	48	44	41	47	46	43	47	46.3±0.92
2	47	52	51	48	45	42	47	47	45	47	47.1±0.91
3	49	52	52	48	45	42	48	48	46	48	47.8±0.95
4	51	54	53	49	46	45	48	48	46	49	48.9±0.95
5	52	54	53	50	47	46	50	49	47	50	49.8±0.84
6	53	54	53	50	48	48	52	49	48	50	50.5±0.73
7	55	54	54	52	49	48	52	50	48	52	51.4±0.81
8	55	55	56	53	49	49	53	50	49	53	52.1±0.88
9	56	56	57	53	49	50	53	51	49	54	52.7±0.93
10	56	56	57	54	50	50	54	51	49	54	53.1±0.91
11	56	56	58	54	51	52	55	52	49	54	53.6±0.82
12	58	56	58	55	52	53	55	53	50	56	54.6±0.83
13	58	56	58	56	52	53	56	53	50	56	54.8±0.84

Table 21. Analysis of covariance - Weekly height at withers (cm) and cumulative increase in height (cm)

Weeks	Mean sum of squares			
	Replication	Treatment	Covariate	Error
1	0.823	0.015	106.449	0.421
2	1.975	4.295	121.969	1.410
3	3.237	5.863	106.226	2.410
4	4.216	7.652	89.712	2.574
5	4.310	9.757*	71.031	2.597
6	4.267	11.794*	38.101	2.287
7	4.122	13.165*	47.972	3.403
8	4.568	13.568*	73.520	3.633
9	5.209	16.078*	80.026	3.843
10	7.095	25.382**	80.707	3.861
11	7.511	32.276**	74.921	3.694
12	6.588	43.262**	53.730	3.778
13	6.675	58.637**	53.413	4.238
Cumulative increase in height	7.268	59.975**	8.413	4.266

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

Table 22. Consolidated data on height at withers (cm) and cumulative increase in height (cm) of kids in the three groups

Weeks	Height at withers		
	Group I	Group II	Group III
0	45.0 ± 0.47	46.2 ± 1.00	45.4 ± 1.01
1	45.9 ± 0.41	46.9 ± 0.92	46.3 ± 0.92
2	48.0 ± 0.58	48.1 ± 0.94	47.1 ± 0.91
3	49.0 ± 0.63	49.2 ± 0.90	47.8 ± 0.95
4	50.3 ± 0.65	50.7 ± 0.94	48.9 ± 0.95
5	51.5 ± 0.73^{a}	51.7 ± 0.88^{ab}	49.8 ± 0.84^{b}
6	52.5 ± 0.57^{a}	52.3 ± 0.77^{ab}	50.5 ± 0.73^{b}
7	53.4 ± 0.64^{a}	53.5 ± 0.90^{ab}	51.4 ± 0.81^{b}
8	54.1 ± 0.72^{a}	53.9 ± 0.99^{ab}	52.1 ± 0.88^{b}
9	54.9 ± 0.66^{a}	54.6 ± 1.02^{ab}	52.7 ± 0.93^{b}
10	56.0 ± 0.78^{a}	55.3 ± 1.03^{ab}	53.1 ± 0.91^{b}
11	56.9 ± 0.68^{a}	56.3 ± 1.15^{a}	53.6 ± 0.82^{b}
12	58.5 ± 0.70^{a}	57.5 ± 1.00^{a}	54.6 ± 0.83^{b}
13	59.4 ± 0.79^{a}	58.0 ± 0.96^{b}	54.8 ± 0.84^{c}
Cumulative increase in height	14.4 ± 0.87^{a}	11.8 ± 0.79^{b}	9.4 ± 0.73^{c}

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

Fig.2 AVERAGE BODY MEASUREMENTS (cm) OF KIDS IN THE THREE GROUPS

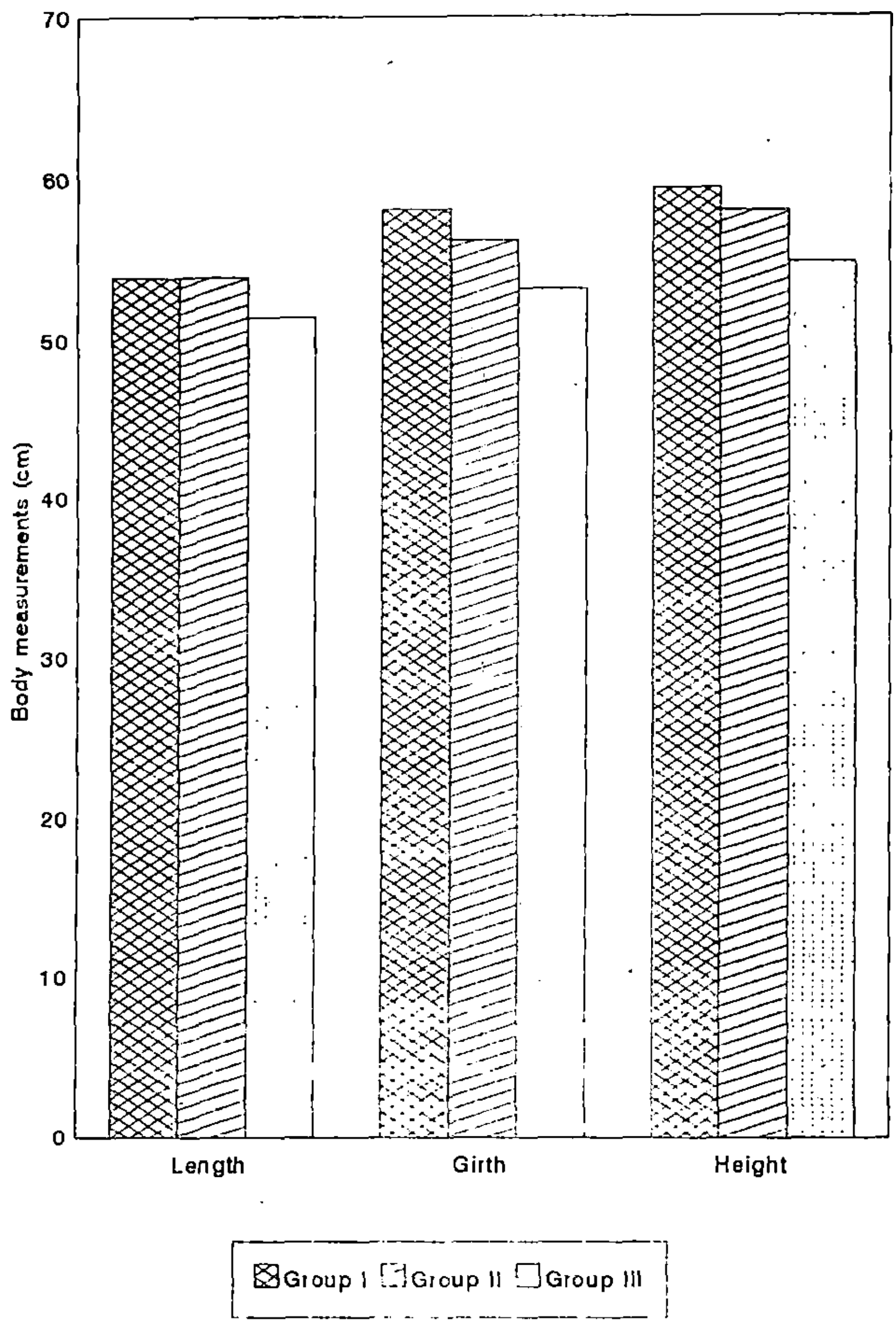


Table 23. Average daily dry matter intake (kg) of ten animals maintained on rations A, B and C

Weeks	Treatments		
	Ration A	Ration B	Ration C
1	2.21	2.44	2.62
2	2.66	2.43	2.64
3	2.87	3.27	2.89
4	3.69	3.94	3.40
5	4.09	4.09	3.40
6	4.23	4.13	3.45
7	4.07	3.53	3.03
8	4.86	4.17	3.37
9	5.03	4.28	3.65
10	5.56	4.76	3.88
11	5.74	4.81	3.02
12	5.16	4.76	3.48
13	5.11	5.25	4.26
Mean±S.E.	4.25 ± 0.31^{a}	3.98 ± 0.24^{ab}	3.31 ± 0.13^{b}

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

Table 24. Analysis of variance - Average daily dry matter intake

Source	Degree of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	5.880	2.940	4.341*	0.021
Error	36	24.383	0.677		

* Significant at 5 per cent level

Fig.3 AVERAGE DAILY DRYMATTER INTAKE (kg) OF ANIMALS MAINTAINED ON THE THREE DIETARY REGIMES

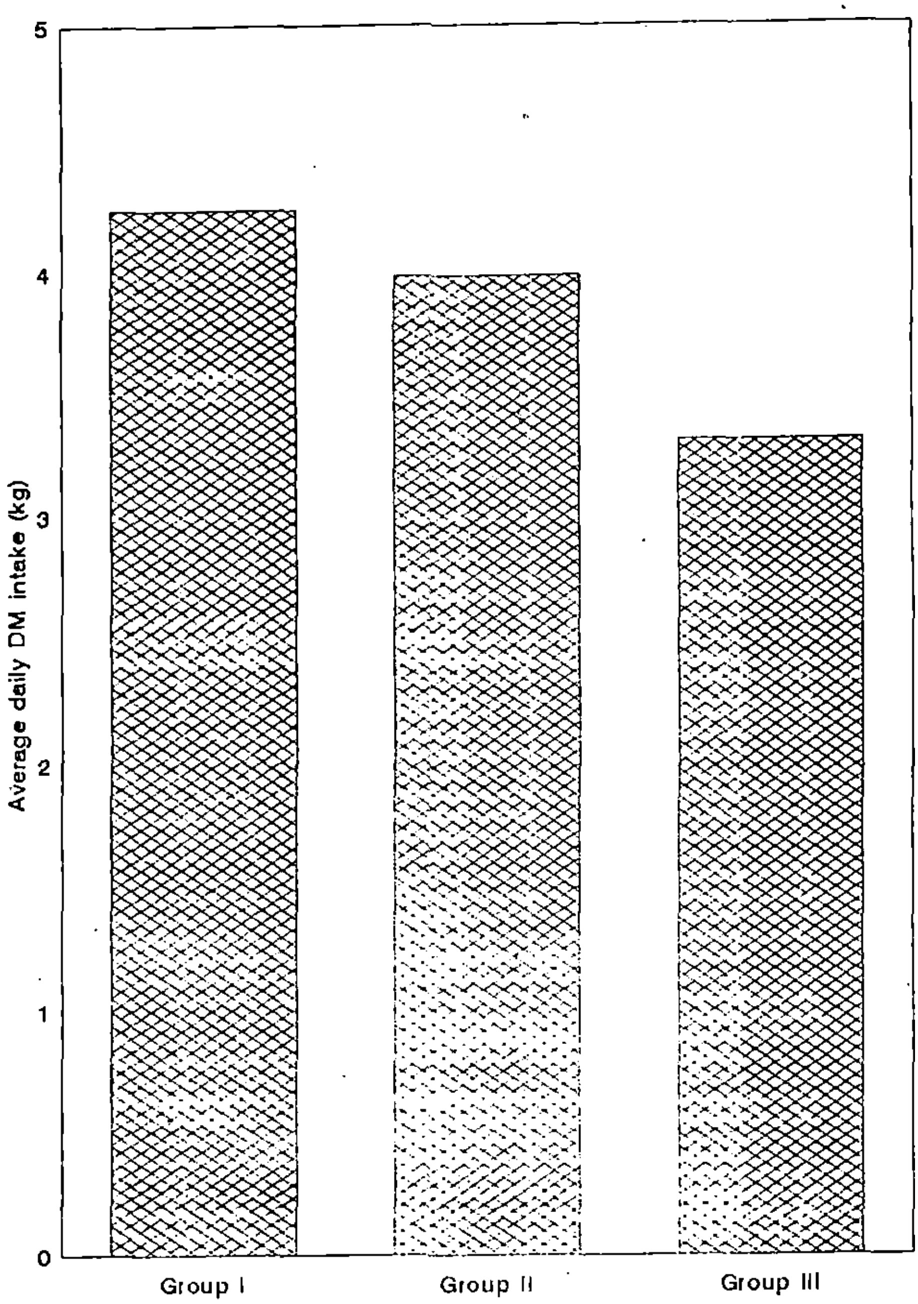


Table 25. Average daily gain (g) of animals maintained on rations A, B and C

Weeks	Treatments		
	Ration A	Ration B	Ration C
1	180.72	142.86	135.00
2	-0.71	65.00	7.14
3	137.14	73.57	52.86
4	121.43	94.29	61.43
5	99.29	108.57	102.86
6	98.57	96.43	57.14
7	107.86	70.71	25.71
8	135.71	58.57	48.57
9	132.86	105.72	78.57
10	137.14	64.29	50.00
11	130.00	59.29	5.72
12	53.57	70.71	69.28
13	112.14	143.57	153.57
Mean±S.E.	111.21 ± 12.38^{a}	88.74 ± 8.22^{ab}	65.22 ± 12.28^{b}

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

Table 26. Analysis of variance - Average daily gain

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	14566.244	7283.122	4.527*	0.018
Error	36	57920.961	1608.916		

* Significant at 5 per cent level

Fig.4 AVERAGE DAILY BODY WEIGHT GAIN (g) OF ANIMALS IN THE THREE GROUPS

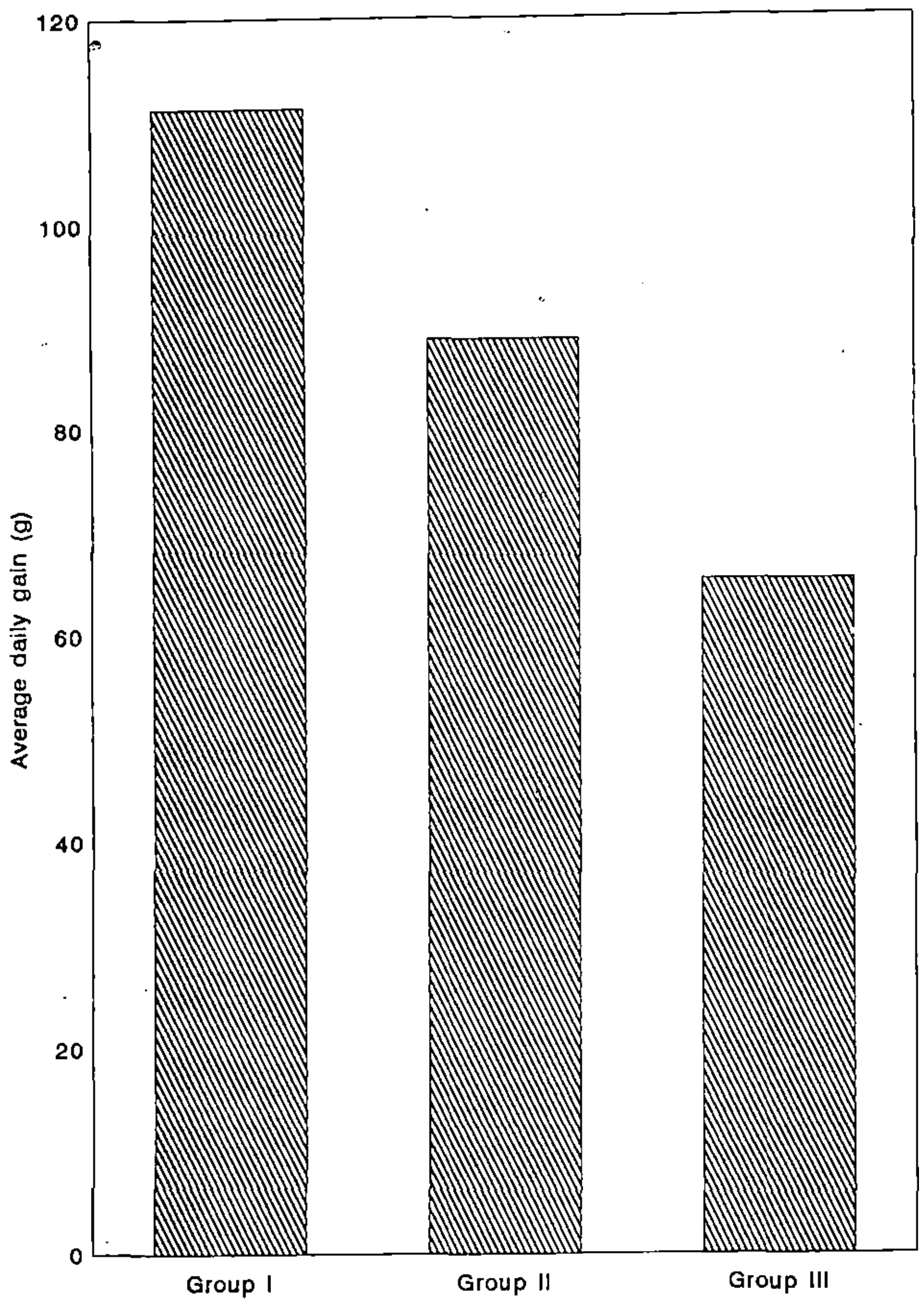


Table 27. Average weekly feed conversion efficiency and cumulative feed efficiency of animals maintained on rations A, B and C

Weeks	Treatments		
	Ration A	Ration B	Ration C
1	1.22	1.70	1.94
2	9.55	3.70	36.96
3	15.45	4.49	5.47
4	3.04	4.07	5.53
5	4.06	3.76	3.22
6	4.29	4.28	6.04
7	3.77	4.19	13.26
8	3.27	7.12	6.94
9	3.79	3.65	4.19
10	4.05	4.44	7.76
11	4.42	8.02	52.85
12	9.63	6.80	5.01
13	4.68	3.66	2.85
Mean±S.E.	5.48±1.06	4.61±0.48	11.69±2.06
Cumulative feed efficiency	4.04	4.29	5.06

Table 28. Analysis of variance - Feed conversion efficiency

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	384.088	192.044	2.270	0.118
Error	36	3045.299	84.592		

Fig.5 CUMULATIVE FEED CONVERSION EFFICIENCY OF ANIMALS IN THE THREE GROUPS

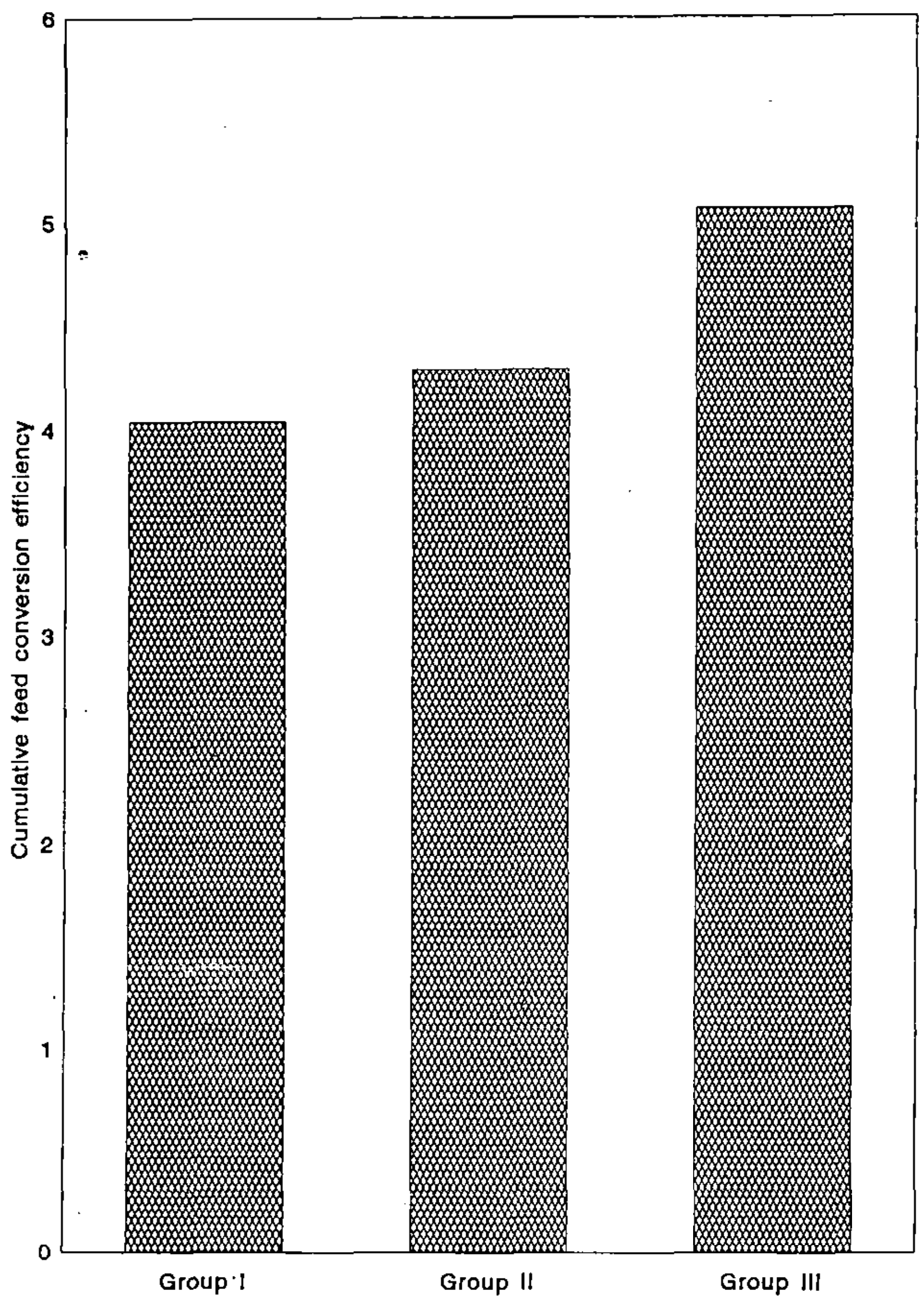


Table 29. Data on cost of production per kg gain (Rs.) of the animals maintained on rations A, B and C

	Treatments		
	Ration A	Ration B	Ration C
Total weight gain (kgs)	95.70	84.55	59.65
Total feed intake on fresh basis (kg)	426.33	402.75	322.91
Total feed cost (Rs.)	2737.53	2678.43	2302.06
Cost per kg gain (Rs.)	28.61	31.68	38.59

Cost of rations

Ration A - Rs.642.15 per 100 kg
Ration B - Rs.665.04 per 100 kg
Ration C - Rs.691.50 per 100 kg

Fig.6 COST OF PRODUCTION PER KILOGRAM GAIN OF KIDS IN THE THREE GROUPS

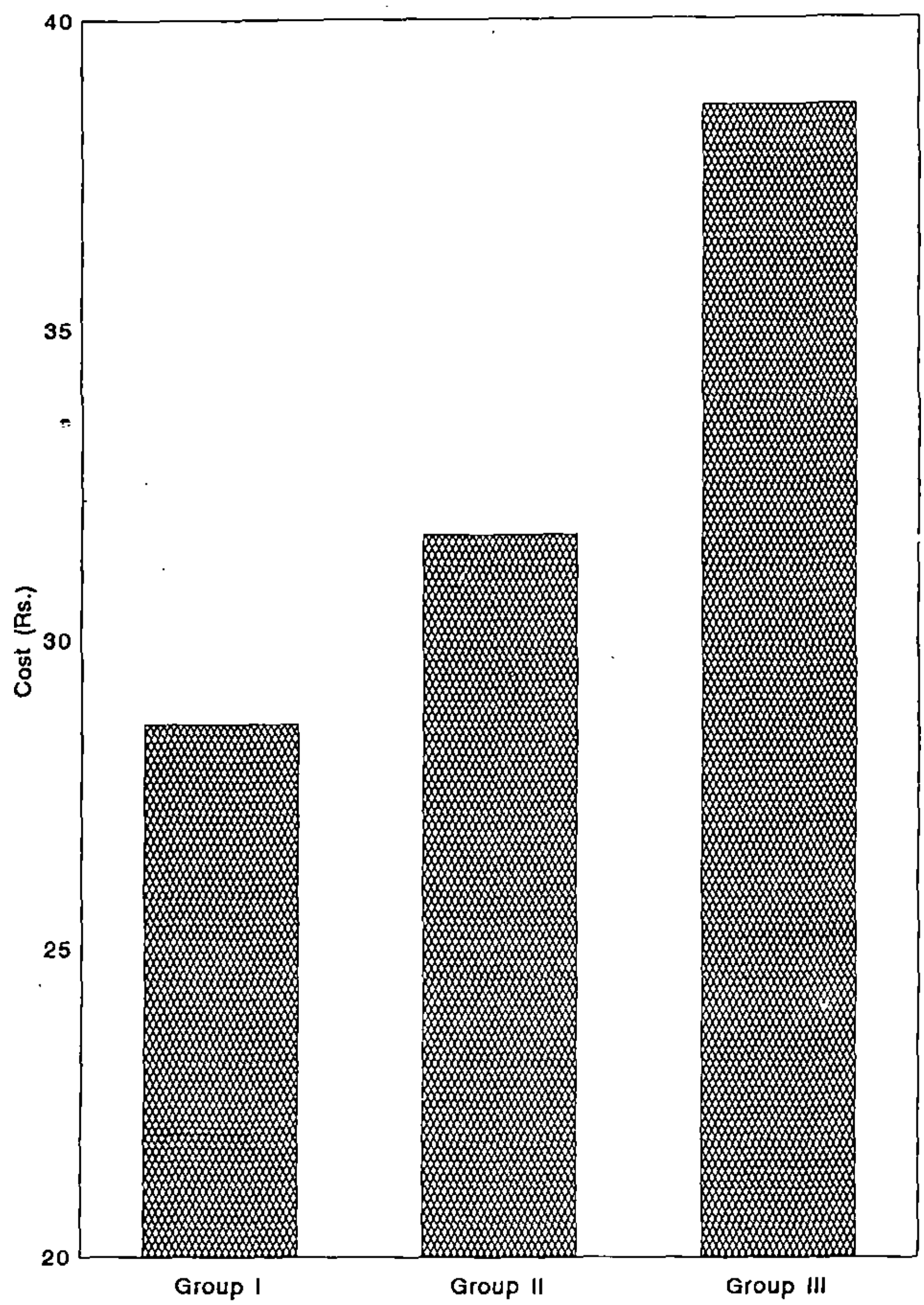


Table 30. Summarised data on body weight changes, dry matter intake, feed efficiency and cost efficiency of kids maintained on rations A, B and C

	Treatments		
	Ration A	Ration B	Ration C
Initial body weight (kg)	7.8± 0.26	7.8± 0.40	7.8± 0.34
Final body weight (kg)	17.4± 0.80	16.3± 0.86	13.8± 0.92
Cumulative weight gain (kg)	9.6± 0.57	8.5± 0.71	6.0± 0.74
Average daily gain (g)	111.21± 12.38	88.74± 8.22	65.22± 12.28
Average daily dry matter consumption (g)	425.20± 0.31	398.00± 0.24	331.00± 0.13
Cumulative feed efficiency	4.04	4.29	5.06
Cost per unit gain (Rs.)	28.61	31.68	38.59

Table 31. Digestibility coefficients of nutrients in animals maintained on ration A (Group I)

Nutrients	Replication				Average with S.E.
	1	2	3	4	
Dry matter	78.57	72.57	75.03	76.18	75.59±0.84
Organic matter	81.43	75.51	77.59	79.17	78.43±0.88
Crude protein	80.44	74.93	74.01	76.93	76.58±0.98
Ether extract	70.09	64.24	65.18	66.47	66.50±0.79
Crude fibre	50.76	46.10	52.40	56.97	51.56±1.29
Nitrogen free extract	87.89	82.86	85.50	85.98	85.56±0.84

Table 32. Digestibility coefficients of nutrients in animals maintained on ration B (Group II)

Nutrients	Replication				Average with S.E.
	1	2	3	4	
Dry matter	82.44	82.83	76.47	70.00	77.94±2.10
Organic matter	84.19	84.33	78.84	72.99	80.09±1.91
Crude protein	83.51	82.64	74.28	70.62	77.76±2.19
Ether extract	75.24	79.27	60.32	56.53	67.97±3.45
Crude fibre	68.37	65.25	79.10	53.84	66.64±3.21
Nitrogen free extract	89.44	90.03	83.02	79.31	85.41±2.11

Table 33. Digestibility coefficients of nutrients in animals maintained on ration C (Group III)

Nutrients	Replication				Average with S.E.
	1	2	3	4	
Dry matter	80.00	78.19	78.64	81.92	79.69±0.60
Organic matter	81.70	80.17	80.58	83.63	81.52±0.58
Crude protein	83.19	79.75	81.77	85.21	82.48±0.87
Ether extract	62.33	56.63	60.80	73.11	63.22±2.13
Crude fibre	68.48	64.75	66.01	69.06	67.08±0.62
Nitrogen free extract	86.88	86.95	86.28	88.37	87.12±0.39

Table 34. Consolidated data on digestibility coefficients of nutrients in animals maintained on rations A, B and C

	Treatments		
	Ration A	Ration B	Ration C
Dry matter	75.59± 0.84	77.94± 2.06	79.69± 0.60
Organic matter	78.43± 0.88	80.09± 1.91	81.52± 0.58
Crude protein	76.58± 0.98	77.76± 2.19	82.48± 0.87
Ether extract	66.50± 0.79	67.97± 3.45	63.22± 2.13
Crude fibre	51.56± 1.29[b]	66.64± 3.21[a]	67.08± 0.62[a]
Nitrogen free extract	85.56± 0.84	85.41± 2.11	87.12± 0.39

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

Table 35. Analysis of variance - Digestibility coefficients of dry matter

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probabi-lity
Treatment	2	16.111	8.055	1.139	0.3623
Error	9	63.650	7.072		

Table 36. Analysis of variance - Digestibility coefficients of organic matter

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probabi-lity
Treatment	2	9.813	4.906	0.780	
Error	9	56.641	6.293		

Fig.7 AVERAGE DIGESTIBILITY COEFFICIENTS OF DRY MATTER IN THE THREE GROUPS

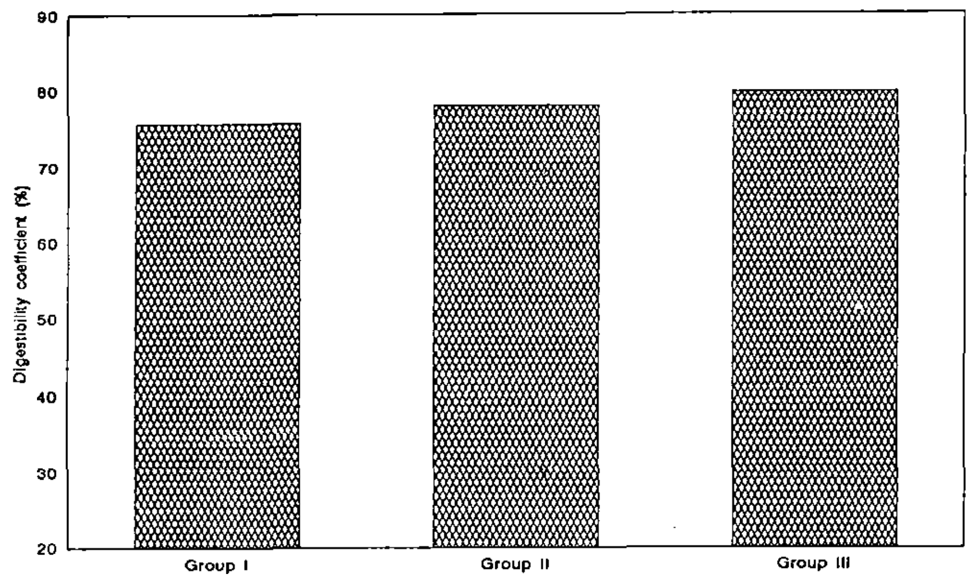


Fig.8 AVERAGE DIGESTIBILITY COEFFICIENTS OF ORGANIC MATTER IN THE THREE GROUPS

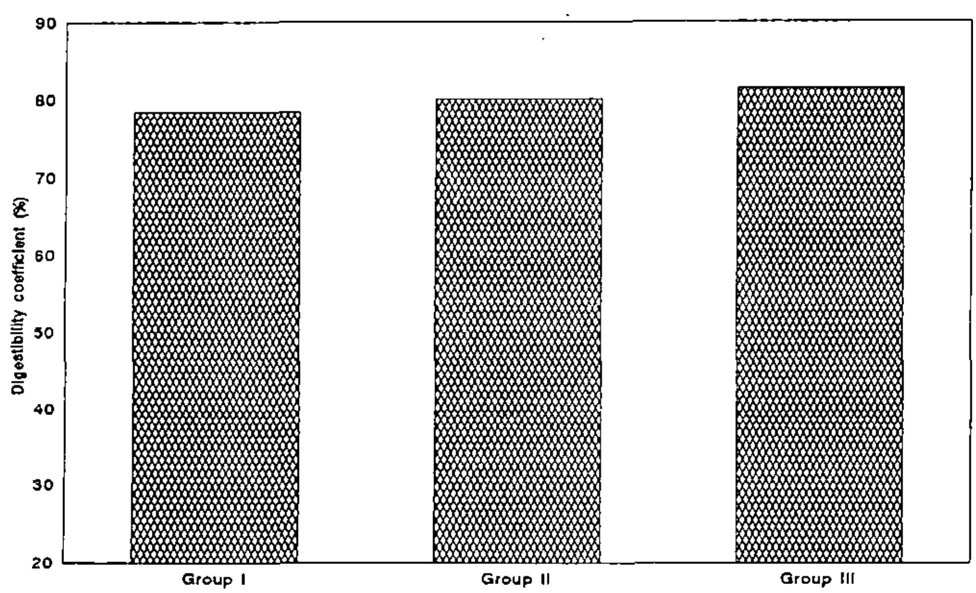


Table 37. Analysis of variance - Digestibility coefficients of crude protein

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	38.939	19.469	2.255	0.161
Error	9	77.717	8.635		

Table 38. Analysis of variance - Digestibility coefficients of ether extract

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	18.005	9.002	0.396	
Error	9	204.675	22.742		

Fig.9 AVERAGE DIGESTIBILITY COEFFICIENTS OF CRUDE PROTEIN IN THE THREE GROUPS

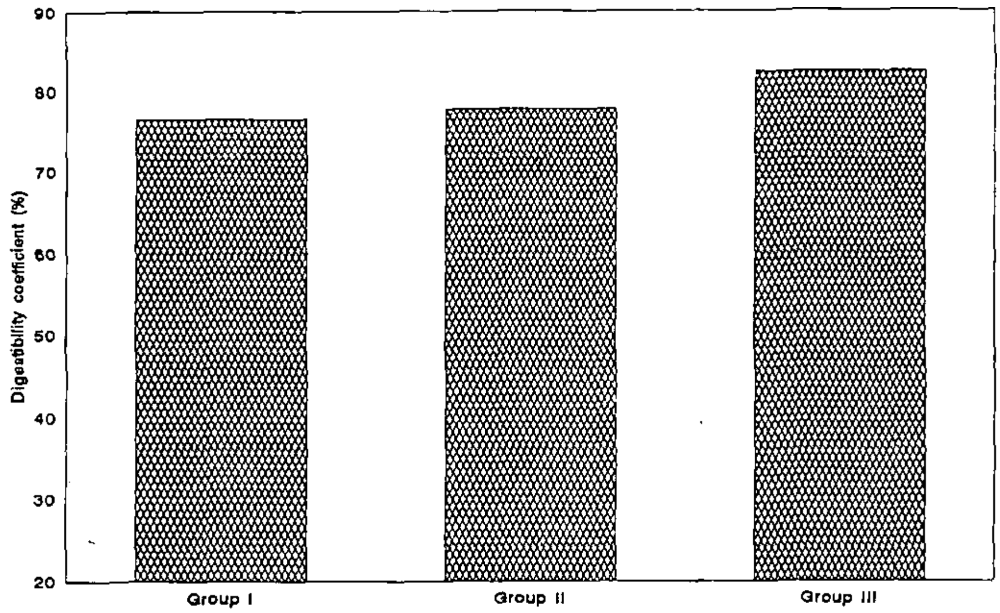


Fig.10 AVERAGE DIGESTIBILITY COEFFICIENTS OF ETHER EXTRACT IN THE THREE GROUPS

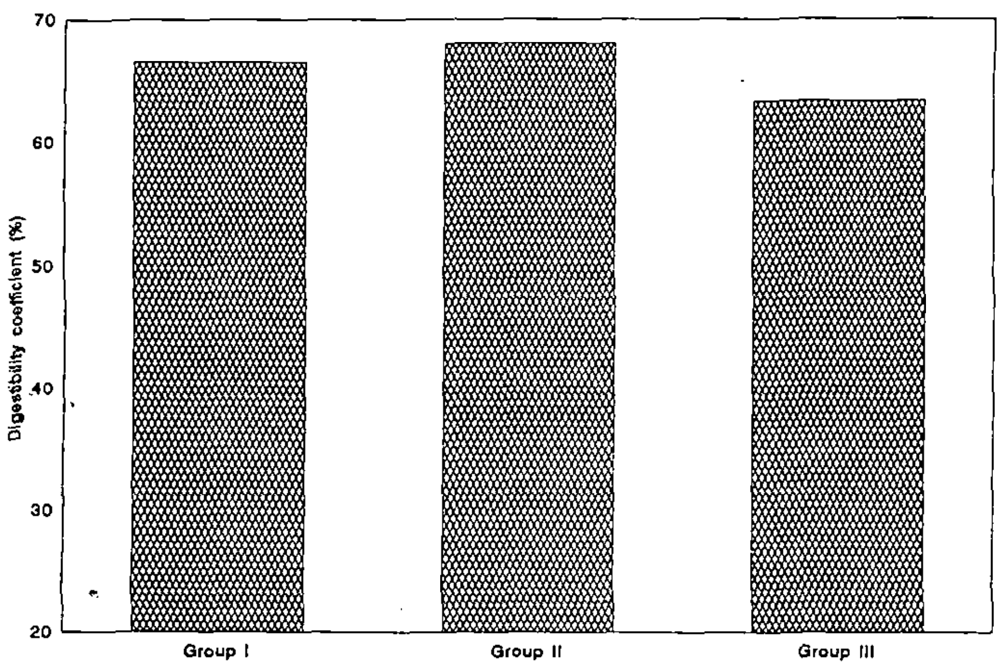


Table 39. Analysis of variance - Digestibility coefficients of crude fibre

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	218.996	109.498	6.654*	
Error	9	148.113	16.457		

* Significant at 5 per cent level

Table 40. Analysis of variance - Digestibility coefficients of nitrogen free extract

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	4.002	2.001	0.284	
Error	9	63.330	7.037		

Fig.11 AVERAGE DIGESTIBILITY COEFFICIENTS OF CRUDE FIBRE IN THE THREE GROUPS

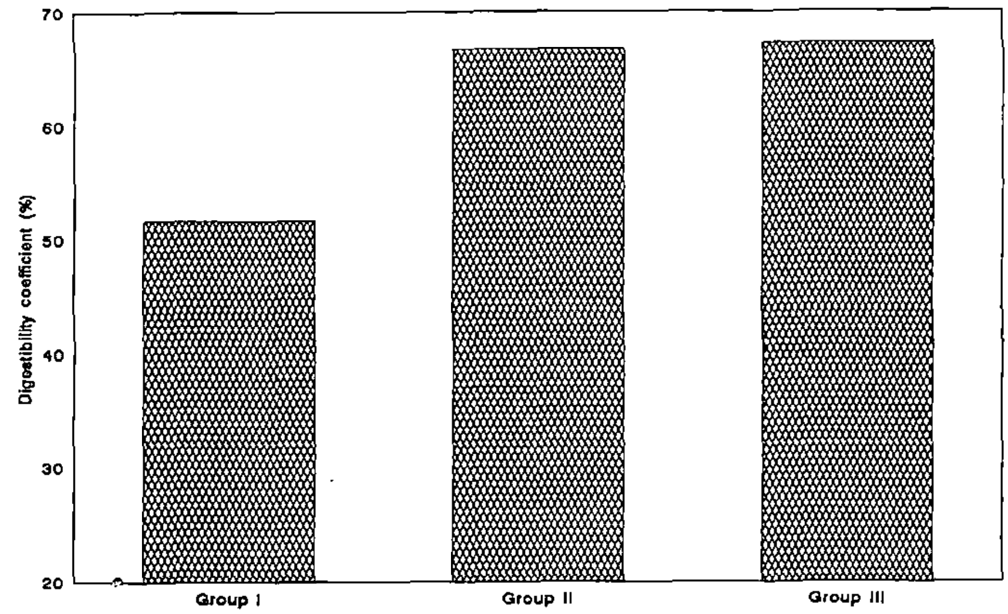


Fig.12 AVERAGE DIGESTIBILITY COEFFICIENTS OF NITROGEN FREE EXTRACT IN THE THREE GROUPS

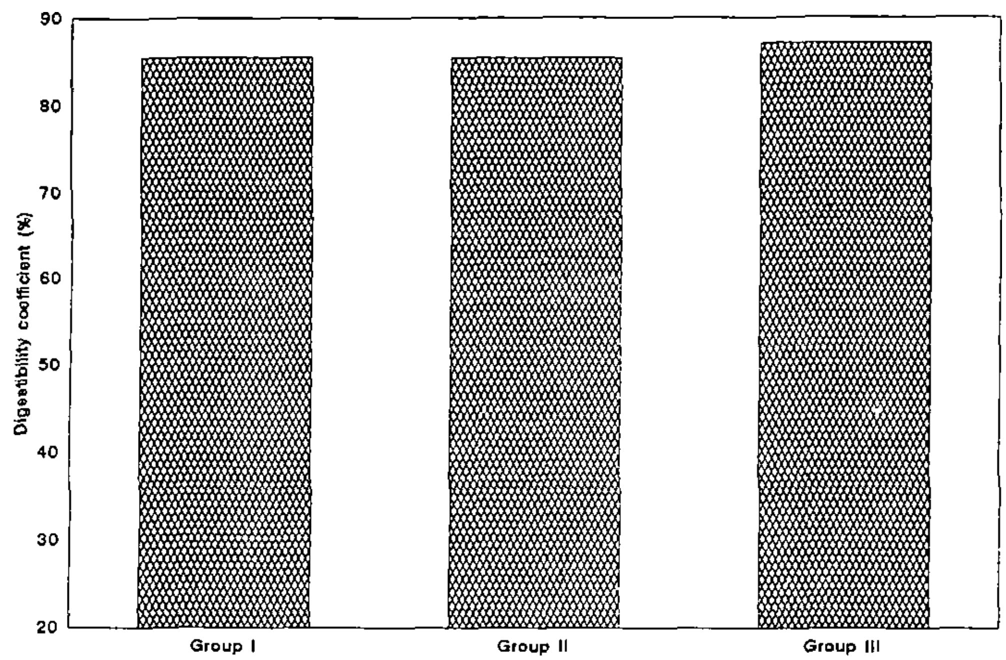


Table 41. Summarised data on average daily intake of dry matter (DM), digestible crude protein (DCP) and total digestible nutrients (TDN) in kg per 100 kg body weight

	Treatments		
	Ration A	Ration B	Ration C
DM intake	3.26± 0.12	3.18± 0.09	3.00± 0.01
DCP intake	0.40± 0.01	0.39± 0.01	0.40± 0.01
TDN intake	2.55± 0.09	2.54± 0.07	2.39± 0.06

Table 42. Analysis of variance - Dry matter intake per 100 kg body weight

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	0.482	0.241	1.882	0.167
Error	36	4.61	0.128		

Table 43. Analysis of variance - Digestible crude protein intake per 100 kg body weight

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	0.001	0.000	0.136	
Error	36	0.072	0.002		

Table 44. Analysis of variance - Total digestible nutrient intake per 100 kg body weight

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	0.201	0.101	1.251	0.298
Error	36	2.894	0.080		

Table 45. 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 I	12.28	78.05
Group II	12.33	79.73
Group III	13.17	79.68

Table 46. Summarised data on nitrogen balance and per cent retention of nitrogen in animals fed on rations A, B and C

Treatments	Ration A	Ration B	Ration C
Number of replications	4	4	4
Nitrogen intake (g/day)	13.87± 0.51	13.11± 0.50	13.86± 0.31
Nitrogen outgo			
Faecal (g/day)	3.25± 1.24	2.96± 2.64	2.43± 0.90
Urinary (g/day)	6.37± 2.32	5.06± 1.84	5.06± 2.34
Total (g/day)	9.62± 3.44	8.02± 3.15	7.49± 2.34
Nitrogen balance (g/day)	4.25± 0.65	5.09± 0.41	6.37± 0.17
Per cent retention of nitrogen	30.60± 4.67^{b}	38.967± 3.27^{ab}	46.095± 2.20^{a}

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

Table 47. Analysis of variance - Per cent retention of nitrogen

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	176.632	88.316	4.656*	0.041
Error	9	170.725	18.969		

* Significant at 5 per cent level

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

Replication	Treatments								
	Ration A			Ration B			Ration C		
	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	22.8	12.0	52.63	20.1	10.2	50.74	19.2	9.4	48.96
2	19.3	9.8	50.78	17.2	9.0	52.33	16.7	8.1	48.50
3	16.6	8.1	48.80	17.3	8.4	48.55	13.5	6.2	45.93
Mean± S.E.	19.57± 1.80	9.97± 1.13	50.74± 1.11	18.20± 0.95	9.20± 0.53	50.54± 1.10	16.47± 1.65	7.90± 0.93	47.80± 0.94

Table 49. Analysis of variance - Dressing percentage

Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Treatment	2	16.208	8.104	2.447	0.167
Error	6	19.874	3.312		

Fig.13 AVERAGE DRESSING PERCENTAGE OF KIDS MAINTAINED ON THE THREE DIETARY REGIMES

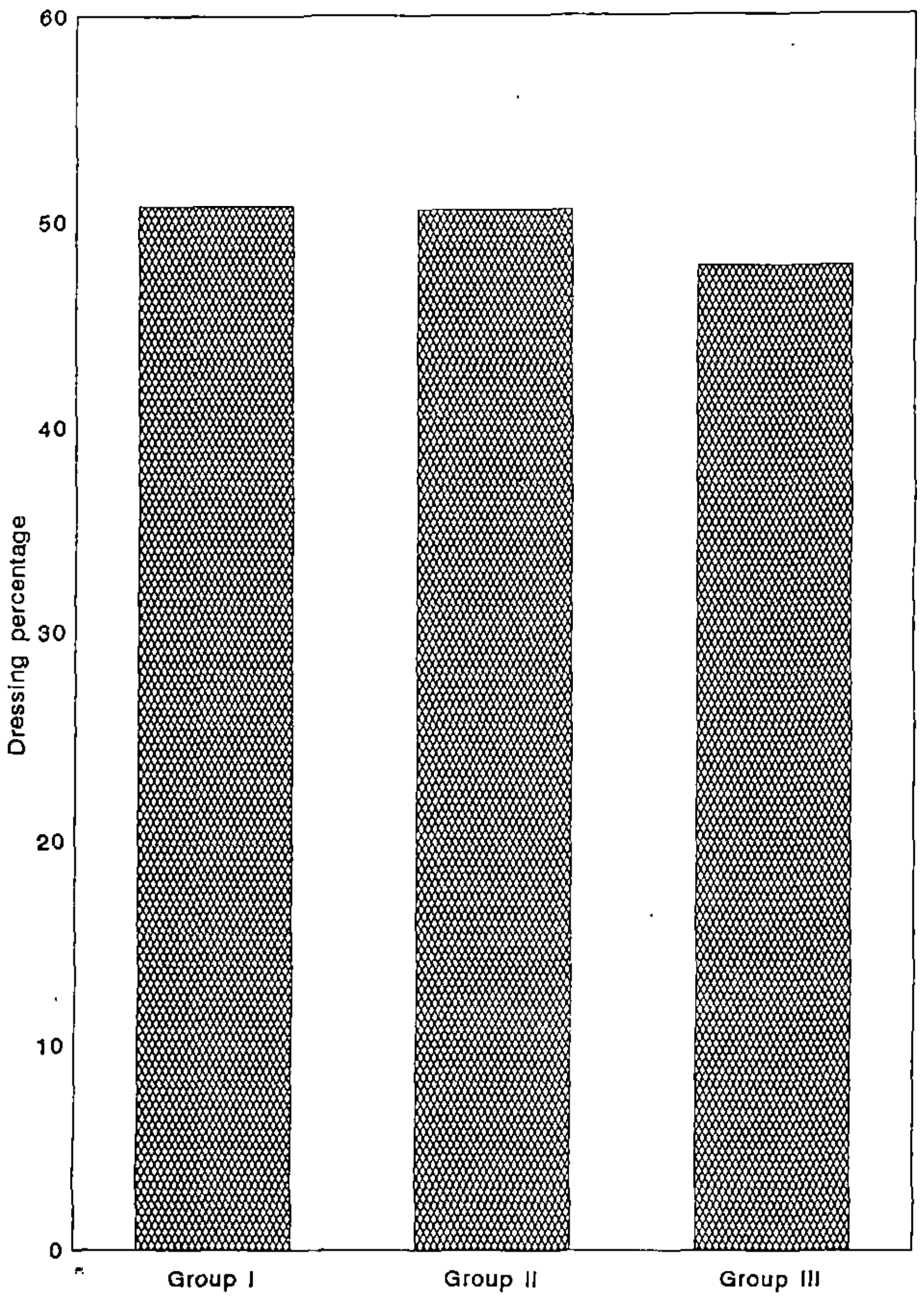


Table 50. Economics

A. Expenditure of rearing kids on three diet treatments

	Ration A	Ration B	Ration C
1. Cost of animals @ Rs.450/animalx10	Rs.4500	Rs.4500	Rs.4500
2. *Cost of feed			
@ Rs.6.42/kg for Ration A	Rs.2737.53	Rs.2678.43	Rs.2302.06
@ Rs.6.65/kg for Ration B			
@ Rs.6.91/kg for Ration C			
3. Miscellaneous (Feeder, waterer, medicines, electricity etc.) @ Rs.50/animalx10	Rs.500	Rs.500	Rs.500
4. Slaughter charges @ Rs.50/animalx10	Rs.500	Rs.500	Rs.500
Total	Rs.8237.53	Rs.8178.43	Rs.7802.06

* Calculations based on feed intake given in Table 29

B. Revenue from each diet treatment calculated on the basis of three animals slaughtered from each group

	Ration A	Ration B	Ration C
1. Average weight of animals	17.4 Kg	16.3 kg	13.8 kg
2. Dressing percentage	50.74%	50.54%	47.80%
3. Sale proceeds of meat @ Rs.100/kg	Rs.883.38	Rs.821.53	Rs.660.12
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.1078.38	Rs.1016.53	Rs.855.12
Calculated revenue for ten animals	Rs.10783.8	Rs.10165.3	Rs.8551.2

C. Gross profit for ten animals for three months (B-A)	Rs.2546.8	Rs.1987.0	Rs.750.8
Gross profit per animal for three months	Rs.254.7	Rs.198.7	Rs.75.1

Fig.14 GROSS PROFIT FOR TEN ANIMALS IN EACH GROUP FOR THREE MONTHS

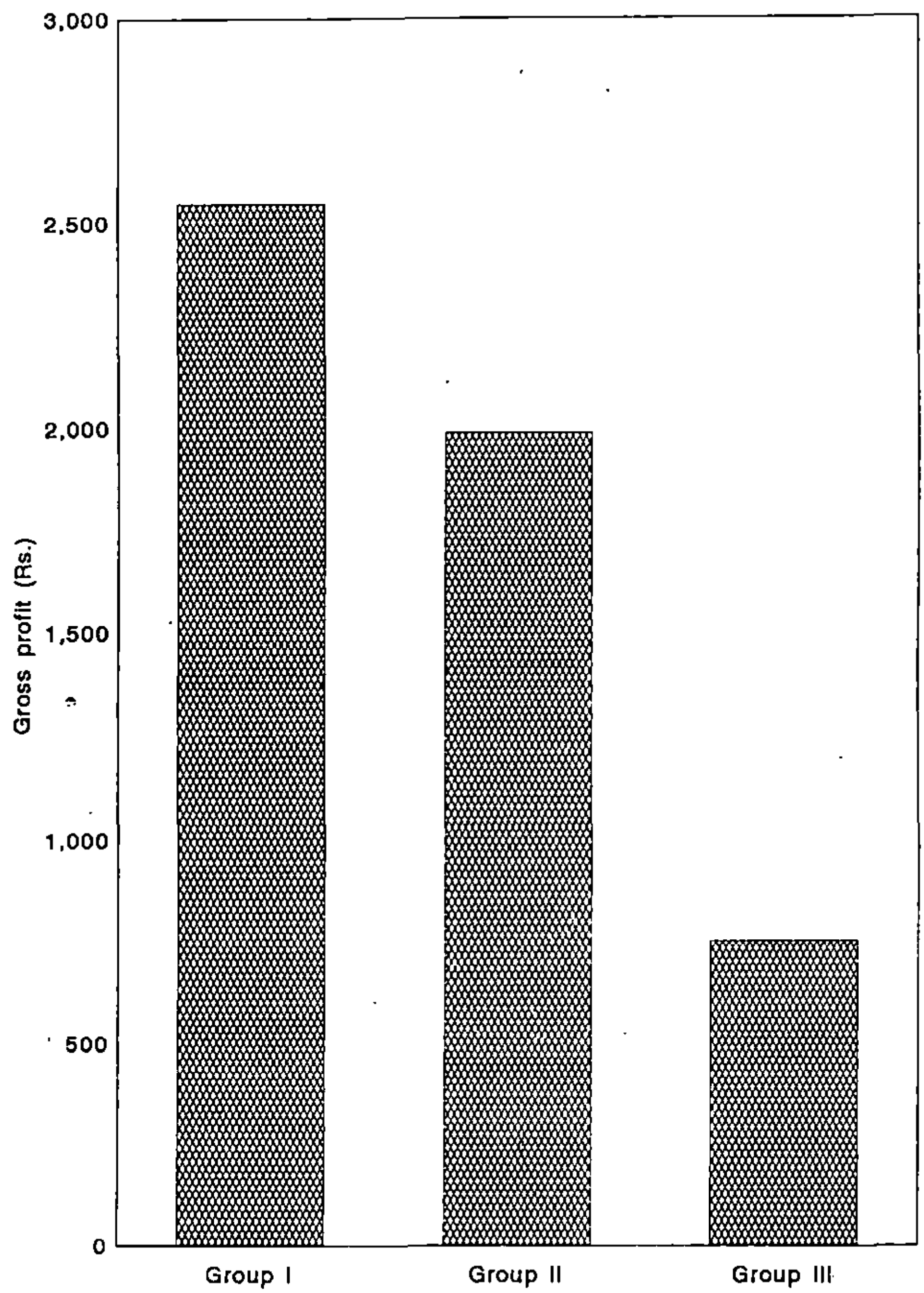


Fig.15 Section of rumen from group I showing long, slender and branched papillae with distinct parakeratosis. H&Ex100

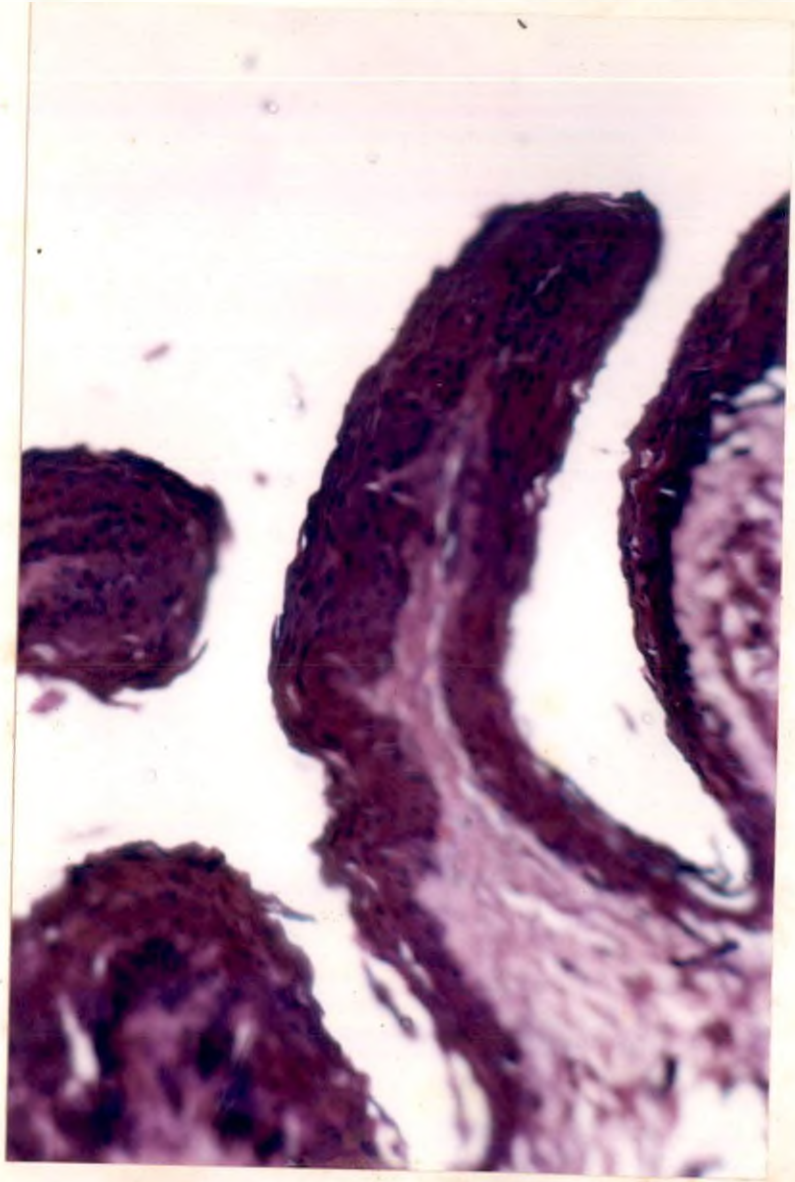


Fig.16 **Section of rumen from group II showing relatively blunt and less branched papillae with mild degree of parakeratosis. H&Ex100**

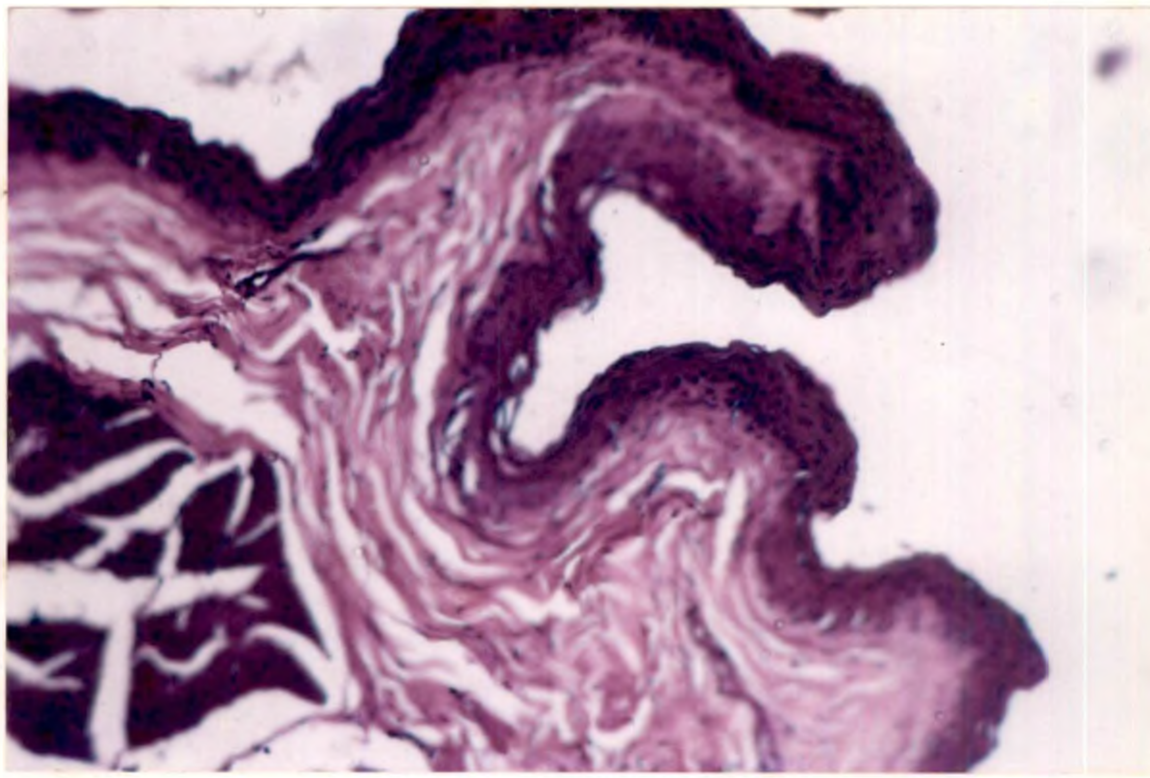
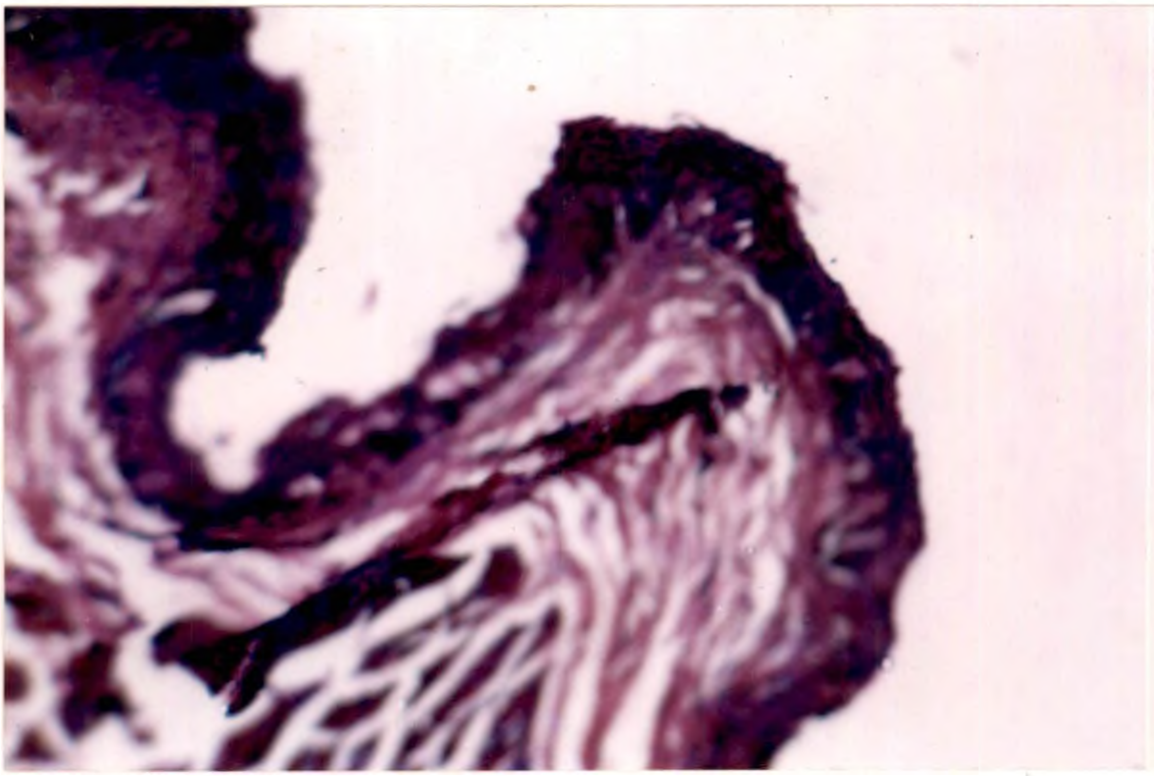


Fig.17 **Section of rumen from group III showing minimum changes. Papillae are more blunt, less branched and degree of parakeratosis is minimum. H&Ex100**



Discussion

DISCUSSION

5.1 Body weight

The kids of groups I, II and III maintained on rations A, B and C recorded cumulative weight gains of 9.6 ± 0.57, 8.5 ± 0.71 and 6.0 ± 0.74 kg respectively during the experimental period of 13 weeks (Table 7). This gain in weight recorded was highly significant ($P<0.01$) between groups I and III as well as between II and III (Tables 6 and 7).

Body weights of animals in the three groups, upto six weeks of experiment did not show any significant difference ($P>0.05$) as can be seen from Tables 6 and 7. However, significant differences in body weight was observed from the seventh week till the end of the experiment ($P<0.05$ in the 7th week and $P<0.01$ from the 8th to the 13th week) as shown in Tables 6 and 7.

The average daily body weight gains during the experimental period of 13 weeks were 111.21 ± 12.38, 88.74 ± 8.22 and 65.22 ± 12.28 g for the groups I, II and III respectively (Table 25). The average daily body weight gain of animals in group I was significantly higher ($P<0.05$) than group III (Table 25 and 26). Although there was numerical difference between groups I and II and II and III, the differences were not statistically significant ($P>0.05$) as shown in Tables 25 and 26.

During the pre-experimental period of two weeks the DM consumption was less as the kids were not accustomed to the rations. Proper intake of feed was observed with the commencement of experiment and initial increase in body weight during the first week (Table 25) can be attributed to the increase in gut contents. This has resulted in slight diarrhoea during the second week with consequent reduced gain in weight (Table 25). The above observations pertaining to the first two weeks are consistent with the results of Martini *et al.* (1996) who observed significant reduction in the growth of lambs fed on a diet supplemented with monensin, two weeks after commencing the feeding experiment.

The undulating growth pattern observed in group III (Table 25) may be due to the occassional respiratory problems associated with the dustiness of the feed.

Several authors have reported varying rates of growth in lambs and kids fed on diets supplemented with monensin. Joyner *et al.* (1979) conducted a growth trial in lambs and observed an average daily body weight gain of 210.00 g on a diet supplemented with 20 ppm of monensin. Patil and Honmonde (1994) reported an average daily body weight gain of 113.78 g in Malpura lambs fed on a concentrate mixture supplemented with monensin at the rate of 22 mg per kilogram. This is in comparison with the average daily gain of group I of the present study. The average daily gain of kids in the present study were less when compared to the results of Joyner *et al.* (1979), which may be due to the genetic difference of the species of animals used.

There are several reports of varying weight gain in lambs and kids fed on complete rations. Reddy and Reddy (1985) reported average daily weight gain of 58.00 and 55.00 g in three to four month old Nellore lambs fed on two different complete rations for a period of 120 days. Saini *et al.* (1987) obtained an average daily weight gain of 61.00 g in Barbari kids weaned at three months of age and reared under intensive system for a period of 90 days. Chahal and Sharma (1992) reported an average daily gain of 92.80 g in crossbred (Alpine x Beetal) male kids of five to six months of age fed on complete rations. Ralston (1997) reported an average daily gain of 43.41 g in Malabari kids fed on a complete diet. Deepa (1978) reported an average daily gain of 62.77, 59.38 and 53.21 g respectively on feeding complete diets containing different roughage sources in Malabari kids. All the above mentioned observations are based on complete feeds containing 16 per cent or more crude fibre. The average daily body weight gain observed in group III of the present study having 16 per cent fibre was 65.22 g which is higher than the gains reported by Reddy and Reddy (1985), Ralston (1997) and Deepa (1998). However, this value is lower than that reported by Chahal and Sharma (1992). Iotsev *et al.* (1989) reported a more pronounced effect in male lambs compared to female lambs when fed on a diet supplemented with 20 ppm monensin. The higher value obtained by Chahal and Sharma (1992) might be due to the fact that their study was conducted exclusively in crossbred (Alpine x Beetal) male kids.

Monensin supplementation was found to be more effective in low fibre rations than high fibre rations as reported by Danner *et al.* (1980), Ostilie *et al.* (1981) and Galyean and Owens (1988).

Zinn *et al.* (1994) studied the influence of forage levels (10 and 20%) on production of volatile fatty acids, with and without supplementation of monensin in feedlot cattle. On low forage diet propionate production was 10.2 per cent higher and acetate production was 13 per cent lower compared to high forage diet. When the low forage diet was supplemented with monensin molar proportion of propionate was further increased by 9.5 per cent while supplementation of monensin in high forage diet reduced the propionate production by 5.5 per cent compared to the respective control groups. These researchers obtained a 10.8 per cent higher average daily gain for the low forage diet when compared to the high forage diet.

In the present study animals in group I fed with less fibre in the diet had better weight gain than the other two groups containing higher levels of fibre in the diets. This is in confirmation with the findings of Danner *et al.* (1980), Ostilie *et al.* (1981), Galyean and Owens (1988) and Zinn *et al.* (1994).

Clary *et al.* (1993) reported that the usual positive response of finishing cattle to ionophores may be altered by fat supplementation. Fat alters access of microbes to ionophores. Rations B and C contained supplemented tallow at 1 per cent and 2 per cent level respectively. Growth is also less corresponding to the quantity of added fat. This negative correlation of growth rate to different levels of fat may be due to blocking of the access of microbes to ionophores (Clary *et al.*, 1993).

5.2 Body measurements

5.2.1 Length

The cumulative increase in body length of kids in groups I, II and III were 17.0 ± 1.26, 15.4 ± 0.84 and 13.5 ± 0.89 cm respectively at the end of the experimental period of 13 weeks (Table 12).

The analysis of covariance on cumulative increase in length (cm) taking initial body length (cm) as covariate reveals that there was no significant difference (P>0.05) between the treatment groups (Tables 11 and 12).

The final body length at the end of the experimental period of 13 weeks were 53.9 ± 1.03, 54.0 ± 1.05 and 51.5 ± 1.18 cm for the groups I, II and III respectively (Table 12).

Gangadevi (1981) observed a body length of 52.0 cm in eight month old Malabari kids weighing 17.7 kg, maintained on a concentrate ration containing 16 per ent crude protein. Ralston (1997) observed a final body length of 54.8 cm in seven to eight month old Malabari kids weighing 15.2 kg, maintained on a complete ration under intensive system of management.

The final body lengths observed in the present study are comparable to the final body length reported by Gangadevi (1981) and Ralston (1997) in Malabari kids of more or less the same age and weight.

Meinert *et al.* (1992) conducted studies in Holstein heifers and reported that monensin supplementation had no significant influence on body length.

The results of the present investigation reveal that monensin supplementation in complete rations with varying levels of crude fibre had no significant influence on body length. This is in agreement with the results of Meinert *et al.* (1992).

5.2.2 Girth

The cumulative increase in chest girth of kids in groups I, II and III were 13.2 ± 0.60, 10.4 ± 0.88 and 8.1 ± 0.61 cm respectively at the end of the experimental period of 13 weeks (Table 17).

The analysis of covariance on cumulative increase in girth (cm) taking initial chest girth (cm) as covariate reveals that the animals in group I and group II had significantly higher ($P<0.01$) cumulative increase in girth than those in group III as shown in Tables 16 and 17.

The final chest girths were 58.1 ± 1.09, 56.2 ± 1.02 and 53.2 ± 1.04 cm for the groups I, II and III respectively (Table 17).

Gangadevi (1981) observed a chest girth of 60.8 cm in eight month old Malabari kids weighing 17.7 kg. Ralston (1997) observed a final chest girth of 57.1 cm in seven to eight month old Malabari kids weighing 15.2 kg.

The final chest girths observed in the present study are lower than that reported by Gangadevi (1981) and comparable to that reported by Ralston (1998) in Malabari kids of more or less the same age and weight.

Meinert *et al.* (1992) conducted studies in Holstein heifers and reported that monensin supplementation had no significant influence on chest girth.

The results of the present investigation reveal that supplementation of monensin in complete rations did not influence the chest girth. The significant difference observed between the groups may be due to the difference in weight of the animals. The above results are in confirmation with the findings of Meinert *et al.* (1992).

5.2.3 Height

The cumulative increase in height at withers of kids in groups I, II and III were 14.4 ± 0.87, 11.8 ± 0.79 and 9.4 ± 0.73 cm respectively at the end of the experimental period of 13 weeks (Table 22).

The analysis of covariance on cumulative increase in height (cm) taking initial height (cm) as covariate reveal that a significant difference ($P<0.01$) could be noted between the three groups, with group I coming on the top followed by groups II and III in the descending order as shown in Tables 21 and 22.

The final height at withers were 59.4 ± 0.79, 58.0 ± 0.96 and 54.8 ± 0.84 cm for the groups I, II and III respectively (Table 22).

Gangadevi (1981) observed a height of 61.2 cm in eight month old Malabari kids weighing 17.7 kg. Ralston (1997) observed a height of 51.3 cm in Malabari kids weighing 15.2 kg.

The height at withers observed in the present study are comparable to that reported by Gangadevi (1981). However, it is higher than that reported by Ralston (1998) in Malabari kids of more or less the same age and weight.

Meinert *et al.* (1992) conducted studies in Holstein heifers and reported that monensin supplementation had no significant influence on height at withers.

The results of the present investigation reveal that monensin supplementation in complete rations did not influence the height at withers. The significant difference observed between the groups may be due to the difference in weight of the animals. The above results are in confirmation with the findings of Meinert *et al.* (1992).

5.3 Dry matter intake

The average daily dry matter (DM) intake per animal in the groups I, II and III, calculated on the basis of the data for ten animals given in Table 23 were 425.20 ± 0.31, 398.00 ± 0.24 and 331.00 ± 0.13 g respectively.

The analysis of variance of the data on average daily DM intake reveal that the DM intake of animals in group III was significantly lower ($P<0.05$) than that of animals in group I (Tables 23 and 24).

Group I had the highest average daily DM intake followed by group II and group III in descending order. The animals in group I gained at a faster rate, had higher body weights which in turn increased their requirements, and hence ate more feed.

The average daily DM intake per kid were 556 g at the tenth week for group I, 476 g at the twelfth week for group II and 426 g at the thirteenth week for group III when the animals in the three groups had average body weights around 15 kg.

ICAR (1985) recommends a DM intake of 600 g/kid of 15 kg body weight for growth at the rate of 50 g/day. The requirement of animals in group I was higher as their rate of growth was 111.21 g/day. NRC (1981) recommends an additional requirement of 360 g DM for growth at 100 g/day over and above the maintenance needs. Therefore the DM intake of all the three groups of animals in the present study was lower than the requirement as mentioned in the standards.

Joyner *et al.* (1979) reported that monensin supplemented at the rate of 20 ppm in lambs decreased the feed consumption by 2 to 18 per cent when compared to the controls. Tyler *et al.* (1992) observed that monensin supplemented at the rate of 20 mg/kg feed in lambs fed on a concentrate diet brings about an approximately 10 per cent decrease in voluntary feed intake. Patel and Honmonde (1994) observed a significant reduction in the daily intake of concentrate mixture in Malpura lambs fed *ad libitum* on a concentrate mixture supplemented with 22 ppm monensin when compared to the control.

Reddy and Reddy (1985) reported average daily DM intakes of 747.00 g and 705.00 g in Nellore sheep fed two different complete rations in mash form containing 17.4 and 18.9 per cent crude fibre respectively. Shyama (1994) observed DM intakes of 562.92, 574.59, 572.30 and 564.00 g per day for kids maintained on rations containing 12 per cent and 16 per cent crude protein with or without supplementation of dried spleen at 0.1 per cent level. Deepa (1998) reported average daily DM intakes of 569.07, 554.00 and 510.52 g respectively in three groups of kids fed complete rations containing different roughage sources.

The average daily DM intake observed in the present investigation was lower than that observed by Reddy and Reddy (1985), Shyama (1994) and Deepa (1998). The significantly low DM intake observed in Group III when compared to groups I and II might be due to the increased bulkiness of the ration.

The average DM intakes calculated per 100 kg body weight were 3.26 ± 0.12, 3.18 ± 0.09 and 3.00 ± 0.01 kg respectively for groups I, II and III (Table 41). Their analysis of variance shown in Table 42 reveal that there was no significant difference (P>0.05) between the three treatment groups.

5.4 Feed conversion efficiency

The cumulative feed conversion efficiency of animals in groups I, II and III were 4.04, 4.29 and 5.06 respectively (Table 27). The analysis of variance of the data on average weekly feed conversion efficiency reveal that there was no significant difference (P>0.05) between the three treatment groups (Table 28).

Joyner *et al.* (1979) reported a feed conversion efficiency of 6.78 in lambs supplemented with 20 ppm monensin. Yazd *et al.* (1979) observed a feed conversion efficiency of 4.40 in lambs fed monensin at the rate of 30 ppm in concentrate mixture. Patil and Honmonde (1994) reported a feed conversion efficiency of 5.31 in Malpura lambs fed on a concentrate diet supplemented with 22 ppm monensin. Martini *et al.* (1996) conducted studies in Masese lambs by feeding them on diets supplemented with monensin (10 mg/kg from 7 to 49 days and 20 mg/kg feed from 49 to 105 days) and observed that the feed conversion efficiency for the whole of the experimental period was 3.78 in the treatment group.

Block and Shellenberger (1980a) reported a feed conversion efficiency of 3.30 in Holstein calves fed on a commercially available pelletted complete ration, which was low in crude fibre. Reddy and Reddy (1985) observed a feed conversion efficiency of 12.45 and 12.77 respectively in Nellore lambs fed two different complete feeds in mash form. The feed conversion efficiency obtained by Chahal and Sharma (1992) in their studies using complete rations in goats was 9.06 for the control group. Deepa (1998) reported feed efficiency values of 9.10, 9.33 and 9.67 respectively for three different complete rations containing different roughage sources, in kids.

The cumulative feed conversion efficiency obtained for all the three groups in the present study was higher than those reported by Joyner *et al.* (1979), Reddy and Reddy (1985), Chahal and Sharma (1992), Patil and Honmonde (1994) and Deepa (1998) and comparable to that of Yazd *et al.* (1979). However, the cumulative feed conversion efficiencies observed in the present study were lower than those reported by Block and Shellenberger (1980a) in calves and Martini *et al.* (1996) in lambs.

Comparisons with the above reports suggest that monensin supplementation in complete rations for kids improved feed conversion efficiency, the magnitude of the response being more in low fibre rations than high fibre rations.

5.5 Cost per unit gain

The cost of production in terms of rupees per kilogram gain were 28.61, 31.68 and 38.59 for animals in the groups I, II and III respectively (Table 29).

Reddy and Reddy (1985) reported that the cost of feed per kilogram live weight gain was Rs.9.28 and Rs.9.45 respectively in Nellore lambs fed two different complete diets in mash form. Chahal and Sharma (1992) observed a feed cost per kilogram live weight gain of Rs.14.09 in kids fed complete rations. Deepa (1998) reported that the cost of production per kilogram gain were Rs.69.54, Rs.60.43 and Rs.59.16 respectively for kids maintained on three different complete rations.

The cost of production per kilogram gain in the present investigation are lower than that reported by Deepa (1998). However, the figures obtained in the present investigation are higher than those reported by Reddy and Reddy (1985) and Chahal and Sharma (1992). Cost estimates of Reddy and Reddy (1985) and Chahal and Sharma (1992) cannot be compared with the present cost estimates due to the escalation of cost of feed ingredients over the period elapsed between the studies.

5.6 Digestibility coefficients of nutrients

5.6.1 Dry matter

The average digestibility coefficients of DM were 75.59 ± 0.84, 77.94 ± 2.06 and 79.69 ± 0.60 per cent respectively for the animals in groups I, II and III (Table 34). Their analysis of variance shown in Table 35 reveal that there was no significant difference (P>0.05) between the three groups.

There are conflicting reports on the influence of monensin on digestibility of DM. Goodrich *et al.* (1984), Beede *et al.* (1985) and Lee *et al.* (1992) reported that monensin supplementation increased the DM digestibility.

Vuuren and Nel (1983) and Ricke *et al.* (1984) reported that digestibility of DM was not influenced by monensin.

Reddy and Reddy (1985) reported DM digestibility coefficients of 56.11 and 59.92 per cent respectively in Nellore lambs fed two different complete rations. Chahal and Sharma (1992) reported a digestibility coefficient of 67.76 per cent in kids fed complete rations. Deepa (1998) observed digestibility coefficient values of 67.04, 60.72 and 56.37 per cent respectively in kids fed three complete rations incorporating different roughage sources.

The results of the present investigation are higher than the values reported by Reddy and Reddy (1985), Chahal and Sharma (1992) and Deepa (1998) with complete rations. The present study suggests that monensin supplementation might have increased the DM digestibility. This is in confirmation with the reports of Goodrich *et al.* (1984), Beede *et al.* (1985) and Lee *et al.* (1992).

5.6.2 Organic matter

The average digestibility coefficients of organic matter were 78.43 ± 0.88, 80.09 ± 1.91 and 81.52 ± 0.58 per cent respectively for the animals in groups I, II and III (Table 34). Their analysis of variance shown in Table 36 reveal that there was no significant difference ($P>0.05$)

between the three groups. However, numerically Group III animals had the highest organic matter digestibility values followed by Group II and Group I in descending order.

Beede *et al.* (1985) reported that monensin supplemented at the rate of 23 mg/kg feed significantly increased the digestibility coefficient of organic matter in goats. Faulkner *et al.* (1985) reported that monensin brought about a significant increase in the organic matter digestibility of steers fed on high fibre diets. Zinn and Borques (1993) reported that supplemental monensin decreased rumen organic matter digestibility which was however compensated by increased post ruminal organic matter digestion to give a total tract digestibility of 81.50 per cent.

Reddy and Reddy (1985) reported that the digestibility coefficients of organic matter were 59.89 and 62.87 per cent respectively in Nellore lambs fed on complete rations. Ram *et al.* (1990) observed values of 59.70, 52.40 and 55.50 per cent respectively for three different complete rations in goats. Chahal and Sharma (1992) conducted studies in kids by feeding them with complete rations and observed that the digestibility coefficient of organic matter was maximum in the control group (70.50%). Rao *et al.* (1995) reported a digestibility coefficient of 58.52 per cent in Nellore rams fed on complete rations.

The values obtained for digestibility coefficients of organic matter in the present study are higher than that reported by Reddy and Reddy (1985), Ram *et al.* (1990), Chahal and Sharma (1992) and Rao *et al.* (1995) with complete rations and comparable to that of Zinn and Borques (1993).

The present findings suggest that monensin supplementation may be effective in increasing organic matter digestibility, irrespective of the fibre level in the ration, with the magnitude of the response tending to be more in the high fibre group (group III). This is in accordance with the findings of Faulkner *et al.* (1985).

5.6.3 Crude protein

The average digestibility coefficients of crude protein were 76.58 ± 0.98, 77.76 ± 2.19 and 82.48 ± 0.87 per cent respectively for the animals in groups I, II and III (Table 34). Their analysis of variance given in Table 37 show that there was no significant difference ($P>0.05$) between the three groups.

Beede *et al.* (1985) and Lee *et al.* (1992) reported that monensin supplementation significantly increased the digestibility of crude protein.

Reddy and Reddy (1985) reported digestibility coefficient values of crude protein as 58.97 and 58.99 per cent respectively in Nellore lambs fed on complete rations. Ram *et al.* (1990) observed values of 57.50, 53.00 and 44.10 per cent respectively in goats fed on complete rations. Chahal and Sharma (1992) observed that the digestibility of crude protein was maximum in the control group (67.27%) when the effect of complete rations in kids was studied. Rao *et al.* (1995) reported a value of 58.52 per cent in Nellore rams fed on a complete ration. Deepa (1998) reported values of 65.26, 59.79 and 54.46 per cent respectively in kids fed three different complete rations containing various roughage sources.

The digestibility coefficients of crude protein obtained in the present study are higher than that reported by Reddy and Reddy (1985), Ram *et al.* (1990), Chahal and Sharma (1992), Rao *et al.* (1995) and Deepa (1998) with complete rations.

The above findings on crude protein digestibility are in accordance with that of Beede *et al.* (1985) and Lee *et al.* (1992) suggesting that monensin supplementation in complete rations might have increased the digestibility of crude protein.

5.6.4 Ether extract

The average digestibility coefficients of ether extract were 66.50 ± 0.79, 67.97 ± 3.45, 63.22 ± 2.13 per cent respectively for the animals in groups I, II and III (Table 34). Their analysis of variance shown in Table 38 reveal that there was no significant difference (P>0.05) between the three groups.

Beede *et al.* (1985) reported that monensin supplemented at the rate of 23 mg/kg feed in a ration containing 17.5 per cent crude protein for goats increased the digestibility coefficients of ether extract significantly.

Reddy and Reddy (1985) reported digestibility coefficient values of ether extract as 50.39 and 55.00 per cent in Nellore lambs fed on two different complete rations. Ram *et al.* (1992) observed values of 51.80, 48.30 and 41.70 per cent in goats fed on three complete rations. Chahal and Sharma (1992) observed a value of 88.10 per cent in kids fed on a complete ration. Rao *et al.* (1995) reported a value of 71.36 per cent in Nellore rams fed on a complete ration. Deepa (1998) reported values of 86.48, 77.53 and 68.30 per cent in kids fed three different complete rations containing various roughage sources.

The results of the present investigation reveal that the digestibility coefficients of ether extract in the three experimental groups are higher than that reported by Reddy and Reddy (1985) and Ram *et al.* (1990) and lower than that reported by Chahal and Sharma (1992), Rao *et al.* (1995) and Deepa (1998).

The present study suggests that monensin supplementation does not appear to have any influence on the digestibility of ether extract in complete rations having different levels of fibre. The above findings are however contradictory to the reports of Beede *et al.* (1985).

5.6.5 Crude fibre

The average digestibility coefficients of crude fibre were 51.56 ± 1.29, 66.34 ± 3.21, 67.08 ± 0.62 per cent respectively for the animals in groups I, II and III (Table 34). Their analysis of variance shown in Table 39 reveal that digestibility coefficient of crude fibre in group I was significantly lower ($P<0.05$) than that in groups II and III.

Monensin significantly increased crude fibre digestibility in animals fed high fibre diets as reported by Faulkner *et al.* (1985) in steers and Bedo (1996) in sheep.

Pulina *et al.* (1995) conducted studies in dairy ewes fed on complete pelleted diets and reported that the digestibility of crude fibre was low in the low fibre group.

Reddy and Reddy (1985) reported digestibility coefficients of crude fibre as 49.91 and 52.87 per cent in Nellore lambs fed on two different complete rations. Ram *et al.* (1990) observed values of 57.90, 47.60 and 63.50 per cent in goats fed on three complete rations. Chahal and Sharma (1992) observed a value of 45.20 per cent in kids fed on a complete ration. Rao *et al.* (1995) reported a value of 64.21 per cent in Nellore rams fed on a complete ration. Deepa (1998) reported values of 36.36, 43.01 and 49.44 per cent respectively in kids fed three different complete rations containing various roughage sources.

The results of the present investigation indicate that the digestibility coefficients of crude fibre in experimental groups II and III are higher than that reported by all the above workers with complete rations. This suggests that monensin supplementation might have been effective in improving digestibility of fibre in complete rations with 12 and 16 per cent crude fibre (groups II and III), with the magnitude of response being more in group III. The above findings are in confirmation with the reports of Faulkner *et al.* (1985) and Bedo (1996).

The low crude fibre digestibility observed in group I of the present study is in accordance with the findings of Pulina *et al.* (1995). Possible reasons may be a reduction in the number of cellulolytic and fibre digesting bacteria (Metzger *et al.*, 1976) and/or a reduction in rumen protozoa (Ushida *et al.*, 1991) with the net result that hemicellulose and lignocellulose digestion in the rumen got reduced. Another possible reason for the low crude fibre digestibility in the eight per cent fibre group (group I) might be that the crude fibre present in concentrates is less digestible.

5.6.6 Nitrogen free extract

The average digestibility coefficients of nitrogen free extract (NFE) were 85.56 ± 0.84, 85.41 ± 2.11 and 87.12 ± 0.39 per cent respectively for the animals in groups I, II and III (Table 34). Their analysis of variance shown in Table 40 reveal that there was no significant difference ($P>0.05$) between the three groups.

Beede *et al.* (1985) reported that monensin supplemented at the rate of 23 mg/kg feed in a ration containing 17.5 per cent CP for goats, increased the digestibility coefficients of NFE significantly.

Reddy and Reddy (1985) reported NFE digestibility coefficient values of 67.74 and 65.78 per cent in Nellore lambs fed on two different complete rations. Ram *et al.* (1990) observed values of 60.30, 53.70 and 55.99 per cent in goats fed on three complete rations. Chahal and Sharma (1992) observed a value of 73.20 in kids fed on a complete ration. Rao *et al.* (1995) reported a value 59.84 per cent in Nellore rams fed on a complete ration. Deepa (1998) reported values of 81.43, 74.19 and 63.83 per cent in kids fed three different complete rations containing various roughage sources.

The digestibility coefficients of NFE obtained in the present study for all the three groups was higher than that reported by all the above workers indicating that monensin supplementation might have been effective in improving the digestibility of NFE irrespective of the fibre content of the ration (Beede *et al.*, 1985).

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

The DCP intake per 100 g DM consumed were 12.28, 12.33 and 13.17 g respectively for groups I, II and III (Table 45). The average DCP intake per animal per day were 52.21, 49.07 and 43.59 g for the experimental groups I, II and III respectively (calculated on the basis of average daily DM intake).

The TDN intake per 100 g DM consumed were 78.05, 79.73 and 79.68 g respectively for groups I, II and III (Table 45). The average TDN intake per animal per day were 331.87, 317.33 and 263.74 g for the experimental groups I, II and III respectively (calculated on the basis of average daily DM intake).

Kids of 15 kg live weight (growth rate 50 g/day) require 30 g DCP and 350 g TDN (ICAR, 1985).

The intake of DCP and TDN when the animals in each group were weighing around 15 kg were as follows: Group I 68.28 g DCP and 433.96 g TDN, group II 58.69 g DCP and 379.51 g TDN and group III 56.10 g DCP and 339.44 g TDN. The above findings indicate that the DCP and TDN intake of the animals of the present study were sufficient to meet the requirements.

5.8 Nitrogen balance

The nitrogen balance in grams per day were 4.25 ± 0.65, 5.09 ± 0.41, 6.37 ± 0.17 respectively for animals in the experimental groups I, II and III (Table 46). The nitrogen retention expressed as a percentage of intake were 30.60 ± 4.67, 38.97 ± 3.27 and 46.10 ± 2.20 per cent respectively for animals in the experimental groups I, II and III (Table 46) and their analysis of variance shown in Table 47 reveal that per cent retention of nitrogen in group I was significantly lower ($P<0.05$) than that in group III.

The significantly high nitrogen retention values obtained in the present study for the 16 per cent fibre group (group III) contradicts the findings reported elsewhere in this study since this group had the least growth. It can be seen that animals in this group (group III) consumed almost the same quantity of nitrogen as that of animals in group I, but excreted less of nitrogen through urine and faeces and hence had greater nitrogen retention. The probable reason can be ascertained by looking at the growth pattern of animals in group III during the feeding trial. During the eleventh week, due to a bout of respiratory infection the growth was poor for animals in group III as reflected by an average daily gain value of 5.72 g/day. This was being made up by compensatory growth over the twelfth and thirteenth week as reflected by average daily gain values of 69.28 and 153.57 g respectively over these two weeks.. Metabolism trial was conducted at 13th week of the experiment. Therefore it becomes clear that in the present study, the animals of group III in the compensatory growth phase retained more nitrogen in their body.

5.9 Dressing percentage

The average dressing percentage values of animals calculated on the basis of live weight and corresponding carcass weight were 50.74 ± 1.11, 50.54 ± 1.10 and 47.80 ± 0.94 per cent respectively for animals in groups I, II and III (Table 48). The analysis of variance of the data on dressing percentage reveal that there was no significant difference ($P>0.05$) between the three treatment groups (Table 49).

There has been conflicting reports about the influence of monensin on dressing percentage. Nockels *et al.* (1978), Sharrow *et al.* (1981) and Vuuren and Nel (1983) reported that monensin does not have a significant influence on dressing percentage in lambs. However, significant influences on dressing percentage were observed with high concentrate monensin supplemented diets by Ostilie *et al.* (1981) in finishing steers and Gotthardt and Hort (1990) in bull calves.

Sharrow *et al.* (1981) reported a dressing percentage value of 47 in monensin supplemented lambs. Saini *et al.* (1987) observed an average dressing percentage of 47.02 in Barbari kids fed on a concentrate ration and slaughtered at six months of age. Skrivanova (1995) reported dressing percentage values of 40.10, 43.30 and 43.80 per cent in White Short - wooled goats fed on complete rations. Upase (1995) observed a dressing percentage of 48.50 in lambs fed complete rations. Ralston (1997) reported a dressing percentage of 49.15 in Malabari kids fed on a complete feed under intensive system.

The dressing percentage values obtained in the present investigation are higher than those reported by Sharrow *et al.* (1981) in lambs fed on a monensin supplemented diet and Saini *et al.* (1987) in Barbari kids fed on concentrate ration. The dressing percentage values obtained in the present study are comparable to that reported by Upase (1995) and Ralston (1997) with complete rations in lambs and kids respectively.

From the results of the present investigation it can be presumed that monensin does not have any significant influence on dressing percentage when supplemented in complete rations having different levels of fibre. This is in accordance with the findings of Nockels *et al.* (1978), Sharrow *et al.* (1981) and Vuuren and Nel (1983).

5.10 Histopathological study of the rumen epithelium

Microscopical examination of the samples of rumen tissues of slaughtered animals reveal that parakeratosis was present in all the slaughtered animals belonging to the three groups (Representative microphotographs are depicted in Fig.15, 16 and 17).

The animals in group I exhibited long, slender and branched rumen papillae. A pronounced thickening of the rumen papillae could also be noticed in this group clearly indicating parakeratosis. Change in cellular morphology viz., 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 of the animals of group I. The animals in group II and group III also exhibited long, slender and branched rumen papillae with associated thickening. However, the extent of these changes noticed was much less when compared to that of animals in group I indicating parakeratosis of only a mild degree in group II and group III. Also the changes in cellular morphology were indistinct in the animals of group II and group III indicating that parakeratosis had not developed to any appreciable degree. Rumen epithelium of animals in group III showed the least changes.

High concentrate complete diets, when fed continuously for a period of time can result in lactic acidosis in ruminants as reported by several workers (Boshinova, 1976; Wheeler *et al.*, 1980 and Marckiewicz *et al.*, 1986).

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. The resultant condition was called parakeratosis.

Block and Shellenberger (1980a and b) reported that calves fed on a commercial ration which was high in concentrate showed long, branched, necrotic papillae that were keratotic and loosely attached.

Ionophore antibiotics like monensin can inhibit the growth of major ruminal lactate producers (Chen and Wolin, 1979 and Dennis *et al.*, 1981) without inhibiting ruminal lactate utilizers (Dennis *et al.*, 1981) with resultant decrease in lactic acid production.

The parakeratosis observed in group I in the present study is in accordance with the reports of Boshinova (1976), Wheeler *et al.* (1980) and Marckiewicz *et al.* (1988). However, clinical symptoms of acidosis such as off feed, indigestion and subsequent reduction in growth rate could not be observed in any of the groups. One probable reason could be that, monensin supplemented in the diets must have prevented development of clinical lactic acidosis as reported by Chen and Wolin (1979) and Dennis *et al.* (1981).

5.11 Economics

The gross profit for ten animals for three months were Rs.2546.76, Rs.1987.01 and Rs.750.79 respectively for the experimental groups I, II and III (Table 50). The higher gross profit obtained for animals in group I in comparison to the other two groups might be due to the better growth and comparatively lower feed cost.

Ionophore supplemented, cost effective rations have been prepared by several workers (Stuart, 1990; Gilb and Baker, 1991 and Horn *et al.*, 1992) and have been found to increase considerably the net return/head.

Considering the low cost involved in supplementing monensin (Rs.4.80/100 kg feed), monensin can be recommended for incorporation in complete rations with eight per cent fibre, with economic benefits.

It can be concluded from the present study that supplementing monensin in low fibre complete rations improves growth and feed efficiency in kids of three to four months of age, reared under intensive system for short periods not exceeding 90 days. It also brings down the cost of production considerably. The benefit of monensin was seen more in animals fed on ration A (crude fibre 8%) followed by those fed on ration B (crude fibre 12%) and ration C (crude fibre 16%). The gross profit that can be expected from a kid of group I, fed on ration A works out to Rs.254 over a period of 90 days.

Summary

SUMMARY

An investigation was carried out in Malabari kids to assess the influence of monensin supplementation in complete rations with different levels of crude fibre. Thirty kids of three to four months of age from the Goat and Sheep Farm of Kerala Agricultural University were divided randomly into three equal groups (I, II and III) and were fed on complete rations A, B and C (containing 8, 12 and 16% crude fibre respectively) for a period of 13 weeks. The rations were isoproteimic and isocaloric (15% CP and 65% TDN) and were supplemented with monensin at the rate of 20 mg/kg.

Records of daily feed intake, weekly body weight and body measurements were maintained. Towards the end of the experiment, a digestion-cum-metabolism trial was carried out to find out the digestibility coefficients of nutrients in the respective rations. At the end of the experiment three male animals from each group were slaughtered to study the dressing percentage. Samples of rumen tissues of the slaughtered animals were collected and processed to study changes in rumen epithelium, if any.

The salient observations made during the present study and the inferences drawn from the results are summarised below:

1. The animals in groups I, II and III showed cumulative weight gains of 9.6,. 8.5 and 6.0 kg during the experimental period. The weight gain of animals in group I and group II was significantly higher ($P<0.01$) than group III. The average daily body weight gains were 111.21, 88.74 and 65.22 g respectively for the groups I, II and III. The daily weight gain of group I was significantly higher ($P<0.05$) than group III. Positive influence of monensin on body weight gain was more pronounced in animals on rations containing lower levels of crude fibre.

2. The cumulative increase in length did not differ significantly ($P>0.05$) between the three groups. The cumulative increase in chest girth was significantly higher ($P<0.05$) in groups I and II when compared to group III. The cumulative increase in height at withers differed significantly ($P<0.01$) between the three groups, with group I coming on top followed by groups II and III in the descending order. Monensin does not seem to have any significant influence on body measurements. The significant difference observed between the groups in girth and height may be due to the difference in body weights.

3. The average daily dry matter intake of the ten animals in the three groups were 4.25, 3.98 and 3.31 kg respectively, group I being significantly higher ($P<0.05$)

than group III. Higher DM intake of group I commensurates with higher body weight gains. The DM intake per 100 kg body weight were 3.26, 3.18 and 3.00 kg respectively for the three groups, with no significant difference ($P>0.05$).

4. The animals in groups I, II and III showed cumulative feed conversion efficiency values of 4.04, 4.29 and 5.06 respectively. Differences in weekly feed efficiency between the three groups were not statistically significant ($P>0.05$). The feed efficiency tended to be better at low levels of fibre in the ration, probably due to the greater influence of monensin.

5. The cost of production per kilogram gain was Rs.28.61, 31.68 and 38.59 respectively for groups I, II and III indicating that there is no economic advantage in supplementing monensin to rations high in crude fibre.

6. The digestibility coefficients of dry matter, organic matter, crude protein, ether extract and nitrogen free extract did not differ significantly ($P>0.05$) between the three groups. The digestibility coefficient of crude fibre of animals in group I was significantly lower ($P<0.05$) than that of animals in groups II and III. This indicates that monensin supplementation improves digestibility of fibre in complete rations having higher levels of fibre.

7. The average dressing percentage was 50.74, 50.54 and 47.80 respectively in the three groups with no significant difference (P>0.05) between the groups.

8. Animals in group I showed a distinct parakeratosis. Parakeratosis of milder degree was present in groups II and III in descending order.

9. Calculated gross profit from ten animals in 13 weeks were Rs.2546.76, 1987.01 and 750.79 respectively for the three groups. Ration A with 8 per cent fibre gave higher profits than the other two in the descending order, ration with 16 per cent fibre at the lower end.

It can be concluded from the present study that supplementing monensin in low fibre complete rations improves growth and feed efficiency in kids of three to four months of age, reared under intensive system for short periods not exceeding 90 days. It also brings down the cost of production considerably. The benefit of monensin was seen more in animals fed on ration A (crude fibre 8%) followed by those fed on ration B (crude fibre 12%) and ration C (crude fibre 16%). The gross profit that can be expected from a kid of group I fed on ration A works out to Rs.254 over a period of 90 days.

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MONENSIN SUPPLEMENTATION IN COMPLETE RATIONS FOR KIDS

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ABSTRACT OF A THESIS

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ABSTRACT

An investigation was carried out to assess the influence of monensin supplementation in complete rations for kids. Thirty Malabari kids of three to four months of age were divided randomly into three equal groups (I, II and III). The animals were maintained on isoproteimic and isocaloric complete rations A, B and C containing eight, twelve and sixteen per cent crude fibre respectively for a period of 13 weeks (91 days). The rations were supplemented with monensin at the rate of 20 mg/kg.

The weight gained by animals during the experimental period was highest in group I followed by groups II and III in the descending order, groups I and II showing significantly higher gains ($P<0.01$) than group III. This is suggestive of the positive influence of monensin in rations containing lower levels of crude fibre.

Monensin did not appear to have any effect on body measurements viz., body length, chest girth and height at withers.

The average daily dry matter (DM) intake of animals in group I was significantly higher ($P<0.05$) than group III, but

there was no significant difference (P>0.05) in DM intake per 100 kg body weight between the three groups.

There was no significant difference (P>0.05) in weekly feed conversion efficiency values between the three groups.

The cost of production per kilogram gain increased linearly with increase in the level of crude fibre in the ration.

The digestibility coefficients of dry matter, organic matter, crude protein, ether extract and nitrogen free extract did not differ significantly (P>0.05) between the three groups. However, the digestibility coefficient of crude fibre was significantly lower (P<0.05) in group I when compared to groups II and III.

The average dressing percentage did not differ significantly (P>0.05) between the three groups.

A distinct parakeratosis was evident in animals of group I. The animals in groups II and III showed milder degrees of parakeratosis in descending order.

The gross profit declined linearly with increase in the level of crude fibre in the ration.

From an overall evaluation of the results obtained during the course of the present investigation, it can be inferred that, supplementing monensin in low fibre complete rations improves growth and feed efficiency in kids reared under intensive system of management. The gross profit that can be expected from a kid of group I fed on ration A works out to Rs.254 over a period of 90 days.