LUCERNE MEAL AS AN INGREDIENT IN CALF STARTER

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "LUCERNE MEAL AS AN INGREDIENT IN CALF STARTER" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Mannuthy,
31-8-1981.

GEETHA, A.

CERTIFICATE

Certified that this thesis, entitled "LUCERNE MEAL AS AN INGREDIENT IN CALF STARTER" is a record of research work done independently by Smt.Geetha, A. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

Dr. E. Stevenson,
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CONTENTS

INTRODUCTION

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Rural economy of India is closely tied up with cattle. India has 226.8 million cattle and buffaloes (Livestock census, 1977), and the level of milk production is one of the world's lowest. With the present level of annual milk production of about 23 million tonnes, the per capita availability of 105 g is far below the minimum nutritional requirement of an adult human being. The present situation in respect of availability of milk in Kerala is much more alarming.

According to 1977 census, the cattle population of Kerala (including buffaloes) was estimated to be about three million, 1.2 million of which being breedable females. The total milk production in the state during 1975-76 was estimated to be 0.55 million tonnes with an average per capita availability of 65 g (Subrahmanyan and Nair, 1979) being one of the lowest in the country and enough to cater to the needs of only 25 per cent of the people of Kerala. To raise the nutritional standards of about 21 million human population of Kerala to a minimum desirable level of 210 g per capita per day, the present level of milk production has to be increased by four to five times at least. Milk, being the major

source of quality animal protein for the majority of our population, the demand for it is always increasing. Improved dairy production is, thus, an important factor for promoting the nutritional standards and socio economic condition of our growing population.

The need for increasing milk production in the country is well recognized and countrys planning has been such in searching solutions by implementation of some bold and aggressive livestock and dairy development projects.

The success of cattle development depends upon proper rearing of calves, since they form the basic units for future stock. There are a large number of cross bred calves in our country and utmost care should be taken even from the calf hood stage itself to develop them to healthy dairy cows and bulls. The main objective of good management and balanced feeding of calves is to obtain optimum growth rate, so that they can attain early maturity. Scientific feeding and management of the calf are, hence, the key factors to development of healthy dairy herds.

A young calf is a monogastric animal and its delicate fore-stomach can accept only milk and other more nutritious

fluid diets till it assumes structural and functional features akin to that of adults. But the use of such diets for a longer period will delay the development of rumen and may add much to the cost of calf rearing. Also, the importance of milk in the nutrition of humans especially those of infants make it too luxurious an item to be fed to calves in sizeable quantities. This prompted animal nutrition workers in the country and abroad in formulating calf diets of non-milk origin. But it is necessary that any milk substitute which is to be fed to calves should be easily digestible and provide the same quantity and quality of nutrients as that of whole milk to prevent any drop in the growth rate. Quite a lot of work has already been reported on the use of milk substitutes and calf starters in raising calves (Makdani et al. 1970; Arora et al. 1975; Henschel et al. 1975; Otterly et al. 1976; Leela Prasad et al. 1977; Roy et al. 1977; Opstvedt et al. 1978).

It is well established that inadequate nutrition is the most important factor in restricting the full expression of the animals production potential. The main handicap in the promotion of livestock is the acute qualitative and quantitative shortage of livestock feeds

in the country. It has been estimated that only two thirds of fodder and one-fourth of concentrates required for providing adequate nutrition to the present animal population are produced in the country. The state imports about 1.5 lakh tonnes of concentrates from other states (Nair, 1976).

Linseed meal, fish meal and soyabean meal have been extensively tried in milk replacer diets with mixed success in the past. Soyabean, though considered as one of the chief protein sources for young calf, is quite an expensive item in India. Fish meal is one of the commonly available and comparatively cheaper sources of quality proteins and there has always been a great demand for it in the country. Further, it is a common feed ingredient in compounded livestock feeds particularly for poultry and pigs. According to the report of the National Commission on Agriculture 1976, the annual demand for fish meal based on the calculated requirements for poultry and pigs only, was estimated to be 70,000 tonnes as against the production of only 20,000 tonnes. In view of the urgent need for minimising the cost of production, the nutritionists have bent on devising means with which our animals can become less dependent on such

expensive feed items by searching for comparatively cheaper feeds like agricultural by-products and industrial waste materials. The development of industries supplying human foods has exerted a profound influence on animal production since some of their by-products can form sources of nutrients to animals. In order to explore the possibility of utilising the various industrial waste materials and agricultural by-products as animal feeds, extensive investigations have been carried out under the auspices of the Indian Council of Agricultural Research.

Green leaves are the world's largest sources of protein and nutritionists have succeeded in extracting leaf proteins, a potential substitute for fish meal and soyabean meal, from plant species hitherto rejected as unpalatable (Pirie, 1977). There are many reports that leaf proteins can be successfully used in the ration for calves, pigs and even poultry. (Koo et al. 1974; Pirie, 1977; Verma et al. 1980). Leaf protein concentrates usually show a favourable amino acid balance. According to Pirie (1977), leaf protein concentrate is rich in carotene and is a satisfactory substitute for fish meal, the limiting amino acid being methionine.

Many sources of leaf proteins such as amaranthus leaf meal (Odwango and Mugerwa, 1980), berseem meal (Verma et al. 1980) have been successfully tried in calf diets.

Alfalfa or lucerne (Medicago sativa), a leguminous crop, is one of the most promising sources for economic production of leaf protein concentrate. Alfalfa leaf meal is rich in most of the essential amino acids (Dimitrova, 1976) though a slight defeciency of methionine has been reported (Lyman et al. 1956; Shur Palekar, 1969). It is high in minerals especially calcium and iron and vitamins A and E. Possibility of using alfalfa protein concentrate in human diet has been stressed by Levy and Fox (1955). Results of a six month long feeding trial (Singh, 1970) with children, indicated that lucerne leaf protein, besides being an efficient lysine source, was also a satisfactory food protein supplement. Nutritional studies with rats (Singh, 1969) have shown that even under a state of vitamin and mineral deprivation, supplementation of rice diets with lucerne protein, significantly improved the performance. Lysine content of leaf protein made from lucerne was reported to be adequate for rats (Singh, 1969). Leela Prasad et al. (1977), Dolge et al. (1953), Kincaid (1980) tried calf

starters with lucerne.

The foregoing considerations clearly indicate that much systematic studies are required to exploit all the available feed resources for the economic rearing of calves. Though lucerne meal is considered as a good protein source, sufficient information as regards to its suitability in calf starters and other milk substitutes is lacking. As such, the present investigation is taken up to study the economic feasibility of utilising lucerne meal in calf starters as a partial or complete substitute for animal protein supplements.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The use of milk replacers and calf starters in the economic feeding of dairy calves has been engaging the attention of nutritionists. Reducing the quantity of whole milk in the diet of calves leads to slow growth rate and reduced vitality in many instances. Many workers stressed the need for whole milk as an essential part of the diet up to a certain age and later to be followed by suitable calf starters (Morrison, 1959; Raheja et al. 1961; Nagdan et al. 1965 and Dave et al. 1971).

Hurley et al. (1957) in a study to compare the different feeding systems in calves reported that it was possible to eliminate whole milk and milk replacers after 30 days of age and rear on good calf starters successfully. Steele (1957) studied the effect of duration of whole milk feeding on growth rate of calves. He found that the total weight gain at 20 weeks of age was significantly more in calves fed 399 pounds of milk from birth to 12 weeks of age than in those fed the same quantity only up to 8 weeks of age. In a study to compare dry skim milk with liquid skim milk added to an 18 per cent starter in the ration of Jersey calves for a period of 5 to 9 weeks, it was found that animals fed on diets containing liquid skim milk gained significantly more

weight and showed higher values for digestibilities of protein and for retention of calcium and phosphorus (Thigpen et al. 1964).

Clark and Whiting (1959) reported that calves fed whole milk at a constant rate of eight pounds per head daily until four weeks old made as rapid growth as those fed milk at a rate of 10 per cent of the body weight, when observed at 16 and 52 weeks of age. It was also noted that calves weaned from milk abruptly at four weeks age gained similar to those fed the same quantity, but weaned gradually. Grimes and Gardner (1959) recorded digestibility coefficients for milk fat as 94 to 97 per cent for milk with fat levels ranging from 3 to 9 per cent. Griffith et al. (1957) reported the apparent digestion coefficient of nitrogen in whole milk as 92 to 94 per cent. In a study to compare the relative growth and appearance of two groups of young calves fed two levels of 350 and 250 pounds of whole milk along with simple as well as complex dry calf starters, Harrison et al. (1960) reported significantly higher daily weight gain and lower starter consumption in respect of the former group.

Mc Coy et al. (1970) stressed the importance of colostrum feeding in the rearing of calves and reported

that serum gamma globulins did not increase by feeding colostrum after 24 hours indicating that the gut was impermeable to colostral proteins by the 24th hour after birth. Kincaid and Hafez (1969) recorded a daily colostrum consumption of 9 to 21.7 per cent of birth weight in Holstein and 4.9 to 16.4 per cent in Hereford calves during their first three days of life. It was also shown that Holsteins and Herefords required 4.56 and 7.16 kg respectively of colostrum for each kg gain in body weight.

The use of milk replacers and other milk substitutes in the economical feeding of calves was stressed by many workers. In a study to compare pelleted milk replacers with liquid replacers in the diets of dairy calves, Bush et al. (1968) reported that the form of the replacer did not markedly influence total weight gain, health or general thriftiness of the calves. Chik et al. (1975) compared the growth rates and feed efficiency of young calves fed on milk replacer, waste milk or fermented colostrum and reported that calves fed the milk replacer recorded the highest dry matter consumption, total weight gain and feed efficiency. In a similar study conducted by Otterly et al. (1976) it was found that weight gain

during 0 to 4 weeks were less for calves fed milk replacer compared to fermented colostrum but almost similar with both the diets during 4 to 6 weeks and in total gain for a period of 12 weeks. When two groups of Karan Swiss male calves maintained on rations with whole milk and milk replacer were compared, it was found that calves in both groups gained at the same rate indicating that milk replacers are equally effective as whole milk in the diets of young calves(Arora et al.1975).

Birth weight has a significant effect on live weight gain of calves (Roy et al. 1955). While studying the growth rates in Haryana calves, Kohli et al. (1962) indicated that there was an increase of 100, 150 and 200 per cent over the birth weight at the age of 3, 6 and 9 months respectively irrespective of the sex of the calf. According to Martin et al. (1962) some of the important factors contributing to significant variation in weight gain of dairy calves are breed, sex, degree of inbreeding and ration.

Studies on the nutritive requirements of young calves and on the desirable levels of nutrients in milk replacer and starter ration were carried out by many workers. Brown et al. (1958) reported that dairy calves from 2 to

84 days of age do not require starters containing more than 12 to 16 per cent crude protein when fed along with a limited amount of whole milk and good quality alfalfa hay. According to Lassiter et al. (1959), milk replacers should contain more than 15.2 per cent crude protein, for optimum growth. Hardison et al. (1959) could not observe any significant difference in daily gain of calves over a period of eight weeks when fed on rations with calculated protein levels of 20.4, 25 and 26.4 per cent. In a study to compare three different levels viz. 15, 20 and 25 per cent of protein in milk replacers, Bush and Schuch (1960) reported that growth rate of calves was greater for the group receiving the higher level of protein. Lassiter et al. (1963) indicated that calves made normal growth when fed milk replacer ration containing 24 per cent protein and their growth rates were equal to those of calves fed higher levels of protein. Bryant et al. (1967) in their studies using 88 numbers of male calves from four to sixty days of age recorded the energy requirement as 48.2 Kcal digestible energy per kg body weight for maintenance and 370 Kcal per 100 g gain for growth. Henschel and Radlo (1975) while studying the effects of protein levels in calf starters on growth and rumen development of Holstein calves reported that those consuming a lower

level of 16 per cent protein showed a tendency towards slower development of rumen and recorded lower rates of body gain. Studies of Morrill and Dayton (1978) indicated that the requirement of protein exceeded 11.7 per cent in air dry starter for weaned calves up to 12 weeks of age. It was also observed that sulphur supplementation stimulates starter consumption by calves adapted to urea utilisation.

Tzeng and Davis (1980) recorded the DL methionine requirement of calves in the absence of cystine to be 0.17 to 0.23 g per kg body weight per day.

Brown and Lassiter (1962) studied the effects of different protein energy ratios on growth rate of dairy calves and observed that the protein to energy ratio influenced growth rates, particularly after the calves were off milk feeding. Their results indicated that the optimum protein energy ratio would be 1: 46 or slightly less. Similar results were reported by Awate et al. (1975).

The effects of different levels and type of fats when added to the rations of young calves were studied by many workers. Lassiter et al. (1957) while comparing the effects of inclusion of different levels of added

fat in milk replacers indicated the advantageous effect of added fat up to 10 per cent level on the growth rate of calves. But a tendency to consume less feed was noticed as the level of fat was increased in the ration. In a similar study to compare the effects of four levels of 5, 10, 20 and 30 per cent stablized lard in milk replacers, Olson and Williams (1959) found that dry feed consumption decreased with increasing levels of fat in the liquid diets. Miller et al. (1959), observed that addition of 5 or 10 per cent of either plant or animal fat in calf starters markedly reduced feed consumption and weight gain. Hodgson and Murdock (1960) studied the effects of physical state of added fat in milk replacers and observed that replacers containing homogenised fat promoted significantly higher weight gain. Similar results were also reported by Hopkins et al. (1959).

Whitaker et al. (1957) studied the influence of source and level of crude fibre in calf starters on growth rate and feed consumption of calves. It was indicated that there were no significant differences in weight gain and starter consumption during a period of either eight or sixteen weeks due to difference in either source or level of crude fibre. In a study to assess the influence of roughage quality on rumen development in dairy calves,

Smith and Sobrevilla (1959) observed that while calves receiving a good quality roughage reached at peak of digestive ability at 2 to 3 weeks equal to that of mature steers, those fed on poor quality roughage failed to reach expected digestive ability even at 18 weeks of age.

There are many reports on the effects of inclusion of various sugars in calf rations (Riggs and Beaty, 1947; Huffman et al. 1954; Heller et al. 1956; Velu et al. 1959 and Shinde and Sangle, 1976). In a study using milk substitutes containing lactose, starch and molasses, Arora et al. (1975) inferred that calves could efficiently utilise the combination of sugars as early as one month of age.

The importance of trace element supplementation of milk replacers and calf starters was stressed by many authors. (Jones et al. 1955; Swanson and Carpenter, 1961; Rice et al. 1967 and Kshirsagar and Mudgal, 1972).

The effects of inclusion of antibiotics in calf ration on growth rates of calves were studied by Katzi-miltiades (1956), Bartley et al. (1956), Mullick (1959), Thomas et al. (1959), Velu and Reed (1960) and Swanson (1963). The above authors concluded that the major advantage of feeding antibiotics such as aureomycin to

calves was the reduction in the incidence of diarrhoea.

There are many reports on the use of enzyme supplements in the rations of dairy calves (Lassiter et al. 1959; Bush et al. 1961and Rust et al. 1965). Lassiter et al. (1959), while studying the effect of pepsin on the growth rate of young dairy calves consumed less feed and required more feed per pound of body gain when compared to control animals. The above authors concluded that feeding of pepsin supplemented plant protein milk replacer ration did not improve the performance of the calves. Wing (1961) and Morryll and Dayton (1977) studied the effect of inclusion of artificial flavours in starter rations and reported that in calves fed on starters containing flavours, feed intakes and body gains were significantly higher when compared to those for the control.

The nutritive values of various non-milk proteins in milk replacers and calf starters were widely studied. The superiority of soyabean oil meal over other vegetable proteins was pointed out by many workers (Morton and Eaton; 1946; Carpentor, 1951; Moller and Huffman, 1953; Stein et al. 1954 and Colvin and Ramsy, 1968).

Moller et al. (1956) reported that vegetable milk

replacers were not satisfactorily utilised until the calf was approximately 25 days of age. Pardue et al. (1962) compared the performance of calves weaned at 24 days of age and fed on rations containing vegetable and animal proteins. Their results indicated that inclusion of dried skim milk provided little additional benefit over vegetable sources of protein in the starter rations fed to early weaned calves. Similar results were reported by Bryant et al. (1963) in their studies with milk replacer diets containing dried skim milk and corn distillers dried solubles.

Fish meal protein was shown to be a suitable substitute for milk protein in milk replacers and calf starters. In a study to compare dried skim milk with fish flour in milk replacer rations providing 20, 40 and 60 per cent of the total protein, Slade and Huber (1965) did not find any significant difference between the control and experimental groups. Harshbarger and Galwicks (1965) showed that milk replacer containing 20 per cent of fish flour produced higher live weight gain, though not statistically significant than those with 50 per cent dried skim milk and 10 per cent fish flour. Huber and Slade (1967) included fish flour as a protein source in milk replacers of Holstein calves and found that average

daily gains and feed efficiencies were not significantly lowered when fish flour furnished up to 40 per cent of dietary protein. The mean digestibility coefficient of fish flour protein was found to be 80 per cent compared to 90 per cent for skim milk protein. Roy et al.(1977) compared the nutritive values of soyabean protein and fish protein with that of milk protein for pre ruminant calves. They found that the digestibility coefficients of dry matter and protein were lower in rations containing non milk proteins. The reduction in weight gain during the first three weeks was greater with soyabean diet than with the diet containing fish protein. According to Pachauri and Negi (1978), it was found possible to reduce the quantity of whole milk in calf ration from 375 to 186 kg by providing fish meal at 20 per cent level in the ration. Opstvedt et al. (1978) studied the effect of inclusion of fish protein concentrates in milk replacers as the principal source of protein and reported that fish protein did not cause any digestive problems and the animals remained healthy. It was also shown that a milk replacer containing fish flour and dried whey was almost similar to an all milk replacer.

Ansaari and Talapatra (1966) did not find any

significant increase in rate of growth or in digestibilities of organic nutrients by the addition of 10 per cent fish meal as a protein supplement in the rations of two to six months old male Haryana calves. Wendlandt et al. (1968) while studying the growth response of calves fed on milk replacers with fish flour providing 50, 75 and 100 percentage of protein, found that feeding replacers with 100 per cent fish protein resulted in excessive death losses at 3 to 4 weeks of age. Makdoni et al. (1970) included fish protein concentrate as the only protein source in liquid diets for young calves and reported that growth rates of calves on diets containing fish protein were less compared to those on a control ration with dried skim milk.

The role of leaf protein in human and animal dietary is well established. Levy and Fox as early as in 1935 stressed the possible use of lucerne in human dietary. Using in vitro studies, Woldegiorgis (1977) reported greater availability for methionine and lysine from leaf protein diets. Pirie (1977) studied the role of leaf protein in animal feeding and reported that leaf protein was a satisfactory substitute for fish meal and was even superior to either soyabean meal or groundnut meal. It was also shown that leaf meals are valuable

sources of carotene and xanthophyll.

Maniothiewicz et al. (1974) compared the feeding value of dried grass meal with that of lucerne meal in the rations of fattening calves of 11 days to 3 months of age. Average daily gains and digestibility coefficients of nutrients were similar with diets containing 5, 15 and 30 per cent levels of grass meal or 30 per cent level of lucerne meal. Prasad et al. (1977) conducted an experiment to assess the feeding value of lucerne extract in the rations of calves. They found that the calves fed lucerne extract grew at a rate of 410 g per day as compared to 476 g by the control animals fed on whole milk diet. Similar studies were carried out by Leelaprasad et al. (1977) using lucerne extract in milk replacer diets. The above authors also reported that while whole milk at 10 per cent rate was superior to milk replacer when fed from birth to 3 months, a milk replacer was found better than a diet of skim milk alone. The feeding of replacer containing lucerne extract was found to be more economical when compared to either whole milk on skim milk feeding.

Oduongo and Mugerwa (1980) compared the performance of calves on diets containing Amaranthus leaf meal and lucerne meal. They showed that Amaranthus leaf meal was

of comparable nutritive value to lucerne meal in early weaner diets and that calves performed well when fed on diets containing up to 40 per cent of Amaranthus leaf meal.

Porter and Kesler (1957), in a study to find out the feasibility of feeding alfalfa silage in the ration of young calves, during the first 16 weeks of life, reported that ad libitum feeding of alfalfa silage as the sole source of roughage resulted in growth rates comparable to feeding of either alfalfa hay alone or alfalfa hay and silage combined. Further, feeding of high quality alfalfa silage during the early days of life did not result in any digestive disorders in calves. When alfalfa pasture, alfalfa green chop and alfalfa hay were compared, Stiles et al. (1970) showed that calves on alfalfa pasture and green chop gained significantly more than those fed on alfalfa hay. Born et al. (1976) did not find any significant difference between wilted dehydrated lucerne and direct cut dehydrated lucerne when included in the rations of growing calves. Leibholz and Russel (1978) studied the effect of feeding chaffed or ground straw and lucerne in the diets of early weaned calves and showed that grinding depressed the intake of lucerne.

In a study to compare the effects of inclusion of

alfalfa pellets, in the rations of Holstein calves on growth and carotene utilisation, Dolge et al.(1953) recorded significantly higher weight gain in calves fed on ration containing alfalfa pellets at levels of 15 and 20 per cent. It was also found that the utilisation of carotene was independent of the level of intake. McCullough and Sisk (1958) reported that alfalfa pellets were not quite palatable until the calves were 10 to 12 weeks of age. Nikolov et al. (1973) did not notice any deleterious effects in calves when fed on pelleted feed containing lucerne at 20 per cent level up to 60 days old and at 30 per cent level from 60 to 120 days old. Kincaid (1960) observed that when fed free choice to early weaned calves, pelleted alfalfa was inferior to long stem hay for stimulating intakes of dry matter. There are many reports on the beneficial effects of alfalfa as a source of carotene in animal rations (Guilbert, 1936; Rousseau et al. 1956; Grifo et al. 1961 and Tekale and Joshi, 1977).

Studies on the nutritive value and on levels of inclusion of alfalfa in the rations of growing lambs were carried out by Bateman and Blaxter (1964), Krause and Klopfenstein (1978) and Thomson and Cammell (1979).

The feeding value of lucerne extract as a source of supplemental protein for growing swine was assessed by Barber et al. (1980). They concluded that freshly produced lucerne juice could be included in the rations of growing pigs to supply half of the normal protein supplement. It was observed by Koo et al. (1974) that inclusion of lucerne meal in the ration of growing and finishing swine tended to give thinner backfat and larger eye-muscle area.

There are also reports of inclusion of alfalfa protein concentrates and leaf extracts in the diets of laboratory animals. Saunders et al. (1973) recorded the digestibility coefficient of protein in alfalfa ranging from 80.5 to 99.9. Hove et al. (1974) showed that at a dietary protein level of 100 g per kilogram body weight, rats grew equally well with lucerne leaf protein concentrate as that with casein. Cheeke and Myer (1975) reported that lysine availability from lucerne protein concentrate was about 80 per cent of that of casein in rats.

MATERIALS AND METHODS

MATERIALS AND METHODS

Animals

Eighteen cross bred calves belonging to the University Livestock Farm, Mannuthy formed the experimental subjects for the study. The calves were weaned at birth and their body weights recorded. The animals were divided into three groups I, II and III as uniformly as possible in regard to body weight and maintained on the respective diets A, B and C for a period of 24 weeks. While the diet A (control) contained fish meal at a level of 10 per cent, diets B and C (experimental) contained lucerne meal at 15 and 20 per cent levels respectively in partial and complete replacement of fish meal, the three rations being made isoprotemic. The animals were housed in individual pens and subjected to similar managemental conditions throughout the course of the experiment. All calves were given colostrum at the rate of 10 per cent of their body weights for a period of seven days. The animals were protected from contagious diseases like foot and mouth, and were also dewormed regularly.

Diets

Percentage ingredient composition and chemical

composition of the experimental diets A, B and C are given below:

Percentage ingredient composition of the experimental diets.

	Diets		
	A	B	C
Groundnut cake	34	40	40
Maize	25	32	32
Wheat bran	23	..	..
Fish meal	10	5	..
Lucerne meal	..	15	20
Molasses	5	5	5
Mineral mixture	1.5	1.5	1.5
Salt	1.5	1.5	1.5

To all the above mixtures were added Vitablend and Aurofac 2 A at the rates of 25 and 250 g respectively per 100 kg of feed. Vitablend (glaxo) contained 50,000 I.U. Vitamin A and 5,000 I.U. of Vitamin D. per gram. Aurofac 2 A (Cyanamid) contained 8 g of aureomycin per kg.

Percentage chemical composition of the experimental diets.

	Diets		
	A	B	C
Moisture	9.6	9.7	10.3
Crude protein	22.9	24.2	23.4
Ether extract	3.1	2.6	3.2
Crude fibre	4.2	6.3	8.9
Total ash	12.1	13.7	10.9
Nitrogen free extract	48.1	41.5	43.3
Calcium	2.04	1.96	1.78
Phosphorus	0.60	1.21	1.09

The animals in all the three groups were fed on the respective diets at the rates shown below:

Age of the calf (days)	Milk (kg)	Concentrate mixture (kg) Diet A/B/C	Green grass (kg)
0 - 7	2.00	..	..
8 - 14	2.00	0.100	..
15 - 21	2.00	0.350	..
22 - 42	1.75	0.600	..
43 - 60	1.75	0.800	0.50
61 - 90	1.50	1.000	0.75
91 - 120	..	1.500	1.00
121 - 150	..	1.750	1.50
151 - 168	..	2.000	2.00

The concentrate feed was always given mixed with either milk or water. The animals were fed on the respective diets twice daily at regular intervals, 8 a.m. in the morning and 3.30 p.m. in the evening. Clean fresh water was provided ad libitum.

Records of fortnightly body weights and body measurements were maintained throughout the course of the experiment. Blood samples were collected from all the animals at monthly intervals for the estimation of plasma protein, haemoglobin, packed cell volume, plasma calcium and inorganic phosphorus. Haemoglobin was estimated by Cyanmethaemoglobin method (Benjamin, 1974), plasma protein by Biuret method (Gornall et al. 1949), plasma calcium by Clark and Collip modification (1925) of Kramer Tisdall Method (1921) and inorganic phosphorus by Fiske and Subba Row (1925) method.

Towards the end of the experiment, a digestion trial was carried out for the estimation of the digestibility coefficients of nutrients in the three rations. Data on total feed intake and faecal output in respect of animals were gathered during a collection period of four days. Faeces was collected as and when it was voided taking all precautions to avoid contamination

with urine and dirt. The faeces collected each day was weighed accurately, mixed well and representative samples at the rate of 1/10 of the total quantity were stored in a refrigerator. The aliquot of faeces taken during the collection period of four days were pooled and preserved for analysis. All the feed and faecal samples were analysed for proximate principles by standard procedures (A.O.A.C., 1970).

Statistical analysis of the results were carried out by the method described by Snedecor and Cochran (1965).

Estimation of Haemoglobin (Cyanmethaemoglobin method)

Principle

Ferrous iron of haemoglobin reacts with potassium ferricyanide and forms methaemoglobin which contains ferric iron. Methaemoglobin then reacts quickly with potassium cyanide and becomes cyanmethaemoglobin. Cyanmethaemoglobin is a stable pigment and its concentration is directly proportional to its optical density.

Reagents

Drabkin's diluent: Dissolved 1.0 g sodium bicarbonate,

50 mg potassium cyanide and 200 mg potassium ferricyanide in distilled water and made up the volume to 1,000 ml.

Procedure

Using 5 ml of Drabkin's diluent, checked the zero of the instrument. Then added 0.02 ml of well mixed sample of whole blood to 5 ml of the reagent. Mixed thoroughly and let stand for at least 15 minutes. Replaced the blank tubes with the unknown sample tubes and noted the readings which gave the haemoglobin content in gram percentage.

Determination of Plasma Protein (Biuret Method)

Principle

Substances containing two or more peptide bonds form a purple complex with copper salts in alkaline solution and the colour intensity is proportional to its concentration.

Reagents

1. Biuret reagent: Dissolved 1.5 g of cupric sulphate ($CuSO_4 . 5 H_2O$) and 6.0 g of sodium potassium tartarate in 500 ml water. Added with constant stirring, 300 ml

of 10 per cent sodium hydroxide solution (prepared from the stock carbonate free 65-75 per cent NaOH solution). Diluted to 1 litre with water and stored in a paraffin lined bottle.

2. Standard solution: Dissolved 250 mg of Bovine serum albumin in 50 ml distilled water so that 1 ml contains 5 mg.

Procedure

Prepared the standard by adding 4 ml Biuret reagent to 1 ml standard bovine serum albumin solution and 50 μl water. Prepared the unknown solution by adding 4 ml Biuret reagent to 1 ml distilled water and 50 μ l plasma. Prepared the blank by adding 4 ml Biuret reagent to 6 ml of distilled water. Made up the volume to 10 ml in all cases. Read the optical density of the unknown and standard solutions at 540 mμ using the blank for adjusting the instrument.

Calculation

$$\text{Plasma protein content (g per cent)} = \frac{\text{Reading of unknown} \times 0.005 \times 100}{\text{Reading of standard} \times 0.05}$$

Determination of Plasma Calcium
(Clark - Collip modification of the Kramer - Tisdall Method)

Principle

Calcium is precipitated directly from the serum as oxalate, and the latter is titrated with potassium permanganate solution.

Procedure

Introduced into a graduated 15 ml centrifuge tube, 2 ml of clear plasma, 2 ml distilled water and 1 ml of 4 per cent ammonium oxalate solution. Mixed thoroughly and allowed to stand for 30 minutes or more. Then centrifuged for about 5 minutes at 1500 revolution per minute. Carefully poured off the supernatent fluid and the tube was inverted and allowed to drain in a rack for 5 minutes, resting the mouth of the tube on a pad of filter paper. Then washed the sides of the tube with two per cent ammonia (3 ml), centrifuged and drained as before. Added 2 ml of approximately normal sulphuric acid (28 ml concentrated acid in 1 litre of water) by blowing it from a pipette directly upon the precipitate so as to break up the material and facilitate solution. Placed the tube in boiling water bath for about one

minute. Titrated with 0.01 N potassium permanganate solution to definite pink colour.

Calculation

1 ml of 0.01 N potassium permanganate solution is equal to 0.2 mg calcium.

Milligrams of calcium in 100 ml blood $= (x-b) \times 0.2 \times \frac{100}{2}$

where x = ml of $KMnO_4$ required in titration

b = blank ie. ml of $KMnO_4$ required to titrate 2 ml of H_2SO_4 solution to pink colour.

Determination of Plasma Inorganic Phosphorus (Fiske and Subba Row Method)

Principle

The proteins of blood are precipitated with Trichlor acetic acid. The protein free filtrate is treated with acid molybdate solution, which forms phosphomolybdic acid from any phosphate present. The phosphomolybdic acid is reduced by the addition of 1, 2, 4 - aminonaphthol sulphonic acid reagent to produce a blue colour, intensity of which is proportional to the amount of phosphate present.

Reagents

1. Molybdate reagent: Dissolved 25 g ammonium molybdate in 200 ml water and added to 300 ml of 10 N sulphuric acid in a litre volumetric flask and diluted with washing to one litre.

2. Aminonaphthol sulphonic acid reagent: Placed 195 ml of 15 per cent sodium bisulphite solution in a glass stoppered cylinder. Added 0.5 g of 1, 2, 4 - aminonaphthol sulphonic acid. Added 5 ml 20 per cent sodium sulphite, stoppered and shook until the powder was dissolved (If not dissolved, added more sodium sulphate, 1 ml at a time but avoiding excess). Since sodium bisulphite was not available ascorbic acid was used at the rate of 1 mg per ml.

3. Standard phosphate solution: Dissolved exactly 0.351 g of pure monopotassium phosphate in water and transferred quantitatively to 1 litre volumetric flask. Added 10 ml sulphuric acid, diluted to the mark with water and mixed.

Again took 5 ml of this and made up to 50 ml with 10 per cent trichlor acetic acid and used as standard which contained 0.04 mg per ml.

Procedure

To 8 ml of 10 per cent trichlor acetic acid solution

in a small flask, added slowly, with mixing, 2 ml of plasma. Stoppered, shook, and filtered through a low ash filter paper. Transferred 5 ml of filtrate to a cylinder or other container graduatedat 10 ml and added 1 ml of the molybdate reagent. Mixed and added 0.4 ml of ascorbic acid and again mixed. Diluted to the mark, mixed and allowed to stand for 5 minutes. Transferred a portion of the coloured solution to a suitable container and read in a photometer at 660 to 720 mμ. Set the photometer to zero density with a blank which is prepared by treating 5 ml of 10 per cent trichlor acetic acid with 1 ml of molybdate reagent and 0.4 ml of ascorbic acid, followed by water to a volume of 10 ml.

Standard solution was prepared by adding 1 ml of molybdate reagent and 0.4 ml of ascorbic acid to 5 ml of the dilute standard phosphate solution containing 0.04 mg of phosphorus made up the volume to 10 ml with water. Mixed and allowed to stand for 5 minutes and determined the density in the Photometer.

Calculation

$$\text{Milligram of inorganic phosphorus in 100 ml blood} = \left(\frac{\text{Reading of unknown}}{\text{Reading of standard}}\right) \times 0.04 \times 100$$

RESULTS

RESULTS

Records of fortnightly body weights of animals maintained on the three dietary treatments A, B and C are shown in tables 1 to 3 and represented by figure 1. Tables 4 to 7 and figures 2 and 3 present total and daily weight gains and feed efficiency of animals in the three groups. The above results are statistically analysed in tables 8 and 9. Data on body measurements of animals recorded at fortnightly intervals are set out in tables 10 to 21. Table 22 presents consolidated data on gains in body measurements. Statistical analysis of the above results are shown in tables 23 to 26.

Digestibility coefficients of nutrients in the three diets determined towards the end of the experiment are set out in tables 27 to 34. Data on blood constituents viz. plasma protein, haemoglobin, packed cell volume, plasma calcium and inorganic phosphorus recorded in respect of animals under the three dietary treatments are presented in tables 35 to 49. Statistical analysis of results of haematological studies are shown in tables 49 to 54.

Table 1. Body weights (kg) of animals maintained on the three dietary treatments

Diet A - Group I

Tattoo number	Fortnights												
	0	1	2	3	4	5	6	7	8	9	10	11	12
178 (F)	20.0	24.0	26.0	28.0	31.0	34.5	38.0	41.5	44.5	47.8	50.9	53.8	56.5
179 (F)	26.0	29.6	32.0	34.5	38.0	41.0	43.5	46.0	48.7	51.5	57.5	60.8	64.2
185 (F)	19.5	23.5	25.5	27.0	29.5	32.5	37.0	39.5	42.0	44.5	47.8	51.4	54.0
186 (F)	16.5	18.0	21.5	24.0	26.5	28.9	32.5	35.0	38.5	43.0	47.0	51.5	53.0
*188 (M)	17.0	22.0	25.5	28.0	31.0	33.0	36.0	37.5	38.0	40.0	42.0	..	..
TM 10 (M)	30.0	31.5	34.0	36.5	39.0	44.5	47.0	51.0	56.0	62.0	68.0	74.0	80.5
Average	21.5	24.8	27.4	29.7	32.5	35.7	39.0	41.8	44.6	48.1	52.2	58.3	61.6
S.E.	±2.2	±2.0	±1.9	±2.0	±2.0	±2.4	±2.2	±2.4	±2.8	±3.2	±3.8	±4.3	±5.1

* The animal died towards the end of tenth fortnight

Table 2. Diet B - Group II

Tattoo number	Fortnights												
	0	1	2	3	4	5	6	7	8	9	10	11	12
190 (M)	23.0	28.0	34.0	36.5	38.0	41.2	44.5	47.5	50.7	52.3	54.5	59.0	65.0
191 (F)	25.5	31.5	34.0	36.5	38.0	40.0	43.0	46.0	48.0	54.4	57.0	59.0	64.0
192 (M)	19.0	23.0	24.5	26.0	28.0	29.5	31.5	33.8	36.0	40.0	43.0	44.0	48.0
194 (F)	21.0	24.0	26.5	29.0	32.5	34.5	36.8	40.0	42.0	45.0	46.0	46.5	50.0
TM 11 (M)	25.0	26.5	28.5	30.0	33.5	36.7	38.5	40.0	41.5	45.5	46.7	50.0	54.5
*TM 13 (F)	20.0	22.5	24.0	..	..	..	..	..	..	..	..	..	..
Average	22.3	25.9	28.6	31.6	34.0	36.4	38.9	41.5	43.6	47.4	49.4	51.7	56.3
S.E.	±1.1	±1.4	±1.8	±2.1	±1.9	±2.1	±2.3	±2.5	±2.6	±2.6	±2.7	±3.1	±3.5

* The animal died towards the end of second fortnight

Table 3. Diet C - Group III

Tattoo number	Fortnights												
	0	1	2	3	4	5	6	7	8	9	10	11	12
648 (M)	23.0	26.5	30.0	32.0	34.0	36.5	40.0	45.0	47.5	50.0	53.0	56.0	60.0
649 (F)	19.0	20.5	23.0	26.5	28.0	30.4	33.0	35.8	38.0	41.2	44.0	46.0	50.0
210 (M)	22.0	24.0	25.8	28.2	32.5	34.5	37.5	40.0	43.0	45.5	46.0	48.0	50.0
211 (F)	23.5	25.5	28.0	32.0	35.5	39.0	42.5	44.8	46.5	51.5	55.0	59.0	63.5
212 (M)	22.0	24.5	27.5	28.5	29.8	31.5	34.0	39.0	41.5	47.0	50.9	52.0	58.0
TM 12 (M)	24.0	28.0	29.5	31.0	33.0	37.5	42.5	46.8	48.9	53.5	58.4	65.0	72.5
Average	22.3	24.8	27.3	29.7	32.1	34.9	38.3	41.9	44.2	48.1	51.2	54.3	59.0
S.E.	±0.7	±1.1	±1.1	±0.9	±1.1	±1.4	±1.7	±1.7	±1.7	±1.8	±2.2	±2.9	±3.5

Figure 1. Body weights of animals maintained on the three dietary treatments

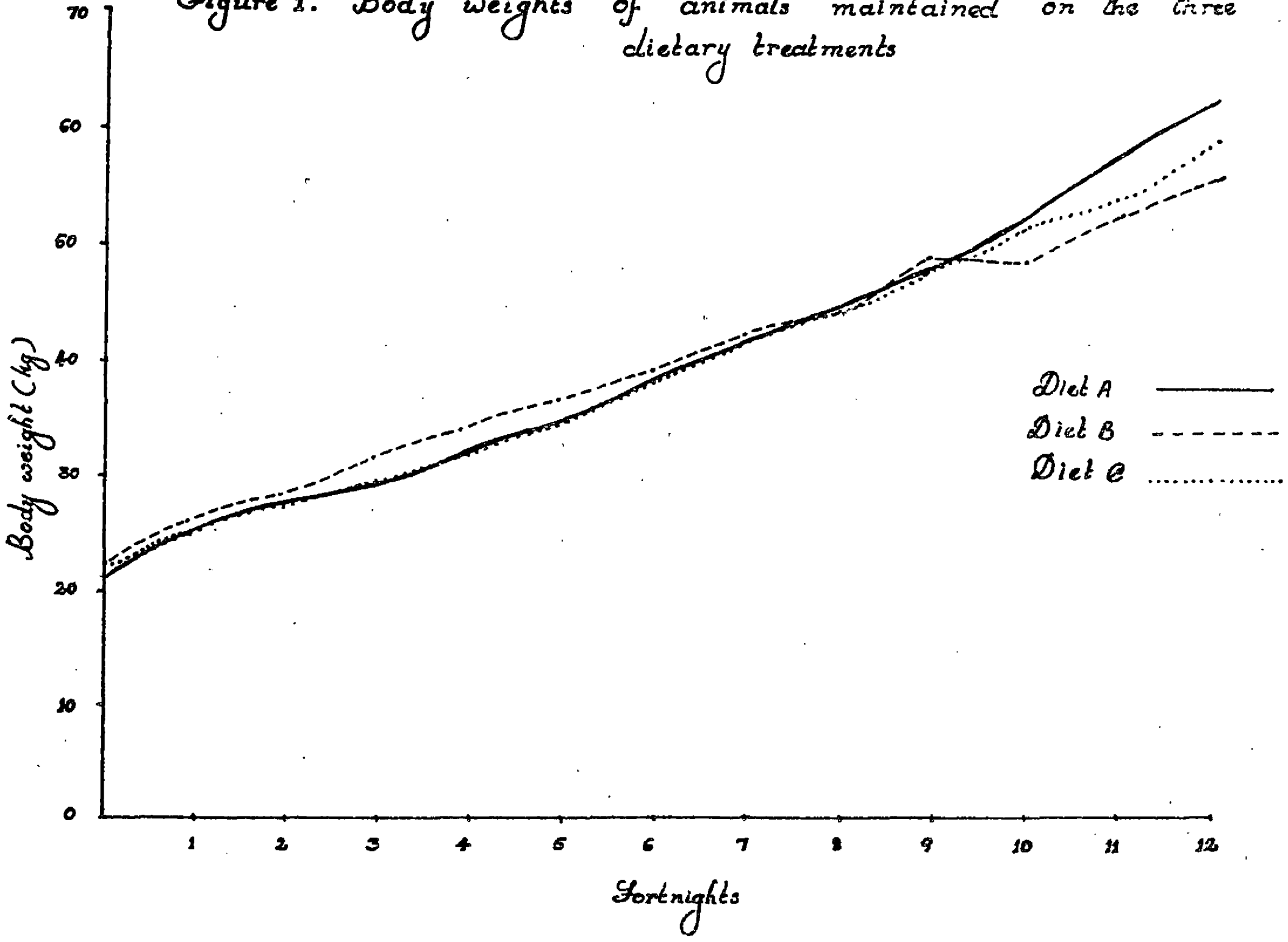

Table 4. Average daily rate of gain in calves maintained under the three dietary treatments

Group	0 - 3 months	3 - 6 months
	(g)	(g)
I	208	269
II	193	208
III	190	247

Table 5. Body weight gain and feed conversion efficiency of calves maintained on the three dietary treatments

Diet A - Group I

Tattoo number	Initial body weight (kg)	Final body weight (kg)	Total gain (kg)	Daily gain (g)	Feed efficiency
178	20.0	56.5	36.5	217	6.2
179	26.0	64.2	38.2	227	5.9
185	19.5	54.0	34.5	205	6.5
186	15.5	53.0	36.5	217	6.2
TM 10	30.0	80.5	50.5	301	4.5
Average	21.5	61.6	39.2	233	5.8
S.E.	±2.2	±5.1	±2.9	±0.02	±0.4

Table 6. Diet B - Group II

Tattoo number	Initial body weight (kg)	Final body weight (kg)	Total gain (kg)	Daily gain (g)	Feed efficiency
190	23.0	65.0	42.0	250	5.3
191	25.5	64.0	38.5	229	5.8
192	19.0	48.0	29.0	172	7.7
194	21.0	50.0	29.0	172	7.7
TM 11	25.0	54.5	29.5	176	7.6
Average	22.3	56.3	33.6	200	6.9
S.E.	±1.1	±3.5	±2.8	±0.02	±0.5

Table 7. Diet C - Group III

Tattoo number	Initial body weight (kg)	Final body weight (kg)	Total gain (kg)	Daily gain (g)	Feed efficiency
648	23.0	60.0	37.0	220	6.0
649	19.0	50.0	31.0	185	7.2
210	22.0	50.0	28.0	167	8.0
211	23.5	63.5	40.0	238	5.6
212	22.0	58.0	36.0	214	6.2
TM 12	24.0	72.5	48.5	289	4.6
Average	22.3	59.0	36.8	219	6.3
S.E.	±0.7	±3.5	±2.9	±0.02	±0.5

Figure 2

Body weight gains of animals maintained on the three dietary treatments

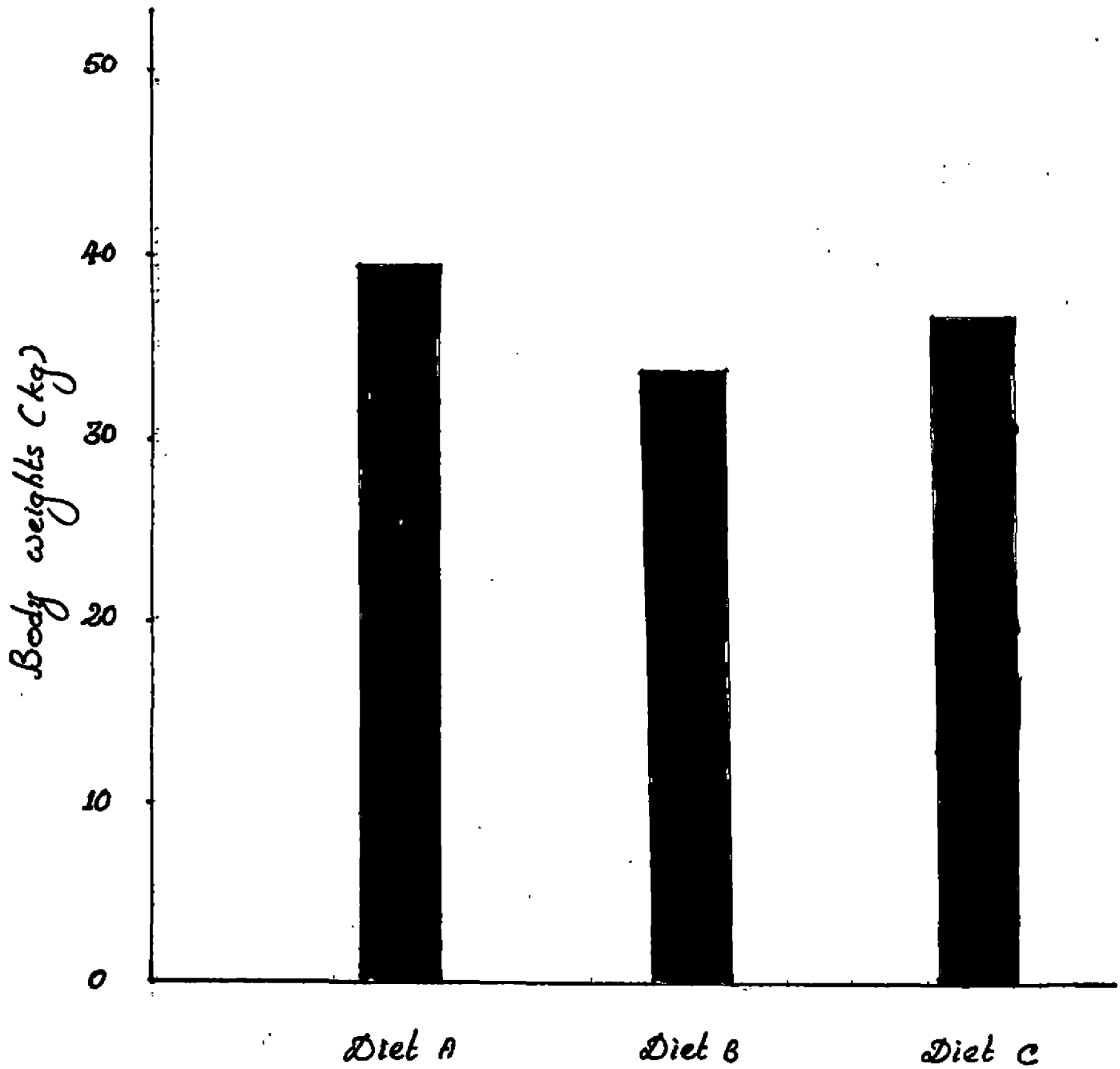

Figure 3

Average cumulative feed efficiency of animals on the different dietary treatments

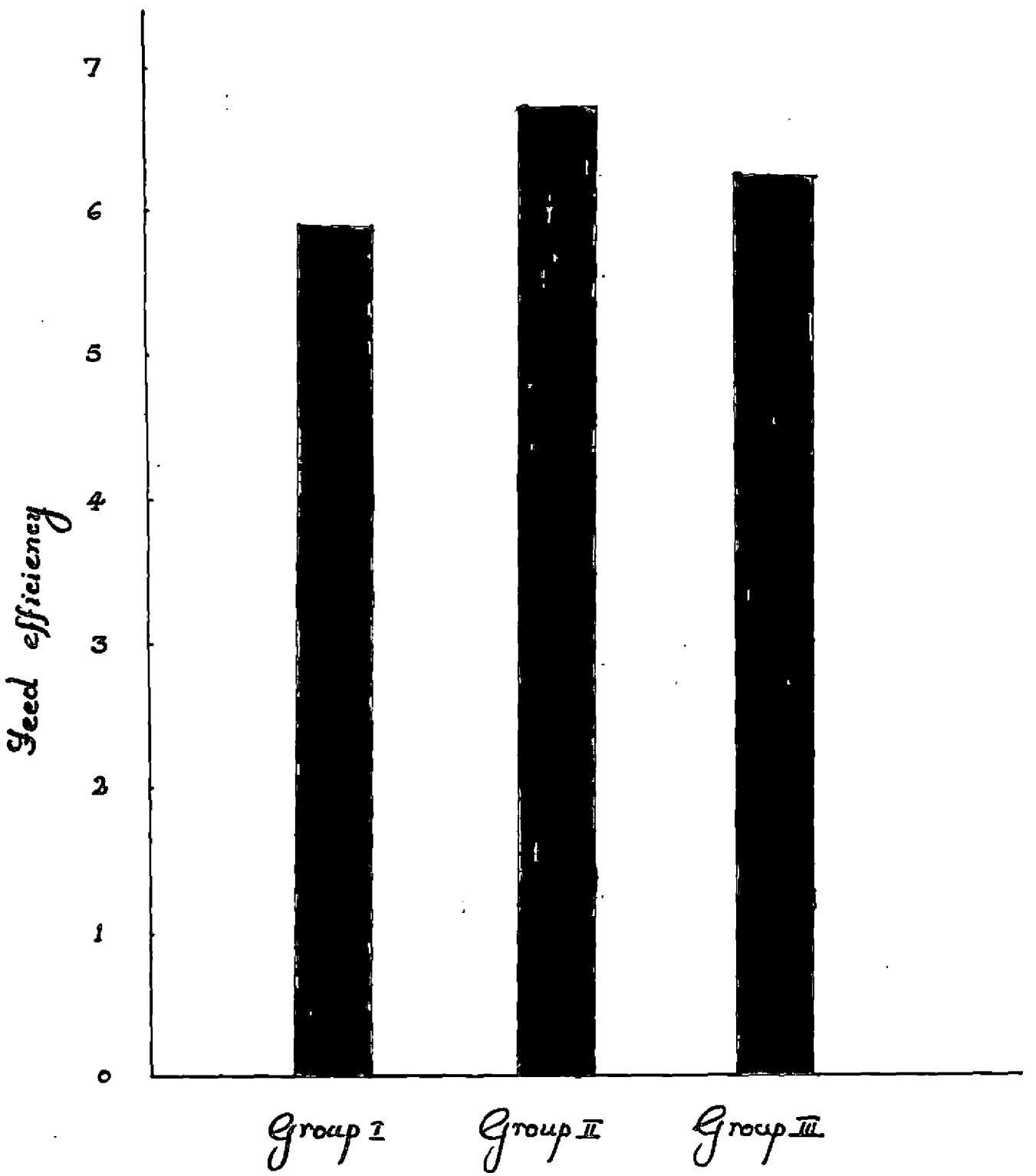

Table 8. Analysis of variance - Total weight gain

Source	df	SS	MSS	F
Treatment	2	79.93	39.97	0.85
Sex	1	16.61	16.61	0.36
Error	12	561.32	46.78	
Total	15	657.86		

Table 9. Analysis of variance - Feed efficiency

Source	df	SS	MSS	F
Treatment	2	18.83	9.41	1.11
Error	13	110.68	8.51	
Total	15	129.51		

Table 10. Body measurements of animals maintained on the three dietary treatments

Body length (cm)

Diet - A - Group I

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
178	50.0	52.5	53.0	54.0	55.0	56.5	60.0	64.0	67.0	68.0	68.0	71.0	76.0	26.0	0.155
179	57.0	62.0	67.0	70.0	72.0	73.0	73.0	74.0	75.0	76.0	78.0	79.0	79.0	22.0	0.131
185	58.0	61.0	62.0	63.0	64.0	65.5	65.5	68.0	69.0	72.0	74.0	76.0	80.0	22.0	0.131
186	50.0	55.0	57.0	58.0	61.0	63.0	65.0	68.0	73.0	77.0	78.0	80.0	83.0	33.0	0.196
188	59.0	65.0	66.0	68.0	69.5	70.0	71.0	72.0	72.0	73.0	73.0	..	..	..	..
TM 10	58.0	64.0	65.0	67.0	68.0	72.0	77.0	80.0	81.0	82.0	82.0	84.0	86.5	28.5	0.170
Average	55.3	59.9	61.7	63.3	64.9	66.7	68.6	71.0	72.6	74.7	75.5	76.0	80.9	26.3	0.157
S.E.	±1.7	±2.1	±2.3	±2.6	±2.6	±2.6	±2.5	±2.3	±2.0	±2.0	±2.0	±2.2	±1.8	±2.1	±0.01

Table 11. Diet B - Group II

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
190	55.0	62.0	63.0	65.0	65.0	66.0	70.0	76.0	78.0	78.0	81.0	84.0	85.0	30.0	0.179
191	50.0	58.0	60.0	60.0	61.0	63.0	69.0	72.0	74.0	76.0	80.0	84.0	84.0	34.0	0.202
192	57.0	59.0	60.0	60.0	62.0	64.0	67.0	69.0	69.0	72.0	73.0	75.0	76.0	19.0	0.113
194	55.0	56.0	57.0	58.0	63.0	65.0	67.0	70.0	72.0	72.0	73.0	73.0	75.0	20.0	0.119
TM 11	54.0	56.0	60.0	62.0	65.0	72.0	74.0	76.0	78.0	79.0	81.0	83.0	85.0	31.0	0.185
TM 13	50.0	54.0	56.0	..	..	..	..	..	..	..	..	..	..	..	..
Average	53.5	57.5	59.3	61.0	63.2	66.0	69.4	72.6	74.2	75.4	77.6	79.8	81.0	26.8	0.160
S.E.	±1.8	±1.2	±1.0	±1.2	±0.8	±1.6	±1.3	±1.5	±1.7	±1.5	±1.9	±2.4	±2.3	±3.1	±0.02

Table 12. Diet C - Group III

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
648	60.0	63.0	64.0	65.0	66.0	72.0	77.0	81.0	82.0	83.0	85.0	85.0	86.0	26.0	0.155
649	55.0	57.0	57.0	62.0	64.0	65.0	66.0	68.0	69.0	69.0	74.0	75.0	77.0	22.0	0.131
210	58.0	59.0	61.0	61.0	63.0	64.0	65.0	68.0	73.0	75.0	75.0	76.0	76.0	18.0	0.107
211	60.0	65.0	66.0	67.0	68.0	70.0	74.0	76.0	78.0	81.0	82.0	83.0	85.0	25.0	0.149
212	68.0	70.5	71.0	72.0	72.0	73.0	75.0	77.0	79.0	80.0	84.0	85.0	87.0	19.0	0.113
TM 12	57.0	60.0	63.0	63.0	67.0	69.0	72.0	74.0	76.0	80.0	83.0	85.0	88.0	31.0	0.185
Average	59.7	62.4	63.7	65.0	66.7	68.8	71.5	74.0	76.2	78.0	80.5	81.5	83.2	23.5	0.140
S.E.	±1.8	±2.0	±1.9	±1.7	±1.3	±1.5	±2.0	±2.1	±1.9	±2.1	±2.0	±1.9	±2.2	±2.0	±0.01

Table 13. Heart girth (cm). Diet A - Group I

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
178	67.0	72.0	74.0	75.0	76.0	77.0	78.0	78.0	79.0	83.0	88.0	90.0	92.0	25.0	0.149
179	71.0	76.0	79.0	80.0	81.0	81.0	82.0	83.0	84.0	86.0	88.0	90.0	94.0	23.0	0.137
185	65.0	70.0	73.0	78.0	79.0	81.0	81.0	83.0	84.0	85.0	86.0	88.0	90.0	25.0	0.149
186	60.0	65.0	72.0	74.0	76.0	78.0	79.0	80.0	82.0	93.0	94.0	95.0	96.0	36.0	0.214
188	67.0	73.0	74.0	75.0	75.0	76.0	78.0	78.0	81.0	81.0	81.0	..	..	..	..
TM 10	72.0	74.0	75.0	76.0	78.0	80.0	84.0	90.0	93.0	97.0	99.0	99.0	101.5	29.5	0.176
Average	67.0	71.7	74.5	76.5	77.6	78.8	80.8	82.0	83.8	87.5	89.3	92.4	94.7	27.7	0.165
S.E.	±1.8	±1.6	±1.0	±0.9	±1.0	±0.9	±1.0	±1.8	±2.0	±2.5	±2.6	±2.0	±2.0	±2.3	±0.01

Table 14. Diet B - Group II

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
190	69.0	78.0	79.0	80.0	81.0	84.0	86.0	86.0	94.0	95.0	98.0	98.0	102.0	33.0	0.196
191	65.0	73.0	74.0	77.0	77.0	80.0	81.0	85.0	90.0	93.0	96.0	96.0	104.0	39.0	0.232
192	64.0	72.0	73.0	73.0	75.0	76.0	77.0	82.0	84.0	84.0	85.0	88.0	93.0	29.0	0.173
194	68.0	70.0	71.0	74.0	77.0	78.0	80.0	80.0	84.0	86.0	89.0	90.0	93.0	25.0	0.149
TM 11	67.0	67.0	70.0	72.0	74.0	76.0	77.0	77.0	83.0	85.0	86.0	91.0	92.0	25.0	0.149
TM 13	64.0	68.0	71.0	..	..	..	..	..	..	..	..	..	..	..	..
Average	65.2	71.3	73.0	75.2	76.8	78.8	80.2	82.0	87.0	88.6	91.2	92.6	96.8	30.2	0.160
S.E.	±0.9	±1.6	±1.3	±1.5	±1.2	±1.5	±1.7	±1.6	±2.1	±2.3	±2.5	±1.9	±2.6	±2.7	±0.02

Table 15. Diet C - Group III

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
648	68.0	70.0	76.0	77.0	77.0	78.0	80.0	84.0	89.0	92.0	94.0	96.0	99.0	31.0	0.185
649	65.0	66.0	67.0	69.0	69.0	72.0	73.0	76.0	76.0	77.0	79.0	82.0	89.0	24.0	0.143
210	68.0	71.0	71.0	72.0	73.0	76.0	78.0	81.0	82.0	86.0	86.0	88.0	89.0	21.0	0.125
211	69.0	72.0	73.0	76.0	76.0	78.0	80.0	85.0	90.0	92.0	93.0	98.0	99.0	30.0	0.179
212	71.0	72.0	73.0	74.0	75.0	77.0	80.0	84.0	87.0	88.0	90.0	91.0	93.0	22.0	0.131
IM 12	73.0	74.0	76.0	78.0	81.0	85.0	90.0	91.0	95.0	96.0	101.0	103.0	104.0	31.0	0.185
Average	69.0	70.8	72.7	74.3	75.2	77.7	80.2	83.5	86.5	88.5	90.5	93.0	95.5	26.5	0.158
S.E.	±1.1	±1.1	±1.4	±1.4	±1.6	±1.7	±2.3	±2.0	±2.7	±2.7	±3.1	±3.1	±2.5	±1.9	±0.01

Table 16. Paunch girth (cm). Diet A = Group I

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
178	69.0	72.0	74.0	75.0	80.0	90.0	87.0	90.0	95.0	99.0	100.0	110.0	112.0	43.0	0.255
179	68.0	73.0	76.0	77.0	86.0	86.0	88.0	92.0	93.0	97.0	103.0	112.0	114.0	46.0	0.274
185	65.0	71.0	72.0	80.0	83.0	86.0	87.0	90.0	93.0	100.0	104.0	106.0	110.0	45.0	0.268
186	63.0	66.0	75.0	84.0	84.0	85.0	89.0	89.0	92.0	100.0	107.0	112.0	115.0	52.0	0.310
188	70.0	74.0	76.0	80.0	82.0	82.0	83.0	87.0	83.0	85.0	86.0	--	--	--	--
TM 10	70.0	71.0	74.0	76.0	79.0	84.0	90.0	98.0	107.0	110.0	114.0	116.0	123.0	53.0	0.315
Average	67.5	71.2	74.5	78.7	82.3	85.5	87.3	91.0	93.8	98.5	102.3	111.2	114.8	47.8	0.285
S.E.	±1.2	±1.2	±0.6	±1.4	±1.1	±1.1	±1.0	±1.6	±3.2	±3.3	±3.8	±1.6	±2.2	±2.0	±0.01

Table 17. Diet B - Group II

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
190	69.0	72.0	75.0	77.0	84.0	85.0	86.0	91.0	100.0	108.0	108.0	111.0	116.0	47.0	0.280
191	65.0	70.0	81.0	87.0	89.0	96.0	96.0	98.0	100.0	103.0	105.0	119.0	123.0	58.0	0.345
192	67.0	72.0	73.0	75.0	77.0	80.0	84.0	90.0	92.0	96.0	98.0	100.0	108.0	41.0	0.244
194	64.0	67.0	70.0	74.0	73.0	79.0	82.0	84.0	100.0	105.0	108.0	112.0	116.0	54.0	0.321
TM 11	64.0	67.0	70.0	72.0	75.0	79.0	83.0	86.0	100.0	104.0	108.0	111.0	114.0	50.0	0.298
TM 13	65.0	68.0	73.0	..	..	..	..	..	..	..	..	..	..	..	..
Average	65.7	69.3	73.7	77.0	79.6	83.8	86.2	89.8	98.4	103.2	105.4	110.6	115.8	50.0	0.298
S.E.	±0.8	±1.0	±1.7	±2.6	±3.0	±3.3	±2.5	±2.4	±1.6	±2.0	±1.9	±3.0	±2.5	± 2.9	±0.02

Table 18. Diet C - Group III

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
648	67.0	74.0	77.0	80.0	84.0	87.0	87.0	91.0	95.0	98.0	100.0	110.0	118.0	51.0	0.304
649	65.0	68.0	70.0	73.0	74.0	77.0	78.0	82.0	84.0	86.0	96.0	100.0	112.0	47.0	0.280
210	70.0	73.0	76.0	76.0	77.0	78.0	82.0	80.0	89.0	95.0	98.0	102.0	107.0	37.0	0.220
211	68.0	70.0	71.0	77.0	80.0	86.0	90.0	99.0	103.0	105.0	114.0	108.0	110.0	42.0	0.250
212	70.0	72.0	73.0	76.0	78.0	79.0	80.0	86.0	88.0	103.0	106.0	110.0	114.0	44.0	0.262
TM 12	71.0	75.0	76.0	80.0	85.0	90.5	95.0	97.0	99.0	113.0	117.0	120.0	123.0	52.0	0.310
Average	68.5	72.0	73.8	77.0	79.7	82.8	85.3	89.2	93.0	100.0	105.2	108.3	114.0	45.5	0.271
S.E.	±0.9	±1.1	±1.2	±1.1	±1.7	±2.2	±2.7	±3.2	±3.0	±3.8	±3.6	±2.9	±2.4	±2.3	±0.01

Table 19. Height at withers (cm). Diet A - Group I

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
178	61.0	66.0	68.0	70.0	71.0	72.5	73.5	74.0	77.0	80.0	82.0	83.0	84.0	23.0	0.137
179	67.0	70.0	75.0	77.0	78.0	79.0	80.0	81.0	81.0	83.0	86.0	87.0	88.0	21.0	0.125
185	66.0	67.0	69.0	71.0	73.0	73.0	75.0	77.0	78.0	80.0	82.0	84.0	86.0	20.0	0.119
186	58.0	60.0	64.0	67.0	69.0	69.0	73.0	75.0	77.0	80.0	82.0	83.0	85.0	27.0	0.161
188	62.0	64.0	67.0	69.0	72.0	74.0	74.0	76.0	77.0	77.0	78.0	..	..	..	..
TM 10	68.0	70.0	72.0	74.0	76.0	78.0	80.0	83.0	83.0	85.0	85.0	86.0	88.0	20.0	0.119
Average	63.7	66.2	69.2	71.3	73.2	74.3	75.9	77.7	78.8	80.8	82.5	84.6	86.2	22.2	0.132
S.E.	±1.6	±1.6	±1.6	±1.5	±1.4	±1.5	±1.3	±1.5	±1.1	±1.1	±1.2	±1.2	±0.8	±1.3	±0.01

Table 20. Diet B - Group II

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
190	71.0	72.0	73.0	75.0	76.0	78.0	79.0	82.0	84.0	86.5	88.0	89.0	90.0	19.0	0.113
191	65.0	67.0	69.0	72.0	73.0	75.0	78.0	80.0	83.0	85.0	86.0	87.0	88.0	23.0	0.137
192	64.0	68.0	70.0	72.0	74.5	76.0	79.0	79.0	80.0	82.0	82.0	83.0	84.0	20.0	0.119
194	64.0	64.5	66.0	67.0	68.0	70.0	71.0	73.0	75.0	76.0	76.0	77.0	79.0	15.0	0.089
TM 11	63.0	66.0	68.0	68.0	70.0	72.0	74.0	78.0	79.0	79.0	80.0	82.0	83.5	20.5	0.122
TM 13	62.0	63.0	65.0	..	..	..	..	..	..	..	..	..	..	..	..
Average	64.8	66.8	68.5	70.8	72.3	74.2	76.2	78.4	80.2	81.7	82.4	83.6	84.9	19.5	0.116
S.E.	±1.3	±1.3	±1.2	±1.5	±1.5	±1.4	±1.6	±1.5	±1.6	±1.9	±2.1	±2.1	±1.9	±1.3	±0.01

Table 21. Diet C - Group III

Tattoo number	Fortnights													Total gain	Daily gain
	0	1	2	3	4	5	6	7	8	9	10	11	12		
648	65.0	67.0	72.0	74.0	77.0	80.0	81.0	83.0	85.0	88.0	88.0	89.0	91.0	26.0	0.155
649	61.0	63.0	65.0	66.0	68.0	71.0	73.0	74.0	76.0	77.0	78.0	79.0	79.0	18.0	0.107
210	65.0	68.0	70.0	71.0	73.0	75.0	78.0	80.0	82.0	83.0	85.0	85.0	86.0	21.0	0.125
211	65.0	67.0	69.0	72.0	74.0	76.0	80.0	84.0	85.0	87.0	87.0	88.0	88.0	23.0	0.137
212	68.0	69.0	71.0	72.0	75.0	76.0	79.0	80.0	82.0	82.0	83.0	84.0	87.0	19.0	0.113
TM 12	67.5	69.0	72.0	74.0	76.0	77.0	78.0	78.0	80.0	84.0	86.0	86.0	88.0	20.5	0.122
Average	65.3	67.2	69.8	71.5	73.8	75.8	78.2	79.8	81.8	83.5	84.5	85.2	86.5	21.3	0.127
S.E.	±1.0	±0.9	±1.1	±1.2	±1.3	±1.2	±1.1	±1.5	±1.5	±1.6	±1.5	±1.5	±1.7	±1.1	±0.01

Table 22. Consolidated data on total gains in body measurements in respect of animals under the three dietary treatments

Diets	Body length (cm)		Heart girth (cm)		Paunch girth (cm)		Height at withers(cm)	
	Total gain	Daily gain	Total gain	Daily gain	Total gain	Daily gain	Total gain	Daily gain
A	26.3	0.157	27.7	0.165	47.8	0.285	22.2	0.132
	±2.1	±0.01	±2.3	±0.01	±2.0	±0.01	±1.3	±0.01
B	26.8	0.160	30.2	0.180	50.0	0.298	19.5	0.116
	±3.1	±0.02	±2.7	±0.02	±2.9	±0.02	±1.3	±0.01
C	23.5	0.140	26.5	0.155	45.5	0.271	21.3	0.127
	±2.0	±0.01	±1.9	±0.01	±2.3	±0.01	±1.2	±0.01

Table 23. Analysis of variance - Total gain in body length

Source	df	SS	MSS	F
Treatment	2	35.51	17.75	0.54
Sex	1	0.14	0.14	0.01
Error	12	390.96	32.58	
Total	15	426.61		

Table 24. Analysis of variance - Total gain in heart girth

Source	df	SS	MSS	F
Treatment	2	38.13	19.07	0.64
Sex	1	1.90	1.90	0.06
Error	12	357.2	29.77	
Total	15	397.23		

Table 25. Analysis of variance - Total gain in paunch girth

Source	df	SS	MSS	F
Treatment	2	55.45	27.73	0.90
Sex	1	9.01	9.01	0.29
Error	13	401.29	30.87	
Total	15	465.75		

Table 26. Analysis of variance - Total gain in height

Source	df	SS	MSS	F
Treatment	2	18.83	9.41	1.11
Sex	1	1.00	1.00	0.12
Error	13	109.67	8.44	
Total	15	129.5		

Table 27. Digestibility coefficients of nutrients in the three rations

Diet A

Tattoo number	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
178	64.9	72.0	75.7	46.4	72.2
179	66.9	74.0	71.4	47.6	72.5
186	66.3	70.9	75.8	46.2	71.9
TM 10	62.2	68.4	78.6	51.6	68.7
Average	65.1	71.3	75.4	48.0	71.3
S.E	±1.1	±1.2	±1.5	±1.2	±0.9

Table 28. Diet B

Tattoo number	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
190	66.6	67.8	66.0	53.6	68.6
191	60.4	64.8	64.2	56.8	65.0
192	71.3	68.9	73.7	56.0	77.7
194	61.3	66.0	70.2	54.9	70.4
TM 11	66.9	65.4	65.8	56.8	78.6
Average	65.3	66.6	68.0	55.5	72.1
S.E.	±2.0	±0.3	±1.7	±0.6	±2.6

Table 29. Diet C

Tattoo number	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
648	61.2	70.4	70.6	52.1	69.3
649	72.2	71.8	74.5	53.3	83.0
210	69.3	67.7	73.4	52.8	82.7
211	61.9	70.9	72.6	54.7	72.2
212	65.3	71.4	70.8	55.4	78.6
TM 12	61.7	69.5	80.9	55.6	72.0
Average	65.4	70.3	73.8	53.7	76.3
S.E.	±1.9	±0.6	±1.5	±0.6	±2.4

Table 30. Analysis of variance - Digestibility coefficient of dry matter

Source	df	SS	MSS	F
Treatment	2	2.25	1.12	0.07
Error	12	199.98	16.67	
Total	14	202.23		

Table 31. Analysis of variance - Digestibility coefficient of crude protein

Source	df	SS	MSS	F
Treatment	2	58.75	29.38	8.99*
Error	12	39.20	3.27	
Total	14	97.95		

Pairwise comparison		C.D. for comparison between
T_1 = 71.34	$T_1 - T_2$ = 4.74*	T_1 and T_2-2.64
T_2 = 66.60	$T_1 - T_3$ = 1.05	T_1 and T_3-2.54
T_3 = 70.29	$T_2 - T_3$ =13.69*	T_2 and T_3-2.38

* Significant at 5 % level.

Table 32. Analysis of variance - Digestibility coefficient of ether extract

Source	df	SS	MSS	F
Treatment	2	145.30	72.65	5.51*
Error	12	158.21	13.18	
Total	14	303.51		

Pairwise comparison		C.D.for comparison between
T_1 = 75.39	$T_1 - T_2$ = 7.42*	T_1 and T_2 - 5.31
T_2 = 67.97	$T_1 - T_3$ = 1.60	T_1 and T_3 - 5.11
T_3 = 73.79	$T_2 - T_3$ = 5.82*	T_2 and T_3 - 4.79

* Significant at 5% level.

Table 33. Analysis of variance - Digestibility coefficient of crude fibre

Source	df	SS	MSS	F
Treatment	2	138.60	69.30	23.37*
Error	12	35.58	2.97	
Total	14	174.18		

T_1 = 48.0
T_2 = 55.5
T_3 = 53.7

$T_1 - T_2 = 7.5^*$
$T_1 - T_3 = 5.7^*$
$T_2 - T_3 = 1.8$

C.D. for comparison between
T_1 and T_2 - 2.50
T_1 and T_3 - 2.42
T_2 and T_3 - 2.27

* Significant at 5 % level.

Table 34. Analysis of variance - Digestibility coefficient of nitrogen free extract

Source	df	SS	MSS	F
Treatment	2	76.25	38.13	1.41
Error	12	324.05	27.00	
Total	14	400.30		

Table 35. Data on blood constituents recorded at monthly intervals in respect of animals in the three groups

Plasma protein (g/100 ml)

Diet A - Group I

Tattoo number	Months					
	1	2	3	4	5	6
178	6.7	7.0	7.7	7.9	6.6	7.9
179	5.7	6.3	7.1	5.8	6.4	6.8
185	5.7	9.4	6.3	7.7	7.9	6.5
186	6.7	4.9	5.6	5.4	6.3	5.6
188	6.0	4.3	5.4	4.4	6.8	5.4
TM 10	8.2	6.7	6.8	5.8	6.5	7.8
Average	6.5	6.4	6.5	6.2	6.8	6.7
S.E.	±0.4	±0.7	±0.4	±0.6	±0.2	±0.4

Table 36. Diet B - Group II

Tattoo number	Months					
	1	2	3	4	5	6
190	5.3	7.7	8.1	7.4	6.3	5.7
191	7.7	5.3	7.8	8.0	6.3	7.0
192	5.7	5.9	6.5	7.4	6.5	6.1
194	4.7	4.8	5.7	7.9	7.1	7.0
TM 11	8.2	7.6	6.3	7.3	7.0	6.9
Average	6.3	6.3	6.9	7.6	6.7	6.5
S.E.	±0.6	±0.6	±0.5	±0.1	±0.2	±0.2

Table 37. Diet C - Group III

Tattoo number	Months					
	1	2	3	4	5	6
648	8.2	7.5	7.9	8.6	6.3	5.7
649	5.3	6.0	6.5	7.9	8.1	7.6
210	6.0	6.5	7.9	8.4	6.3	5.4
211	7.1	7.0	7.3	7.4	6.6	6.1
212	5.9	7.0	7.1	5.8	5.3	6.1
TM 12	7.1	7.4	7.0	7.4	6.5	5.9
Average	6.6	6.9	7.3	7.6	6.5	6.1
S.E.	±0.4	±0.2	±0.2	±0.2	±0.2	±0.3

Table 38. Haemoglobin (g/100 ml)

Diet A - Group I

Tattoo number	Months					
	1	2	3	4	5	6
178	12.6	10.6	12.0	12.8	12.6	12.2
179	12.0	12.8	10.2	12.8	10.4	10.4
185	10.2	11.6	10.8	11.8	12.2	12.8
186	10.8	11.0	12.6	11.8	10.4	10.8
188	9.6	10.4	11.2	9.8	8.4	8.0
TM 10	12.2	12.8	9.6	11.2	10.8	9.6
Average	11.2	11.5	11.1	11.7	10.8	10.6
S.E.	±0.5	±0.4	±0.5	±0.5	±0.6	±0.7

Table 39. Diet B - Group II

Tattoo number	Months					
	1	2	3	4	5	6
190	12.2	12.0	10.0	10.8	11.0	10.0
191	12.8	10.6	12.4	10.8	9.2	10.8
192	9.2	10.6	11.2	9.0	10.4	11.6
194	12.4	12.6	11.8	11.2	11.8	10.2
TM 11	10.0	10.8	10.4	10.2	11.4	10.2
Average	11.3	11.3	11.2	10.4	10.8	10.6
S.E.	±0.5	±0.4	±0.4	±0.4	±0.5	±0.3

Table 40. Diet C - Group III

Tattoo number	Months					
	1	2	3	4	5	6
648	12.2	12.6	10.8	10.2	11.2	10.2
649	12.0	10.6	11.8	10.2	11.2	11.2
210	12.2	10.2	12.8	10.6	10.6	10.4
211	12.4	9.6	9.8	11.6	12.4	11.6
212	12.4	11.6	11.8	12.4	10.4	10.8
TM 12	12.6	12.6	11.8	9.8	10.8	10.6
Average	12.3	11.2	11.5	10.8	11.1	10.8
S.E.	±0.9	±0.5	±0.4	±0.4	±0.3	±0.2

Table 41. Packed cell volume (%)

Diet A - Group I

Tattoo number	Months					
	1	2	3	4	5	6
176	42.0	40.0	42.0	40.0	38.0	38.0
179	40.0	38.0	36.0	38.0	32.0	30.0
185	34.0	36.0	35.0	34.0	36.0	32.0
186	38.0	34.0	36.0	35.0	32.0	30.0
188	32.0	30.0	33.0	30.0	28.0	26.0
TM 10	38.0	39.0	32.0	33.0	32.0	30.0
Average	37.3	26.2	35.7	35.0	33.0	31.0
S.E.	±1.5	±1.5	±1.4	±1.5	±1.4	±1.6

Table 42. Diet B - Group II

Tattoo number	Months					
	1	2	3	4	5	6
190	38.0	36.0	32.0	34.0	33.0	32.0
191	40.0	36.0	38.0	32.0	30.0	30.0
192	32.0	30.0	33.0	30.0	32.0	33.0
194	38.0	40.0	36.0	34.0	35.0	30.0
TM 11	34.0	32.0	30.0	32.0	34.0	30.0
Average	36.4	34.8	33.8	32.1	33.0	31.0
S.E.	±1.3	±1.7	±1.4	±0.8	±1.0	±0.6

Table 43. Diet C - Group III

Tattoo number	Months					
	1	2	3	4	5	6
648	42.0	40.0	38.0	34.0	36.0	34.0
649	34.0	32.0	40.0	38.0	32.0	30.0
210	40.0	38.0	40.0	32.0	33.0	30.0
211	40.0	32.0	30.0	35.0	36.0	33.0
212	42.0	36.0	34.0	36.0	32.0	32.0
TM 12	40.0	40.0	39.0	32.0	33.0	32.0
Average	39.7	36.3	36.8	34.5	33.7	31.8
S.E.	±1.2	±1.5	±1.6	±1.0	±0.8	±0.7

Table 44. Plasma calcium (mg %)

Diet A - Group I

Tattoo number	Months					
	1	2	3	4	5	6
178	12.1	8.9	10.4	11.2	12.2	9.5
179	10.5	9.8	11.5	11.8	11.6	12.3
185	11.1	12.0	11.2	10.4	11.9	10.6
186	10.6	9.8	11.0	10.2	11.4	9.8
188	11.9	10.8	10.4	9.6	8.5	6.8
TM 10	9.4	10.7	10.5	11.2	9.4	10.3
Average	10.8	10.3	10.8	10.6	10.5	10.2
S.E.	±0.4	±0.4	±0.2	±0.3	±0.9	±0.5

Table 45. Diet B - Group II

Tattoo number	Months					
	1	2	3	4	5	6
190	8.3	10.5	11.6	12.2	12.3	10.8
191	10.3	10.4	9.8	11.2	8.5	10.4
192	8.5	9.3	10.2	11.7	9.4	10.2
194	10.5	7.3	9.4	12.7	10.6	11.6
TM 11	10.4	12.3	11.9	9.8	10.9	12.4
Average	9.6	10.0	10.6	11.5	10.3	11.1
S.E.	±0.4	±0.8	±0.5	±0.5	±0.7	±0.4

Table 46. Diet C - Group III

Tattoo number	Months					
	1	2	3	4	5	6
648	7.2	9.3	10.2	9.8	11.1	10.5
649	7.0	8.4	9.6	8.5	9.8	10.2
210	10.1	7.0	8.4	8.0	12.1	11.8
211	10.8	9.4	11.2	10.4	9.5	10.6
212	10.7	11.8	12.4	10.5	10.7	11.2
TM 12	11.4	10.6	11.8	9.5	10.3	12.4
Average	9.5	9.4	10.6	9.5	10.6	11.1
S.E.	±0.8	±0.7	±0.6	±0.4	±0.4	±0.4

Table 47. Plasma inorganic Phosphorus (mg %)

Diet A - Group I

Tattoo number	Months					
	1	2	3	4	5	6
178	5.94	5.47	5.43	5.70	5.77	5.04
179	6.86	6.73	5.50	5.26	5.06	4.88
185	5.43	6.03	6.06	5.84	5.60	5.26
186	5.96	5.73	5.34	5.14	5.34	5.86
188	5.66	5.68	5.15	5.21	5.90	6.46
TM 10	6.22	6.46	6.45	6.03	6.18	5.94
Average	6.05	6.02	5.66	5.53	5.64	5.57
S.E.	±0.19	±0.20	±0.20	±0.15	±0.16	±0.25

Table 48. Diet B - Group II

Tattoo number	Months					
	1	2	3	4	5	6
190	5.89	5.26	5.32	6.06	5.08	5.78
191	5.72	6.35	5.43	4.98	4.68	5.15
192	5.99	5.22	5.75	5.23	5.82	5.48
194	6.06	5.26	6.45	4.82	5.68	5.97
TM 11	6.00	5.49	6.18	5.92	4.94	5.12
Average	5.86	5.52	5.83	5.40	5.24	5.50
S.E.	±0.9	±0.21	±0.22	±0.25	±0.22	±0.17

Table 49. Diet C - Group III

Tattoo number	Months					
	1	2	3	4	5	6
648	5.57	6.31	5.84	5.41	5.53	5.42
649	5.88	6.47	5.44	4.88	5.78	6.60
210	5.43	5.06	6.48	6.25	6.42	5.94
211	5.25	5.65	6.25	5.75	5.20	4.76
212	5.91	5.85	6.04	4.88	5.86	6.47
TM 12	6.06	5.85	5.68	5.20	5.47	5.06
Average	5.68	5.90	5.96	5.40	5.71	5.71
S.E.	±0.13	±0.20	±0.16	±0.22	±0.17	±0.31

Table 50. Analysis of variance - Plasma protein (g/100 ml)

Source	df	SS	MSS	F
Treatment	2	1.01	0.51	0.68
Error	14	10.37	0.74	
Total	16	11.38		

Table 51. Analysis of variance - Haemoglobin (g/100 ml)

Source	df	SS	MSS	F
Treatment	2	0.17	0.08	0.06
Error	14	18.31	1.31	
Total	16	18.48		

Table 52. Analysis of variance - Packed cell volume (%)

Source	df	SS	MSS	F
Treatment	2	2.70	1.35	0.19
Error	14	98.83	7.06	
Total	16	101.53		

Table 53. Analysis of variance - Plasma calcium (mg %)

Source	df	SS	MSS	F
Treatment	2	3.03	1.52	1.50
Error	14	14.12	1.01	
Total	16	17.16		

Table 54. Analysis of variance - Plasma inorganic Phosphorus (mg/100 ml)

Source	df	SS	MSS	F
Treatment	2	0.12	0.06	0.17
Error	14	5.26	0.38	
Total	16	5.39		

DISCUSSION

DISCUSSION

The results obtained during the course of the experiment are discussed below in separate heads:

Growth

From the results presented in tables 1 to 7 and their statistical analysis in table 8, it can be seen that all the animals under the three dietary treatments (Diet A, B and C) showed the normal trend of growth during the course of 24 weeks of the present study, the average total gains in body weight being 39.2, 33.6 and 36.8 kg respectively for animals in group I, II and III. The growth rate in respect of all the three groups of animals (Fig. 1) were found to be similar, the rate of gain being more from 3 to 6 months as compared to the same for the period from 0 to 3 months (Table 4). Ranjhan (1977) has reported average daily gains for different cross bred and pure bred animals separately for the two periods, the values obtained in the present study being comparatively lower, though the trend of gain was similar. It can be seen from the data presented in tables 5 to 8 and figure 2 that though the control diet containing fish meal at a level of 10 per cent promoted better growth in calves, there were no significant differences between the three diets in this regard. The average daily

gains for the animals in three groups I, II and III were 233, 200 and 219 g respectively. The three rations, the control and those containing lucerne meal at 15 and 20 per cent levels, were of equal palatability and were isocaloric, as evidenced by the almost similar feed consumption of animals in all the three groups. The almost similar growth rate obtained for animals maintained on the three experimental diets indicate that lucerne meal can substitute good quality animal protein sources like fish meal. The assortment of amino acids of a protein is an important factor to be considered for its inclusion in calf starters. The rates of growth obtained for all the experimental animals point to show that lucerne meal can fairly meet the amino acid requirement of calves normally provided through animal proteins sources. Pirie (1977), studied the role of leaf proteins in animal feeding and reported that leaf proteins are satisfactory substitute for fish meal. The amino acid composition of mixed bacterial and protozoal protein is similar to that of leaf proteins, the only marked difference being the higher content of lysine and to a lesser extent of leucine, isoleucine and phenyl alanine in protozoal protein (Ranjhan and Krishnamohan, 1981). Reportts on the growth

rate and daily gain of pre ruminant calves are many and varied. Ansaari and Talapatra (1963) reported a daily gain of 560 g in calves fed on a ration containing 10 per cent fish meal. Leelaprasad et al. (1977) reported total liveweight gains of 41.5 and 46 kg on milk replacer containing lucerne extract and whole milk respectively in calves over a period of three months. Prasad et al. (1977) recorded a daily gain of 420 g in calves fed a similar milk replacer diet containing lucerne extract at a level of 40 per cent. Francis (1978) obtained a total gain of 43 kg for cross bred calves fed with a calf starter ration containing 10 per cent fish meal, over a period of 24 weeks. Kohli et al. (1962) recorded increases of 100, 150 and 200 per cent over the birth weights at 3, 6 and 9 months of age respectively, irrespective of the sex of the calf. The overall increase obtained in the present study were found to be 183, 151 and 165 per cent respectively for the animals in the three dietary groups I, II and III during the period of 24 weeks. The lowered growth response and daily gains obtained in calves during the course of the present study may be due to certain other factors besides nutritional. Martin et al. (1961) have reported about the important factors like breed, sex, degree of inbreeding and type of rations fed contributing

to significant variation in the weight gain of dairy calves. Birth weight also is reported to have a significant effect on liveweight gain of calves (Roy et al. 1955). The comparatively lower weight gains obtained in the present study might be also due to the low birth weights of calves used in the experiment. Henderson (1954) recorded daily gains of only 227 g for small breeds of cattle having a birth weight of 22 to 23 kg.

Body measurements

Data on body measurements recorded at fortnightly intervals and presented in tables 10 to 26 showed that there were no significant differences among the three dietary treatments (Diets A, B & C) in regard to any of the parameter studied. The results indicate that the gain in body measurements such as body length, heart girth, paunch girth and height at withers take place parallel to gains in body weights, indicating a positive correlation between body weight and body measurements. The values for the total and daily gain in body lengths recorded in the present study were found to be 26.3, 26.8 and 23.5 cm and 0.157, 0.160 and 0.140 cm respectively for animals in groups I, II and III. In similar experiments using calf starters containing fish meal

at a level of 10 per cent, Francis (1978) recorded lower values of 22.3 and 0.133 cm respectively for total and daily gains in body length. On the other hand, Shinde and Sangle (1976) reported relatively higher total gains in length of 56 to 58 cm in calves fed on two different calf meals over a period of 24 weeks. The gains in total and daily heart girth reported in the present study were found to be 27.7, 30.2 and 26.5 and 0.165, 0.180 and 0.158 cm respectively for the animals in groups I, II and III. Shinde and Sangle (1976) recorded higher daily gains in heart girth of 0.191 and 0.208 cm respectively on two separate calf meals. On the other hand, Francis (1978) recorded a relatively lower value of 0.146 cm on a similar dietary regime as used in the present study. Paunch girth also showed a similar trend in gains. The total and daily gains for the three groups I, II and III respectively were 47.8, 50.0 and 45.5 and 0.285, 0.298 and 0.271 cm. Francis (1978) reported almost a similar average value of 0.287 cm. The values in respect of total gain and daily gain of height at withers were shown to be 22.2, 19.5 and 21.3 and 0.132, 0.116 and 0.127 cm respectively for groups I, II and III. Wing (1963) and Francis (1978) recorded almost similar values for gain of height at withers in calves during a period of 24 weeks. On the other hand,

Shinde and Sangle (1976) reported an increase in height at withers ranging from 28 to 29.4 cm in cross bred (Jersey and Sindhi) calves during a similar duration of experiment.

Feed efficiency

From the data on feed efficiency presented in tables 5 to 7 and from the statistical analysis of results (Table 9), it can be seen that there were no significant differences between the three dietary treatments, the values for the three groups I, II and III being 5.8, 6.9 and 6.3 respectively (Fig.3). The relatively higher feed efficiency of the control diet only supports the better growth rate shown by animals in control group when compared to those on the experimental groups. Smith et al. (1965) while studying the effects of different levels of cellulose in semipurified diets, recorded feed efficiencies ranging from 4.21 to 5.99 for Holstein calves averaging 130 kg body weight.

Digestion coefficients of nutrients

The results of digestion trials carried out towards the end of the feeding experiment (Tables 27 to 34) reveal that though there were no significant differences

in the digestibility in respect of dry matter and nitrogen free extract, digestibilities of crude protein, ether extract and crude fibre were found to vary between groups, the valuesbeing higher in the control diet (Diet A). Significant difference was obtained between control diet (Diet A) containing 10 per cent fish meal and diet B containing 15 per cent lucerne meal. The higher digestibilities of crude protein in the control diet was reflected in the higher weight gains of animals maintained on that diet. The almost similar digestibility coefficients of protein and ether extract of diet A (control) and diet C indicate that the diet with 20 per cent lucerne meal was as efficiently utilised as the control diet. The reason for the significantly lower digestibilities of crude protein and ether extract in diet B cannot be explained on the basis of present data as is the case for lower feed efficiency and weight gain on that diet.

Blood values

Results of haematological studies carried out during the course of the experiment (Table 35 to 49) and statistical analysis of the results (Table 50 to 54) did not reveal any significant difference among the different dietary treatments in any of the parameter studied. The

values on plasma protein, haemoglobin, packed cell volume, plasma calcium and inorganic phosphorus of animals maintained on diets A, B and C were almost similar between groups and fall in within the normal range for the species.

The data on blood values indicate that all the animals maintained normal nutritional status and that inclusion of lucerne meal at levels of 15 and 20 per cent in place of fish meal did not exert any deleterious effect on the physiological well being of the animals.

An overall critical assessment of the results obtained in the present study indicates that lucerne meal can form a substitute for quality animal proteins sources like fish meal since three isoproteimic rations with lucerne meal at 15 and 20 per cent levels, in partial or complete replacement of fish meal, supported almost equal growth rates and feed efficiency in calves without showing any deleterious effect on the health of the animals. Further, the study throws more light on the role of leaf protein in animal feeding and on the urgent need to devise suitable and cheaper calf starters with a view to reduce the level of milk feeding and to economise calf rearing.

SUMMARY

SUMMARY

An investigation was carried out to assess the feeding value of lucerne meal as a possible substitute for animal protein sources like fish meal in calf starters. Eighteen cross bred calves, weaned at birth, were divided into three groups (Groups I, II and III) of six animals each as uniformly as possible in regard to body weight and were distributed under three dietary treatments viz., Diet A (control) and Diets B and C (experimental). While Diet A contained fish meal at a level of 10 per cent, experimental diets B and C contained 15 and 20 per cent respectively of lucerne meal in partial or complete replacement of fish meal, all the diets being isoproteinic. The calves were given colostrum for a period of first seven days and afterwards maintained on the respective calf starters with limited whole milk as well as greens in quantities as per standards followed, for a period of 24 weeks.

Records of fortnightly body weights and body measurements were maintained throughout the course of the experiment. Haematological studies were carried out at monthly intervals, to assess the nutritional status of animals. Towards the end of the feeding experiment, a digestion trial was carried out to find out the digestibility of

nutrients in the three rations.

Results on growth indicated that though the control diet containing fish meal at a level of 10 per cent promoted better growth in calves, there were no significant differences among the three dietary treatments in this regard, the overall average daily gains of animals being 233, 200 and 219 g respectively for Groups I, II and III. The three rations appeared to be equally palatable and were isocaloric as indicated by the uniform food consumption of animals. The almost similar growth rates of animals in the three groups indicated that lucerne meal can substitute fish meal in calf starters and fairly meet the amino acid requirements of pre ruminant calves.

Data on fortnightly body measurementsof animals revealed that gains in measurements took place parallel to gains in body weight indicating a positive correlation between body weight and body measurements. Also, there were no significant differences among the three dietary treatments in respect of body measurements in as much as almost similar gains in body length, heart girth, paunch girth and height at withers were obtained in animals of all the three groups, over a period of twenty four weeks.

The overall feed efficiency of animals were also found to be almost similar, the values being 5.8, 6.9

and 6.3 respectively for the groups I, II and III, further supporting the observations on growth rates of animals.

Results of digestion experiments indicated that though there were no significant differences in respect of digestibilities of dry matter and nitrogen free extract, digestibilities of crude protein, ether extract and crude fibre were found to vary between diets. While the control diet recorded higher digestibilities, significant difference was obtained only between control and diet B, indicating that diet C with 20 per cent lucerne meal was almost equally utilised as the control.

Data on haematological constituents did not reveal any significant difference among the three diets in respect of any of the parameter studied. Further, the values on blood constituent viz., plasma protein, haemoglobin, packed cell volume, plasma calcium and inorganic phosphorus recorded fall within the normal range characteristic of the species indicating that the animals maintained normal nutritional status and inclusion of lucerne meal at levels as used in the present study did not exert any deleterious effect on the health of the animals.

From an overall assessment of the results obtained in the present study it can be concluded that lucerne meal can form a substitute for fish meal in calf starters for promoting growth in calves.

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LUCERNE MEAL AS AN INGREDIENT IN CALF STARTER

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ABSTRACT OF A THESIS

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ABSTRACT

An investigation was carried out to assess the feeding value of lucerne meal as a possible substitute for fish meal in calf starters. Eighteen cross bred calves, weaned at birth, were divided into three groups (Groups I, II and III) of six animals each as uniformly as possible in regard to body weight and maintained on three isoproteimic calf starter diets, A, B and C containing 0, 15 and 20 per cent levels respectively of lucerne meal in partial or complete replacement of fish meal.

Records of fortnightly body weights and body measurements were maintained throughout the course of the experiment. Haematological studies were carried out at monthly intervals. Digestibility coefficients of nutrients in the three rations were determined by conducting a digestion trial towards the end of the experiment.

Though the control diet appeared better in promoting growth in calves, the overall daily gains and feed efficiency were almost similar with all the three dietary treatments clearly indicating that lucerne meal can replace fish meal at the levels used and fairly meet the amino acid requirements of the calves. Gains i body measurements took place parallel to gains in bo weight showing a positive correlation between body weig and body measurements.

The normal and similar values for blood constituents indicated that all the animals maintained normal nutritional status and inclusion of lucerne meal at levels as used in the present study did not exert any deleterious effect on the health of the animals.

An overall critical assessment of results clearly indicated that with isoproteimic diets lucerne meal can be safely included in calf starters at levels of 15 and 20 per cent in partial or complete replacement of fish meal.