# EVALUATION OF FEEDING VALUE OF RUBBER SEED CAKE FOR PROMOTING GROWTH IN CALVES



By

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**THESIS**

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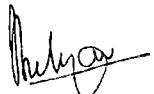
DECLARATION

I hereby declare that this thesis entitled "EVALUATION OF FEEDING VALUE OF RUBBER SEED CAKE FOR PROMOTING GROWTH IN CALVES" is a bona fide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.



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CERTIFICATE

Certified that this thesis, entitled "EVALUATION OF FEEDING VALUE OF RUBBER SEED CAKE FOR PROMOTING GROWTH IN CALVES" is a record of research work done independently by Shri T.V. Viswanathan 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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# C O N T E N T S

# INTRODUCTION

# INTRODUCTION

In the field of livestock wealth India occupies a unique position, possessing the largest cattle population of the world. Indian cattle are held in high esteem all over the world for their special attributes such as draft ability, heat tolerance, resistance to diseases and ability for converting the coarse forages into protein rich products.

According to the eleventh Livestock Census, there were 179 million cattle and 58 million buffaloes in India (Bhattacharya, 1976), Kerala State accounting for 2.86 million and 0.47 million respectively (Farm Information Bureau, 1977). Although the cattle and buffaloe population has almost reached a point of saturation at present, it will continue to increase at a slow rate upto 1980 (National Commission on Agriculture, 1976).

The present per capita availability of milk in India is estimated to be around 110 g against the recommended level of 200 g for adults per day (Ranga-Rau, 1975). While the average annual milk yields of the Indian cow and buffaloe are only 157 and 504 g respectively, the milk yields of improved cows in Denmark, U.S.A., U.K., Switzerland and Israel are more than 20 times than that of the Indian cow and over seven *times* than that of the buffalo (Bhattacharya, 1976). This disparity in the productivity of animals has largely been attributed to the

extent of application of science and technology in the field of Animal Husbandry. Wright (1937) has stated that milk production can be increased by at least 60 per cent by better feeding and management alone. Kay (1946) stated that even 300 per cent increase in milk production is possible by better feeding and management alone.

India is short to the extent of 40 per cent in roughages and 70 per cent in concentrates to meet the livestock needs (Venkatachalar, 1976). Only about 4 per cent of the cultivated area is under fodder crops in contrast to about 25 per cent in U.K. and nearly 60 per cent in U.S.A. (Venkatachalar, loc cit). It has been reported that of the available sources of cattle feed, about 80 per cent is from agro-industrial by-products and the rest is from cultivated fodder (Ulhas, 1976).

The present population of 4000 million in the world is expected to increase to 7000 million by the year 2000 and nearly 500 million people now face dietary protein and energy shortages (National Academy of Sciences, 1971). In this situation, it is essential to formulate rations for animals by minimising or even avoiding the incorporation of items that are use in human diets. The utilisation of agro-industrial by-products in the rations of animals, thus, assumes paramount importance.

It is an accepted fact that the object in designing ratio

for livestock is to maximise the returns over the feed costs. To achieve this object, one of the possible methods is to supply digestible nutrients to the animal at a lower cost. The utility of any feed stuff will, thus, have to be judged by its ability to supply the digestible protein and energy at a competetive price. It, therefore, becomes imperative to explore the possibility of utilising agricultural and industrial by-products which hitherto go as waste.

The Indian Council of Agricultural Research have initiated extensive investigations on the feeding value of the various agricultural wastes and industrial by-products available in the country for different species of animals. Of the several such unconventional feeds, rubber seed cake - a by-product of rubber plantation - has attracted the attention of the scientists and farmers in the State of Kerala.

In India, rubber is grown over an area of approximately 224,428 hectares (Rubber Research Institute of India, 1977) of which 202,320 hectares are in Kerala (Farm Information Bureau, 1977). The world production of rubber seed cake has been estimated as 150,000 tons (British Rubber Development Board, 1948). It has been estimated that about 46,965 tonnes of rubber seed is now wasted in Kerala (Varghese, 1972).

Though there are few reports on the feeding value of rubber seed cake to animals and birds (Sen, 1952; Morrison, 195 Buvanendran and Siriwardene, 1970 and Nadarajah et al. 1975),

detailed information on its suitability as an ingredient in the rations of calves is lacking. A detailed investigation was, therefore, carried out to assess the suitability and feeding value of rubber seed cake as an ingredient in the concentrate mixture for growing calves.

# REVIEW OF LITERATURE

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The common rubber tree (Hevea brasiliensis) belongs to the family Euphorbiacea (Encyclopaedia Britannica, 1957). This tree grows well in almost all types of soil and in areas having a rainfall upto 100 inches. The optimum temperature for growth of this tree is from 70-90°F at an altitude below 2000 feet. It is a large tree growing upto 125 feet in height and reaching a circumference of 12 feet under natural conditions. The tree has a well developed and very thick bark, which is its most important part as it yields the latex from which the natural rubber is produced. The flowers appear in the form of a big inflorescence with pale green colour and have an abundant content of nectar. The fruit is green till fully mature and appears as a lobulated oval capsule divided into three compartments, each containing a single, oval hard seed. The seeds are mottled brown in colour. When fully ripe, the capsule explodes and ejects the seeds. The seeds are formed during summer and mature seeds are dispersed from June onwards till September. The secondary seed fall which occurs at the commencement of the winter season is of less importance as compared with that of the main crop (Anon, 1969).

Varghese (1972) reported that the total cost of rubber seed oil and cake produced annually from Kerala comes to the tune of Rs. 1.4 crore of which the cost of cake alone amounts to Rs.48.9 lakhs. According to him, rubber seed which now fetch no price to the cultivator is estimated to cost Rs.200/- per ton

and that it is possible to collect one ton of rubber seed from four hectares of land under cultivation.

A rubber tree will bear approximately 300 fruits each having three to four seeds in it weighing four to six g each. A minimum of 350 trees can be planted in a hectare (Anon, 1969). Of the total weight of the seeds, the shell and kernel form 37 and 63 per cent respectively (Anon, loc cit). After extraction of oil, the cake accounts for 55 per cent of the kernel (Rubber Research Institute of India, 1977). From the above information and taking into consideration that on an average, only 85 per cent of the trees of the plantation would be able to produce seeds (Nadarajah, 1969). It has been calculated that about 37,500 tonnes of rubber seed cake will be available annually in Kerala.

Composition and nutritive value of rubber seed have been studied by many workers. The shelling percentage (Kernels as a percentage of undecorticated seeds) of rubber seed has been reported as 57 per cent, the shells making up 43 per cent of the whole seed (Orok and Bowland, 1974). Figures ranging from 45.0-69.7 per cent have also been reported (Anon, 1948; Nobori and Takehara, 1948 and Rubber Research Institute of India, 1977). Rubber seed oil which forms 35-52 per cent of the kernel (Nobori and Takehara, 1948; Siqueira et al. 1956; Azeemoddin and Rao, 1962 *and* Rubber Research Institute of India, 1977), is used mainly in soap manufacture, paint industry, production of factice, epoxidised vegetable oil and as a lubricating oil (Rubber Research Institute of India, 1977). Also, it has been used effectively against *flies*,

lice and similar pests (Medical Research Institute, Ceylon, 1950).

Rubber seed cake contains 23.6 to 29.9 per cent of crude protein (Buvanendran and Siriwardene, 1970; Hyder Ali, 1970 and Siriwardene and Nugara, 1972). Morrison (1957) has reported a crude protein value of 28.8 per cent for rubber seed oil meal. Reported values for crude protein in rubber seed kernel range from 16.87-22.10 per cent (Siqueira et al. 1956; Azeemoddin and Rao, 1962; FAO, 1972 and Orok and Bowland, 1974).

Rajaguru and Vohra (1975) reported the amino acid composition of decorticated rubber seed expressed as weight percentage of protein as: isoleucine 3.1-4.2, leucine 4.8-5.9, lysine 2.8-4.2, methionine 1.1-2.2, cystine 1.4-2.0, phenylalanine 2.8-3.8, threonine 2.8-3.1, tyrosine 2.6-2.8, tryptophan 1.2-1.4 and valine 4.2-6.5. Fatty acid composition of decorticated rubber seed as weight percentage has been reported to be: myristic 0.1, palmitic 8.1, stearic 10.5, arachidonic 0.3, (FAO, 1972). Siqueira et al. (1956) recorded a figure of 450 micro gram for thiamine, 2500 micro gram for nicotinic acid and 250 micro gram for carotene for 100 g of untreated rubber seed kernel.

Pope (1930) claimed that rubber seeds are edible. Lauw Tjan Giok et al. (1967) reported that rubber seed is used by people living in or near the plantations in Nigeria and that there was no evidence of toxicity when rubber seed was fed to animals. No saponin or alkaloid was detected in rubber seed oil

cake when fed as cattle feed (Anon, 1929). Sankunny et al. (1964) found no toxic symptom in rats on feeding rubber seed at a level of 29.6 per cent in their diet.

Earlier, Gorter (1912) reported that rubber seed kernel contains a cyanogenetic glucoside ie. a compound which decomposes as a result of enzyme action in a very slightly acid medium, yielding hydrocyanic acid as one of the products. This cyanogenetic glucoside has been claimed to be similar to that present in manioc viz., linamarin, which is the glucoside of acetone cyanohydrin. The mild smell of hydrocyanic acid in moist kernel especially when dried in the copra kiln or in the smoke house is an evidence of the presence of this compound. It is reported that the hydrocyanic acid content diminishes rapidly during the first eight weeks of storage and thereafter the decrease is much more gradual (George et al. 1932). Hydrocyanic acid concentration is found to be 20 mg/100 g in rubber seed products (Bredemann. 1931), 200 mg, 8.9 mg and 3.4 mg per 100 g in fresh seeds, cooked dried materials and defatted dried pressed cake respectively (Lauw Tjin Giok et al. 1967) and 9 mg/100 g of rubber seed cake (ICAR Report, 1976).

Feeding trials carried out on weanling rats fed on synthetic as well as milk based diets incorporating rubber seed cake at 30 per cent level showed no significant change in body weight gain, nutritional status or feed intake of animals when compared with those of the control. It was, however, observed that animals

receiving rubber seed cake evinced black foetid diarrhoea. Though no mortality was observed during the course of the study, histopathological examination of the internal organs of animals receiving rubber seed cake, when slaughtered at the termination of the experiment showed necrotic enteritis (ICAR Report, 1971).

Lauw Tjin Giok et al. (1967) studied the nutritive value of rubber seed protein in rats and reported that rubber seed cake would be a potential source of high protein feed for cattle and sheep. The quantity of sulphur containing amino acids particularly that of methionine was found to be 1.1-2.2 g/100 g of protein (Lauw Tjin Giok et al. 1967; Orok and Bowland, 1974 and Rajaguru and Vohra, 1975). The other essential amino acids were also reported to be present in acceptable levels. Lauw Tjin Giok et al. (1967) claimed that the higher levels of lysine and tryptophan would make rubber seed cake a useful supplementary protein to maize. They also reported that at 20 per cent dietary level of protein (about 60% dried rubber seed in the diet), food intake, protein efficiency ratio and growth rate of rats were comparable with those obtained on rats fed diets with casein at the same level.

Orok and Bowland (1974) reported that a level of 7 to 12 per cent of rubber seed cake prepared from fresh or autoclaved decorticated rubber seed could be utilised efficiently in either soybean meal or peanut meal supplemented diet for rats. Rubber

seed meal was particularly useful as a supplement to peanut meal diets which were generally inferior to diets containing soybean meal (Orok and Bowland, 1974a). Rats fed rubber seed cake supplemented diets consumed less when compared to those receiving other diets which has been attributed to higher digestible energy and metabolizable energy contents of the rubber seed meal supplemented diets. Gross energy per g of rubber seed cake was reported to be 6.5 K cal (Orok and Bowland, 1974). Oluyemi et al. (1976) reported gross energy values of 7.11, 6.99, 4.48 K cal/g for raw rubber seed, autoclaved rubber seed meal and defatted rubber seed meal respectively.

Studies carried out on poultry showed that rubber seed meal could be successfully incorporated upto a level of 20 to 25 per cent in broiler and layer rations (Buvanendran and Siriwardene, 1970). Rajaguru (1971) observed that when pullets were raised on diets with different levels of rubber seed meal (10-40%) from third month of age, though matured late, the egg production was normal in all the groups. Increasing the percentage of rubber seed meal in the diets lowered egg size, shell thickness, hatchability of incubated eggs and weights of chicks hatched out. Buvanendran (1971) reported that rubber seed meal at a level of 20 per cent in the ration caused embryonic mortality and suggested that cyanogenetic glycosides could not be responsible for this effect. Rajaguru (1971) and Rajaguru and Wettimuny (1971) have also observed embryonic mortality in chicks and have attributed this to the amino acid imbalance of rubber

seed meal lowering the biological value of proteins in diets. Rajaguru (1971) suggested that rubber seed cake contained an unidentified antifertility factor, though it had no effect on the quality of semen of the cocks used for artificial insemination.

Growth studies in pigs using rubber seed cake replacing 10 per cent of the coconut oil cake in the ration showed that the material can profitably be used without any deleterious effect on the rate of growth, feed efficiency and on carcass characteristics of the animals (ICAR Report, 1972). Nadarajah et al. (1975) observed that when breeding sows were fed on a ration containing 10 per cent rubber seed meal the fertility of the herd was drastically affected. On the other hand, diets containing 50 per cent rubber seed meal showed excellent results in terms of weight gain and quality of flesh in porkers.

Rubber seed meal has been reported as a possible cattle feed supplement (Ellett et al. 1931; Dawson and Messenger, 1932; Sen, 1952; Morrison, 1957 and Lauw Tjin Giok, 1967). On the other hand, it was suggested that the use of rubber seed cake as animal feed may be unwise because of poisoning from prussic acid (Anon, 1948). Rubber seed cake was found to be unsatisfactory as a feed for calves (Bredemann, 1931). It was suggested that a large part of its oil has to be extracted to make rubber seed meal a suitable cattle feed (Dawson and Messenger, 1932; Sen, 1952 and Nadarajah et al. 1975). Bhushan (1958) claimed

that rubber seed meal is one of the most digestible concentrated cattle feeds available.

Ellett et al. (1931) reported that though rubber seed meal is less palatable, it is an efficient medium protein concentrate for milch cows, closely comparable with linseed meal for milk production. Lactation studies involving eight cows, in a seven week switch over trial, incorporating rubber seed cake at 20 per cent level replacing the entire portion of gingelly cake (20%) in the concentrate mixture failed to produce any significant difference in either milk production (FCM) or in the characteristics of butter fat (ICAR Report, 1976).

Morrison (1957) reported values of 20.4 and 63.4 for DCP and TDN respectively in rubber seed oil meal. Hyder Ali (1970) recorded values of 18.5 and 53.8 for DCP and TDN respectively for rubber seed cake. DCP and TDN of rubber seed cake for swine were found to be 16.65 and 78.86 respectively (George, 1970).

# MATERIALS AND METHODS

## MATERIALS AND METHODS

Twenty four cross-bred calves (Sindhi x Jersey) of 8-14 months of age, from the University Livestock Farm, Mannuthy, were randomly distributed under three dietary treatments ($T_1$, $T_2$ and $T_3$) as uniformly as possible in regard to age, sex and weight. The three groups of animals were fed on concentrate rations containing 0, 15 and 30 per cent levels respectively of rubber seed cake. Calves were protected against common contageous diseases and were also dewormed periodically. All animals were fed according to Feeding Standards prescribed by Sen and Ray (1971). Paddy straw formed the sole roughage.

Records of daily feed consumption and fortnightly body weights of animals were maintained throughout the period of the experiment. Linear body measurements like length, girth and height were taken at the beginning, third and sixth month of the study as detailed by Russel (1975). Haematological values namely, RBC, haemoglobin, plasma protein, calcium and inorganic phosphorus were determined at the beginning, third and sixth month of the study as per the methods detailed by Omer (1965) and Swenson (1970).

A digestion-cum-metabolism trial involving five day's collection period was conducted at the end of the study (Hattan and Owen, 1970). Known quantities of the feed were taken everyday for dry matter determination. Composite samples were taken

after pooling the samples collected during the five days of the trial for the determination of the rest of the proximate principles.

Table 1. Percentage composition and cost of concentrate mixtures.

| Items | $T_1$ | $T_2$ | $T_3$ | Cost (Rs/quintal) |
|---|---|---|---|---|
| Rubber seed cake | - | 15 | 30 | 85.00 |
| Cotton seed cake | 30 | 15 | - | 133.00 |
| Groundnut cake | 22 | 22 | 22 | 147.50 |
| Rice bran | 20 | 14 | 5 | 44.40 |
| Maize bran | 20 | 23 | 26 | 119.00 |
| Maize | 5 | 8 | 14 | 110.00 |
| Mineral mixture (Dicalcium phosphate) | 1 | 1 | 1 | 650.00 |
| Salt | 2 | 2 | 2 | 15.00 |
| Vitamin A, $B_2$, $D_3$ (Rovimix) | 12.5 g | 12.5 g | 12.5 g | 11,955.00 |
| DCP (Calculated value) | 16.1 | 16.1 | 16.0 | |
| TDN ( " ) | 69.8 | 69.3 | 69.6 | |
| Cost in Rs./quintal | 118.83 | 115.84 | 114.81 | |

All precautions were taken to ensure the collection of dung quantitatively, uncontaminated by urine, any feed residue or dirt. The dung was collected manually at 10 a.m. everyday. The dung voided during the previous 24 hours was weighed accurately and representative samples were taken after thorough mixing. Dry matter content of dung for each animal was determined everyday

separately. A representative sample of dung collected from each animal was preserved in a refrigerator. A known quantity of dung was taken from the pooled samples for protein estimation. Dried dung of each animal was preserved in labelled air-tight containers for further analysis. The process of collection, weighing, sampling and drying of dung was continued till the end of the trial.

The urine from males was collected by urine collection bags whereas that from females was collected manually and preserved in polythene cans containing 100 ml of 25 per cent of sulphuric acid. The quantity of urine voided was measured daily and 1/1000th of the volume was taken for the estimation of nitrogen. Another sample was preserved for estimation of calcium and phosphorus.

The analyses of the feeds and faeces were carried out as per the standard methods described in A.O.A.C. (1970).

For the statistical analyses of the results obtained during the course of the present study, methods described by Snedecor and Cochran (1969) were followed.

One animal each from the control and the 30 per cent group was slaughtered at the end of the experiment for histopathological studies.

# R E S U L T S

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The results of the chemical analysis of the experimental rations ($T_1$, $T_2$ and $T_3$) are presented in Table 2. Mean values of body weights of the animals taken at fortnightly intervals are shown in Table 3 and represented in Fig. 1. Statistical analysis of the data on the body weight gain is presented in Table 4. The mean values of linear body measurements of the calves are set out in Table 5 and in Figs. 2 to 4 and statistically analysed in Tables 6 to 8. In Table 9 data on haematological values of calves determined during the experimental period are presented. The results of digestion-cum-metabolism trial conducted at the termination of the experiment are shown in Table 10, and statistically analysed in Table 11. The average value of feed consumption, feed efficiency and the economics involved are detailed in Table 12 and presented in Figs. 5 and 6.

Table 2. Chemical composition of the experimental rations.
(Percentage on dry matter basis)

| | Concentrate | | | Roughage | Rubber seed cake |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | Paddy straw | |
| Dry matter | 91.4 | 92.0 | 91.4 | 93.8 | 92.9 |
| Crude protein | 22.4 | 23.2 | 22.6 | 3.9 | 24.6 |
| Ether extract | 7.5 | 8.2 | 6.3 | 1.9 | 12.0 |
| Crude fibre | 16.8 | 11.3 | 6.8 | 31.2 | 2.9 |
| Nitrogen-free extract | 43.8 | 47.9 | 55.8 | 47.1 | 53.0 |
| Total ash | 9.5 | 9.4 | 8.5 | 15.9 | 7.5 |
| Acid insoluble ash | 3.1 | 3.9 | 2.5 | 12.5 | 0.16 |
| Calcium | 0.72 | 0.75 | 0.82 | 0.63 | 0.35 |
| Phosphorous | 0.95 | 0.94 | 0.87 | 0.18 | 0.62 |
| Hydrocyanic acid mg/100 g | - | - | - | - | 8.7 |

Table 3. Summarised data on fortnightly average body weights (kg) of calves maintained on the experimental rations.

| Treatments | Number of animal | Fortnights | | | | | | | | | | | | | Overall average daily gain per animal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| $T_1$ | 8 | 85 ±4.4 | 89 ±4.5 | 92 ±6.5 | 100 ±5.4 | 108 ±5.3 | 112 ±7.2 | 119 ±7.4 | 129 ±7.5 | 135 ±5.6 | 139 ±7.2 | 143 ±7.7 | 155 ±4.2 | 161 ±7.2 | 422 g |
| $T_2$ | 7 | 85 ±1.1 | 90 ±1.4 | 91 ±3.4 | 99 ±3.4 | 108 ±2.7 | 113 ±2.7 | 121 ±2.0 | 131 ±3.1 | 138 ±4.0 | 141 ±4.1 | 148 ±5.6 | 156 ±2.5 | 161 ±2.6 | 422 g |
| $T_3$ | 8 | 85 ±3.5 | 89 ±4.1 | 91 ±6.2 | 100 ±6.8 | 108 ±6.6 | 115 ±6.5 | 125 ±6.6 | 135 ±6.1 | 144 ±8.0 | 151 ±7.8 | 160 ±8.1 | 166 ±9.6 | 174 ±8.6 | 494 g |

Table 4. Analysis of variance. Weight gain.

| Source | df | SS | MSS | F |
|---|---|---|---|---|
| Fortnight | 11 | 1003.71 | 91.25 | 10.24** |
| Treatments | 2 | 65.00 | 32.50 | 3.65* |
| Sex | 1 | 63.83 | 63.83 | 7.16** |
| Error | 249 | 2217.72 | 8.91 | |
| Total | 263 | 3350.26 | | |

* Significant at 5% level.

** Significant at 1% level.

Pairwise comparison.

| Treatments | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|
| Mean | 76 | 76 | 89 |

C.D. for $T_1$ and $T_2$ - 2.17

" $T_1$ and $T_3$ - 1.99

" $T_2$ and $T_3$ - 2.17

Table 5. Average linear body measurements of calves maintained on the experimental rations.

| | Height (cm) | Length (cm) | Girth (cm) |
|---|---|---|---|
| Initial | | | |
| $T_1$ | 90 ± 2.6 | 95 ± 3.1 | 109 ± 2.7 |
| $T_2$ | 90 ± 3.2 | 95 ± 2.3 | 108 ± 3.7 |
| $T_3$ | 89 ± 3.3 | 94 ± 1.8 | 107 ± 2.3 |
| 3rd month | | | |
| $T_1$ | 95 ± 3.3 | 102 ± 1.0 | 121 ± 2.0 |
| $T_2$ | 96 ± 3.9 | 103 ± 3.4 | 121 ± 3.7 |
| $T_3$ | 96 ± 4.1 | 104 ± 4.2 | 122 ± 5.5 |
| 6th month | | | |
| $T_1$ | 100 ± 2.7 | 110 ± 2.0 | 130 ± 1.5 |
| $T_2$ | 101 ± 3.7 | 113 ± 1.6 | 130 ± 2.3 |
| $T_3$ | 102 ± 1.8 | 114 ± 2.4 | 133 ± 4.6 |

Table 6. Analysis of variance. Height

| Source | df | SS | MSS | F |
|---|---|---|---|---|
| Period | 1 | 272.70 | 272.70 | 37.88** |
| Treatment | 2 | 63.92 | 31.96 | 4.44* |
| Error | 42 | 302.34 | 7.20 | |
| Total | 45 | 638.96 | | |

* Significant at 5% level.

** Significant at 1% level.

Pairwise comparison.

| Treatments | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|
| Mean | 7.06 | 8.21 | 7.88 |

C.D. for $T_1$ and $T_2$ - 2.08

" $T_1$ and $T_3$ - 2.01

" $T_2$ and $T_3$ - 2.08

Table 7. Analysis of variance - Length.

| Source | df | SS | MSS | F |
|---|---|---|---|---|
| Period | 1 | 986.28 | 986.28 | 21.54** |
| Treatment | 2 | 91.57 | 45.79 | 2.61 |
| Error | 42 | 736.95 | 17.55 | |
| Total | 45 | 1814.80 | | |

** Significant at 1% level.

Table 8. Analysis of variance - Girth.

| Source | df | SS | MSS | F |
|---|---|---|---|---|
| Period | 1 | 1071.39 | 1071.39 | 104.83** |
| Treatment | 2 | 226.56 | 113.28 | 11.08** |
| Error | 42 | 429.40 | 10.22 | |
| Total | 45 | 1726.96 | | |

** Significant at 1% level.

Pairwise comparison.

| Treatments | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|
| Mean | 16.3 | 17.64 | 21.31 |

C.D. for $T_1$ and $T_2$ - 2.58
" $T_1$ and $T_3$ - 2.52
" $T_2$ and $T_3$ - 2.58

Table 9. Summarised data on haematological values of calves maintained on the three experimental rations. (Average with standard error)

| | $T_1$ | | | $T_2$ | | | $T_3$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial | 3rd month | 6th month | Initial | 3rd month | 6th month | Initial | 3rd month | 6th month |
| RBC million/$mm^3$ | 8.08±0.6 | 7.99±0.3 | 7.87±0.2 | 7.68±0.4 | 6.98±0.4 | 7.60±0.2 | 7.44±0.5 | 7.30±0.2 | 7.02±0.3 |
| Haemoglobin g/ 100 ml of blood | 9.0± 0.1 | 10.2 ±0.4 | 9.2 ±0.4 | 8.4 ±0.5 | 9.9 ±1.1 | 9.6 ±0.4 | 8.3 ±0.2 | 9.9 ±0.3 | 8.7 ±0.1 |
| Plasma protein g/100 ml. | 8.4 ±0.2 | 9.8 ±0.4 | 8.4 ±0.3 | 9.1 ±0.3 | 9.5 ±1.0 | 8.5 ±0.4 | 9.1 ±0.3 | 10.1 ±0.2 | 8.7 ±0.4 |
| Plasma calcium mg/100 ml. | 12.4 ±0.2 | 12.7 ±0.4 | 10.4 ±0.2 | 12.8 ±0.4 | 11.8 ±0.4 | 11.3 ±0.3 | 12.4 ±0.4 | 12.8 ±0.4 | 10.9 ±0.3 |
| Plasma inorganic phosphorous mg/100 ml. | 7.8 ±0.2 | 7.4 ±0.3 | 7.7 ±0.4 | 7.7 ±0.3 | 7.8 ±0.1 | 7.8 ±0.3 | 7.4 ±0.8 | 7.6 ±0.3 | 7.9 ±0.4 |

Table 10. Average digestibility coefficients, digestible nutrients and nitrogen and mineral balances.

| Treatments | Digestibility coefficient of the exptl. rations | | | | | | DCP intake g/day/animal | TDN intake g/day/animal | Nitrogen balance g/day/animal | Mineral balance g/day/animal | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry matter | Organic matter | Crude protein | Ether extract | Crude fibre | N.F.E. | | | | Calcium | Phosphorous |
| $T_1$ | 49.6 ± 2.1 | 53.4 ± 2.0 | 57.7 ± 2.1 | 70.4 ± 1.7 | 62.2 ± 1.7 | 45.1 ± 2.8 | 347 ±15.8 | 2412 ±102.7 | 16.5 ± 1.4 | 10.1 ± 0.4 | 6.4 ± 0.5 |
| $T_2$ | 51.2 ± 2.4 | 54.5 ± 2.5 | 56.2 ± 1.1 | 77.1 ± 1.9 | 60.1 ± 2.2 | 49.7 ± 3.4 | 359 ± 8.5 | 2625 ±104.6 | 17.2 ± 2.3 | 9.7 ± 1.2 | 6.3 ± 0.6 |
| $T_3$ | 55.1 ± 2.6 | 58.4 ± 3.1 | 58.7 ± 2.4 | 69.9 ± 2.5 | 66.0 ± 2.1 | 52.8 ± 3.9 | 375 ±16.6 | 2694 ±153.8 | 19.2 ± 2.6 | 11.2 ± 1.0 | 7.0 ± 0.8 |

Table 11. Analyses of variance of digestibility coefficients, nitrogen and mineral balances.

| | | Dry matter | Organic matter | Crude protein | Ether extract | Crude fibre | N.F.E. Nitrogen | Calcium | Phosphorous |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | df | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | SS | 127.20 | 108.76 | 24.40 | 242.12 | 121.30 | 235.95 | 31.36 | 9.17 | 2.09 |
| | MSS | 63.60 | 54.38 | 12.20 | 121.06 | 60.70 | 117.98 | 15.68 | 4.58 | 1.05 |
| Error | df | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | SS | 972.79 | 954.20 | 640.80 | 730.40 | 1027.00 | 1469.70 | 709.02 | 138.41 | 80.65 |
| | MSS | 48.63 | 47.71 | 32.04 | 36.52 | 51.30 | 73.49 | 35.45 | 6.92 | 4.03 |
| Total | df | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| | SS | 1099.90 | 1062.96 | 665.20 | 972.52 | 1148.30 | 1705.65 | 740.38 | 129.24 | 78.56 |
| F | | 1.31 | 1.14 | 0.38 | 3.32 | 1.18 | 1.61 | 0.44 | 0.66 | 0.26 |

Table 12. Average feed consumption, feed efficiency and economics.

| Treatments | Total feed intake | | Total weight gain | Feed efficiency | | Cost of raising a year old calf for a period of six months | | | Cost/kg gain | | | Cost for 100 kg gain | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentrate (kg) | Paddy straw (kg) | (kg) | Kg conc. per kg gain | Kg total ration per kg gain | Concentrate (Rs) | Paddy straw (Rs) | Total (Rs) | Conc. (Rs) | Paddy straw (Rs) | Total (Rs) | Conc. (Rs) | Paddy straw (Rs) | Total (Rs) |
| $T_1$ | 384 | 441 | 76 | 5.05 | 10.85 | 456.46 | 101.22 | 557.68 | 6.01 | 1.35 | 7.36 | 601 | 135 | 736 |
| $T_2$ | 378 | 435 | 76 | 4.97 | 10.69 | 437.88 | 99.62 | 537.50 | 5.77 | 1.31 | 7.08 | 577 | 131 | 708 |
| $T_3$ | 388 | 440 | 89 | 4.36 | 9.30 | 445.00 | 100.76 | 545.76 | 4.99 | 1.24 | 6.23 | 499 | 124 | 623 |

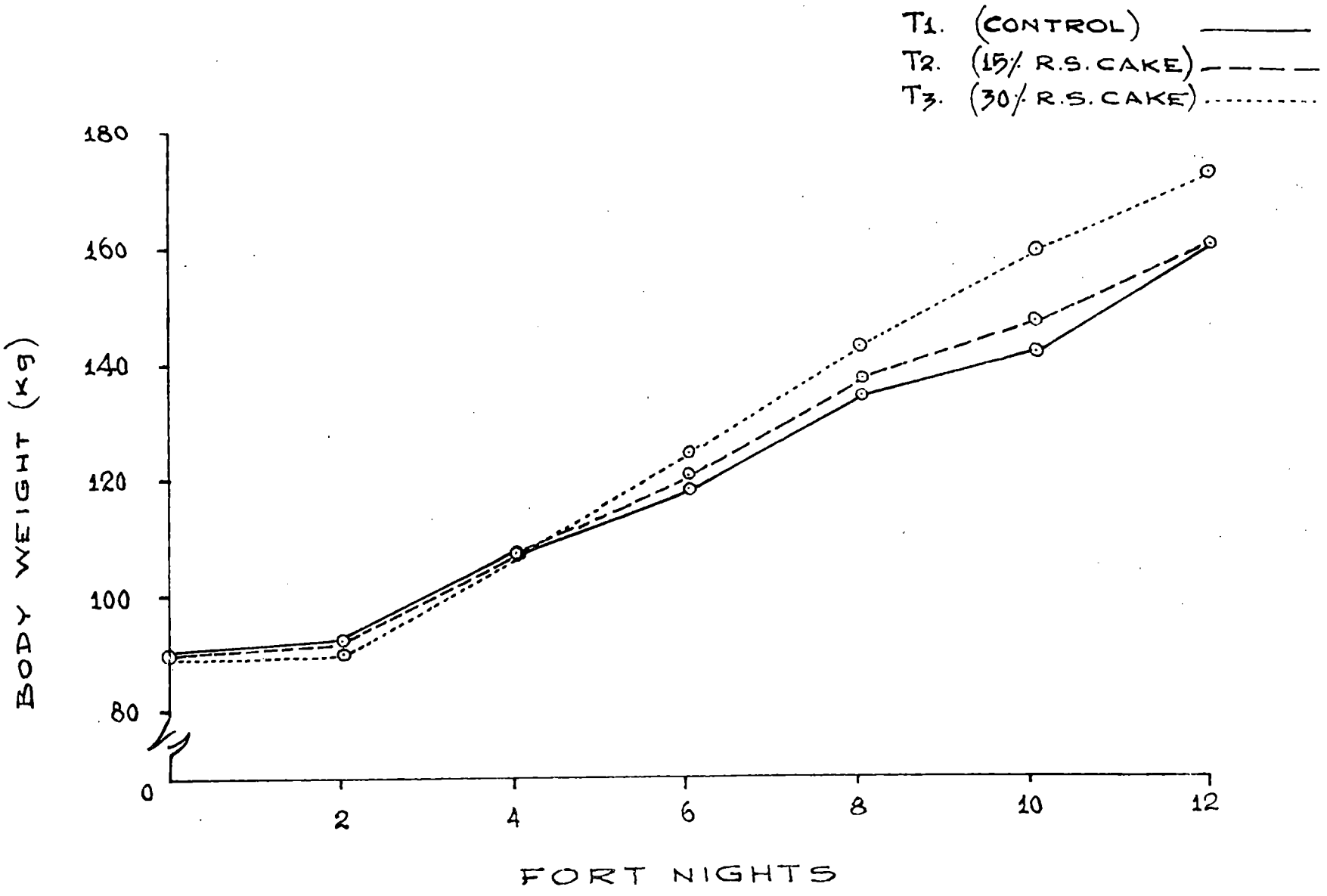



FIG. I. AVERAGE BODY WEIGHT OF CALVES

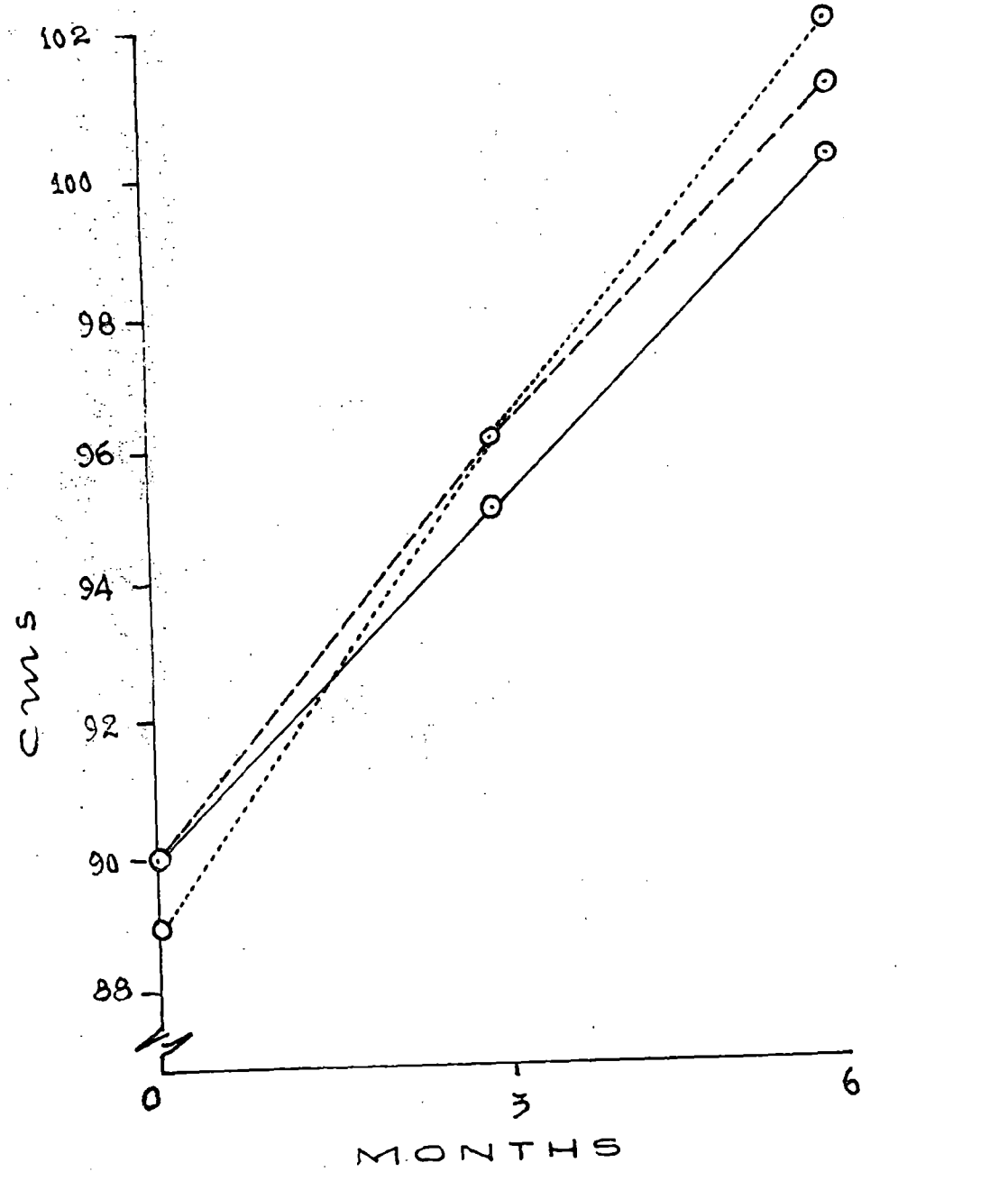



FIG. II. AVERAGE HEIGHT OF CALVES

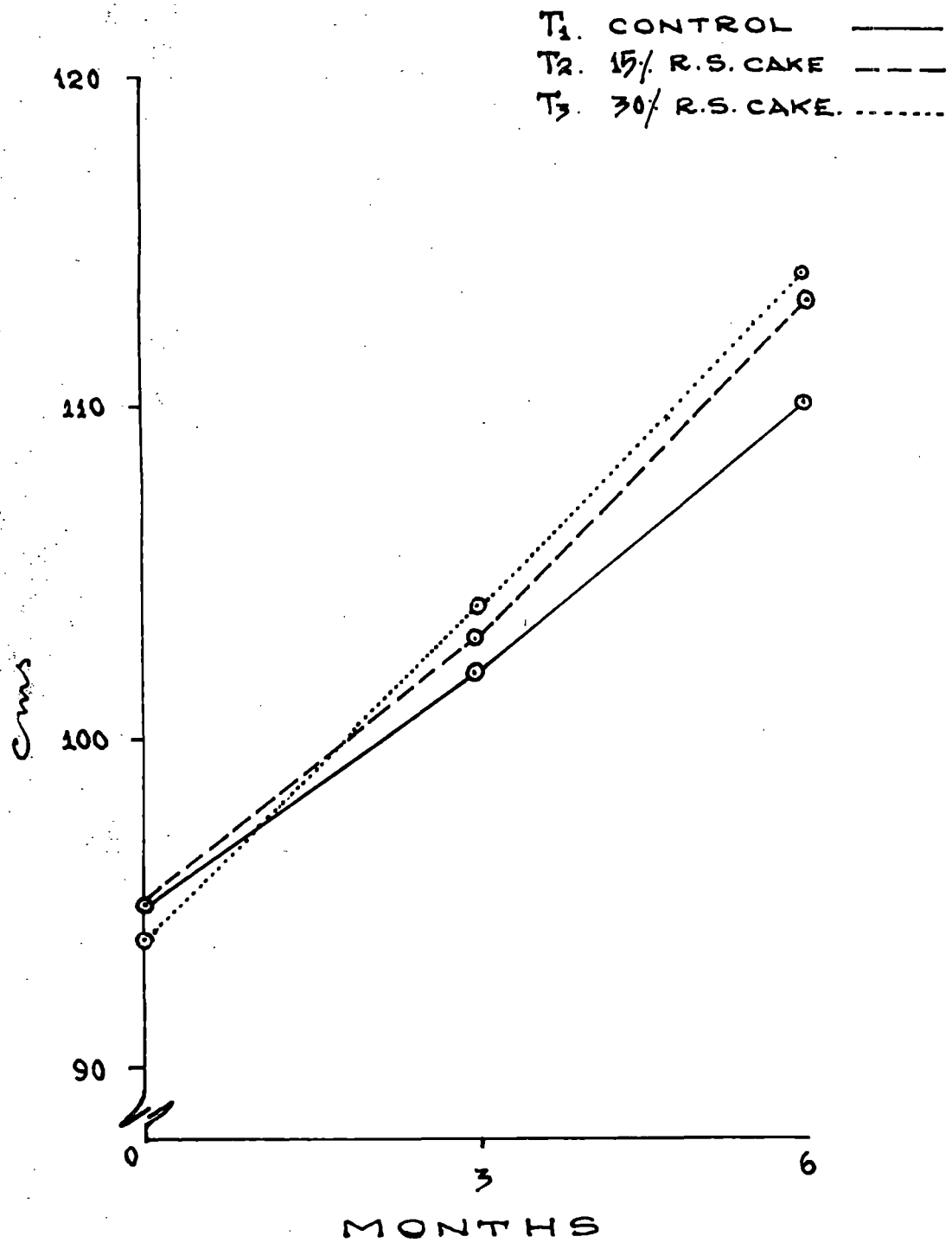



FIG. III. AVERAGE LENGTH OF CALVES

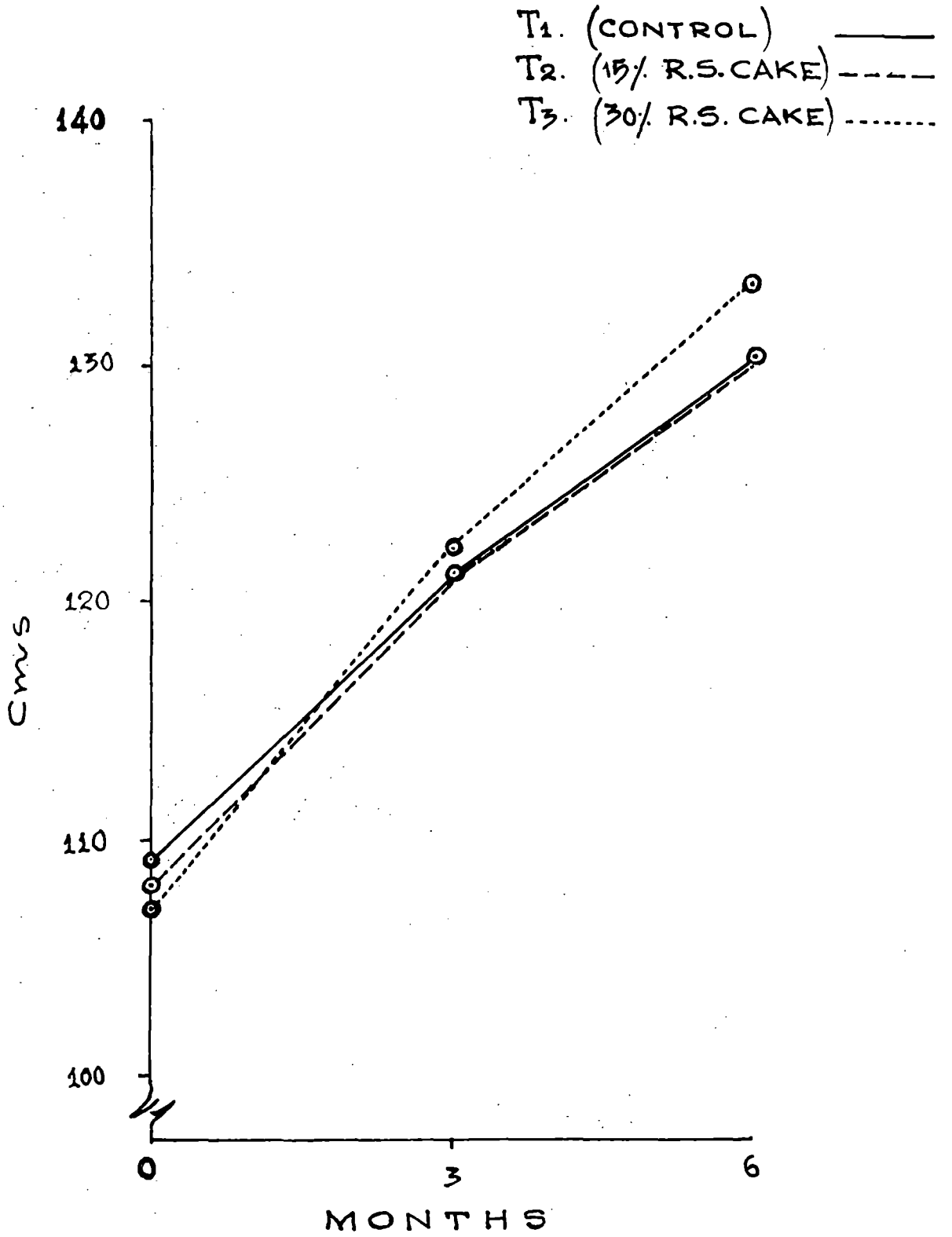



FIG. IV. AVERAGE GIRTH OF CALVES

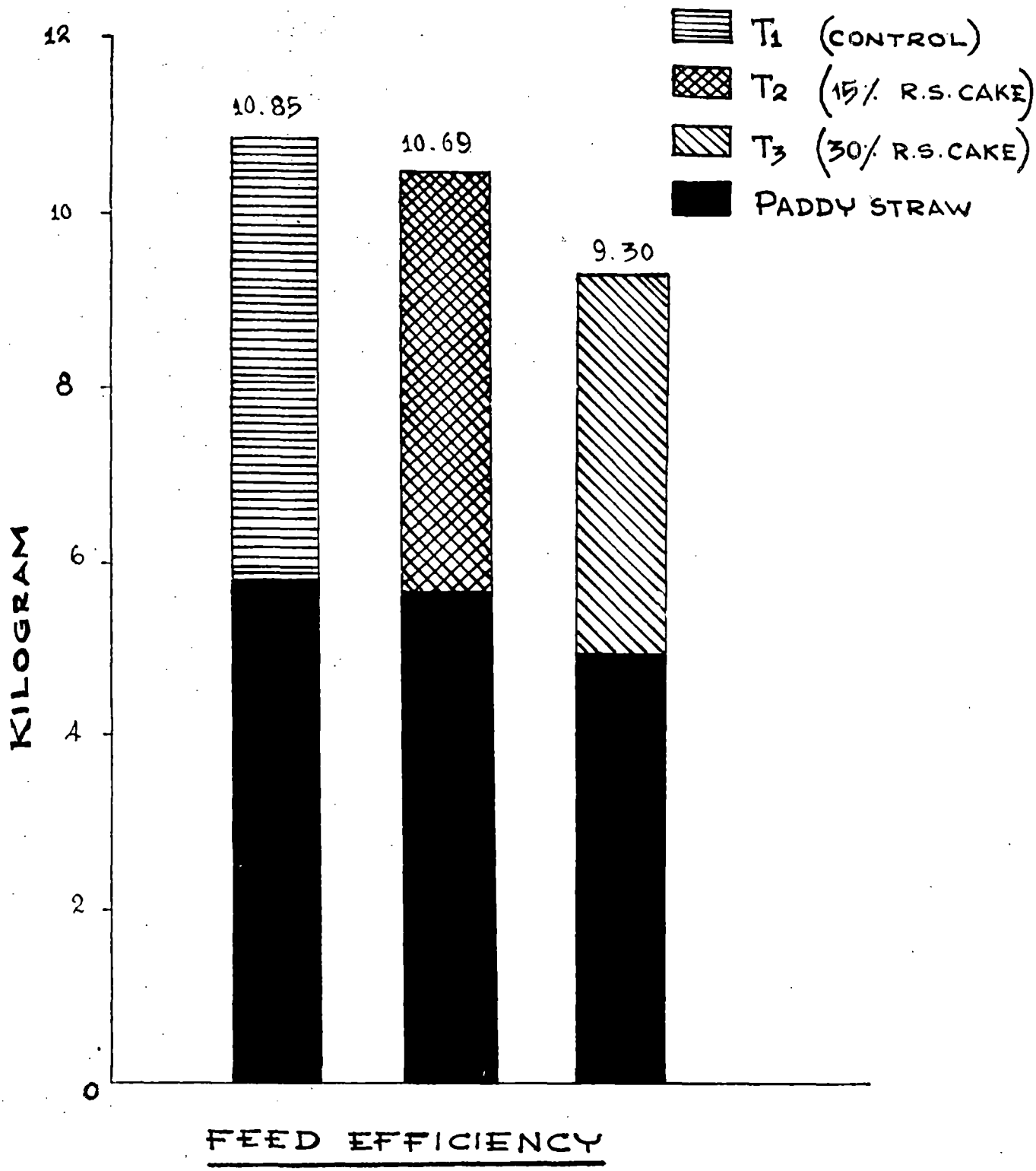



FIG. V. FEED REQUIRED PER KILOGRAM BODY WEIGHT GAIN

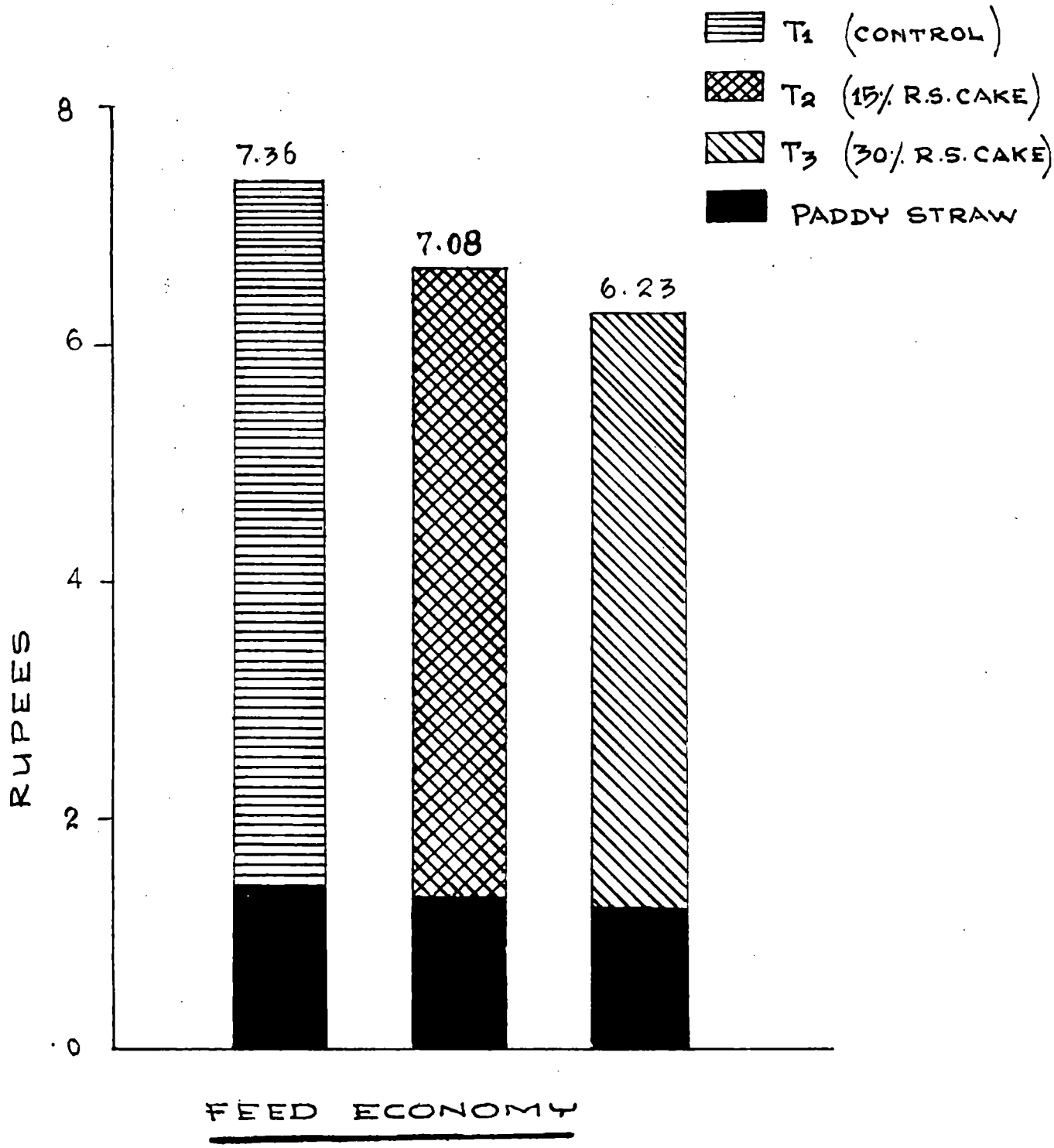
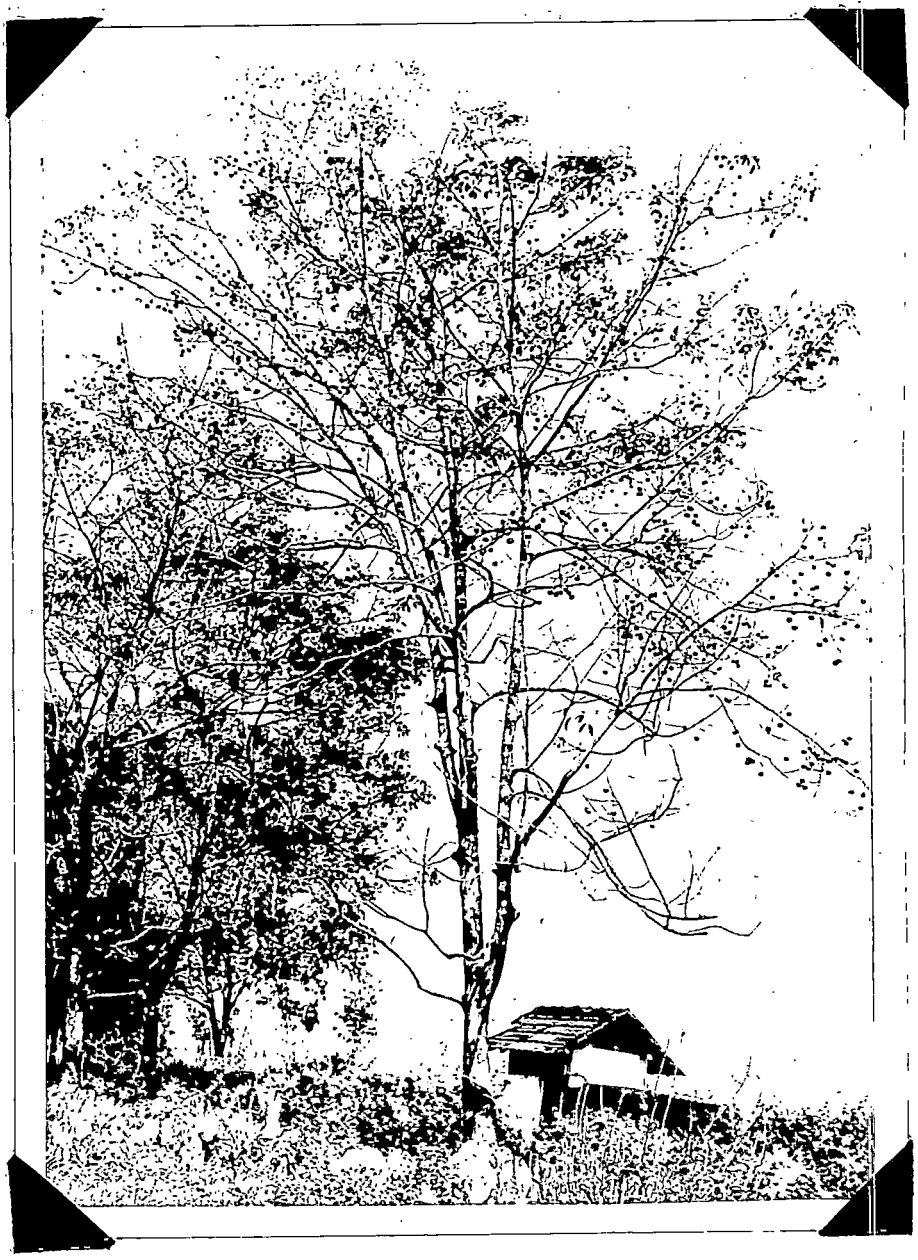
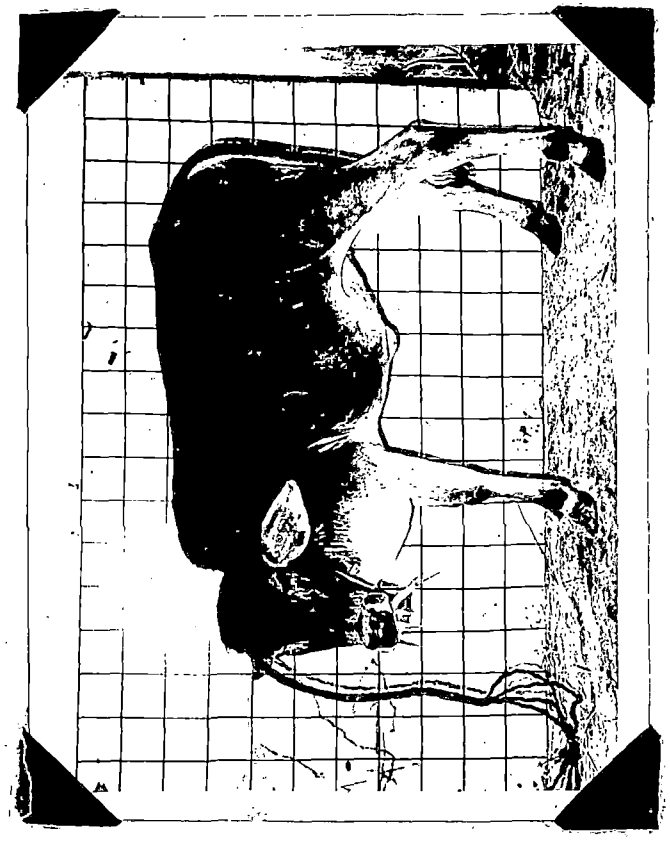
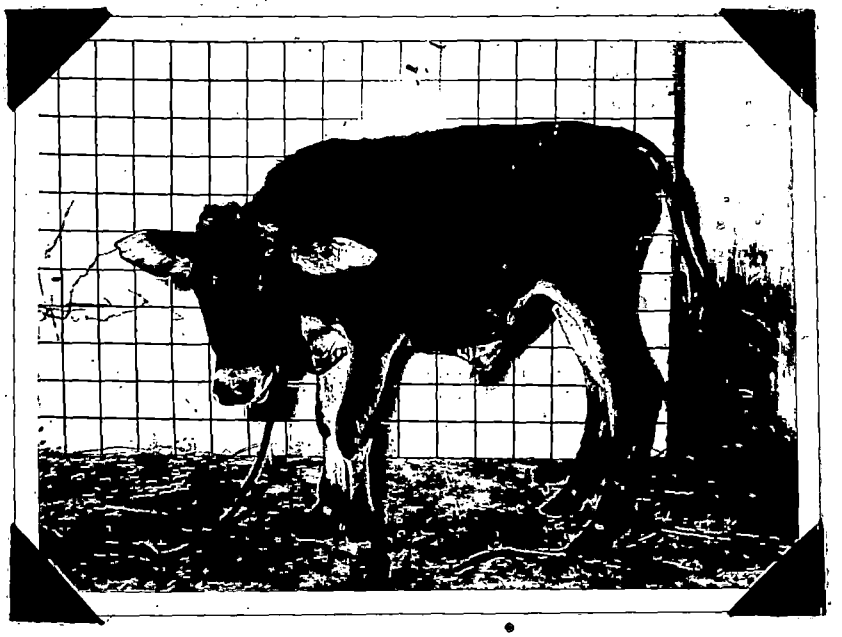
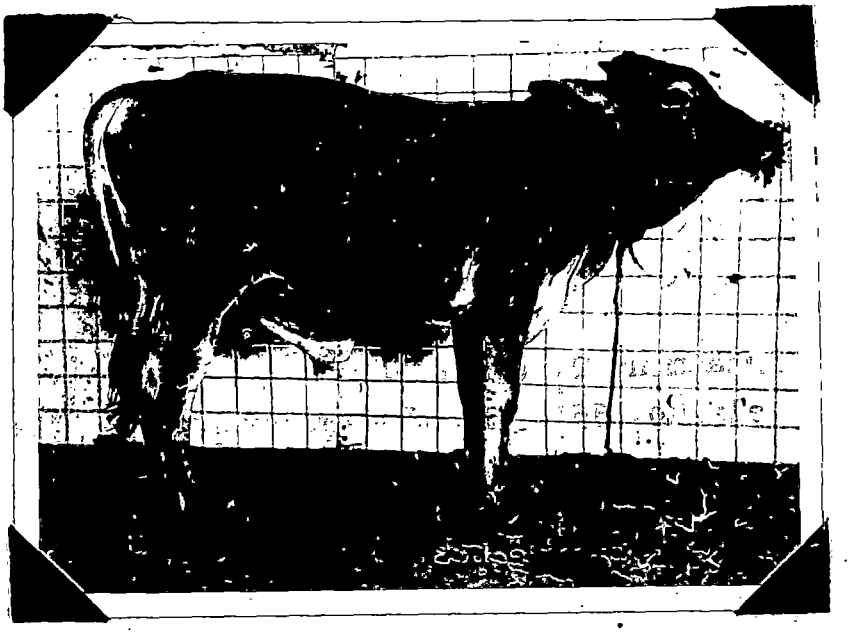


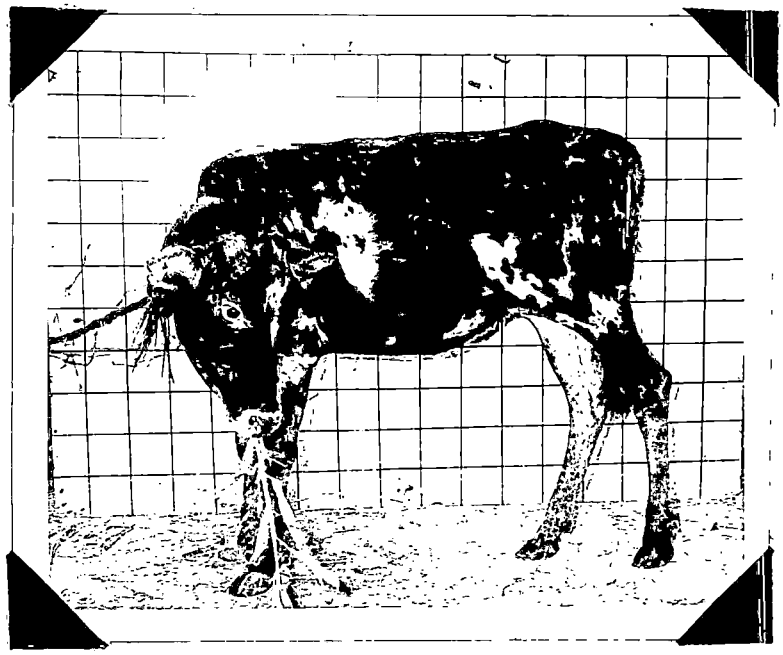

FIG. VI. COST OF FEED PER KILOGRAM BODY WEIGHT GAIN

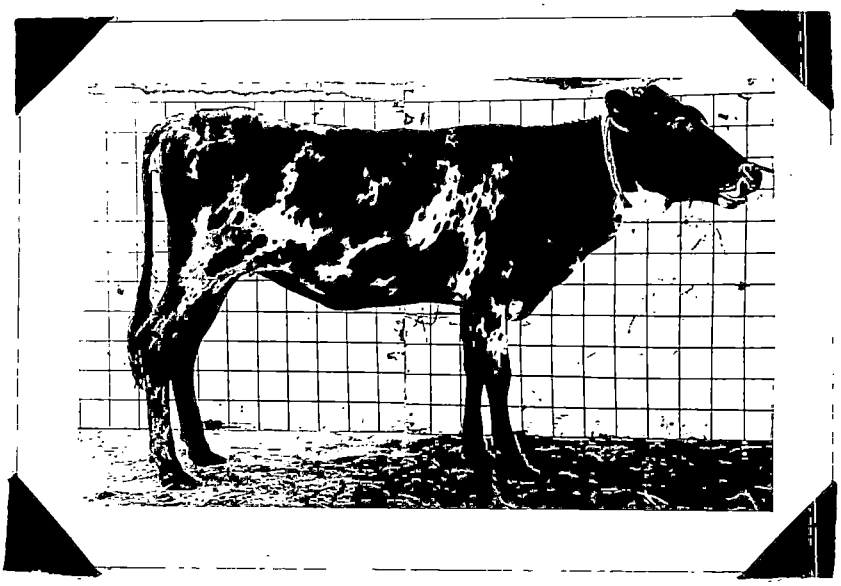


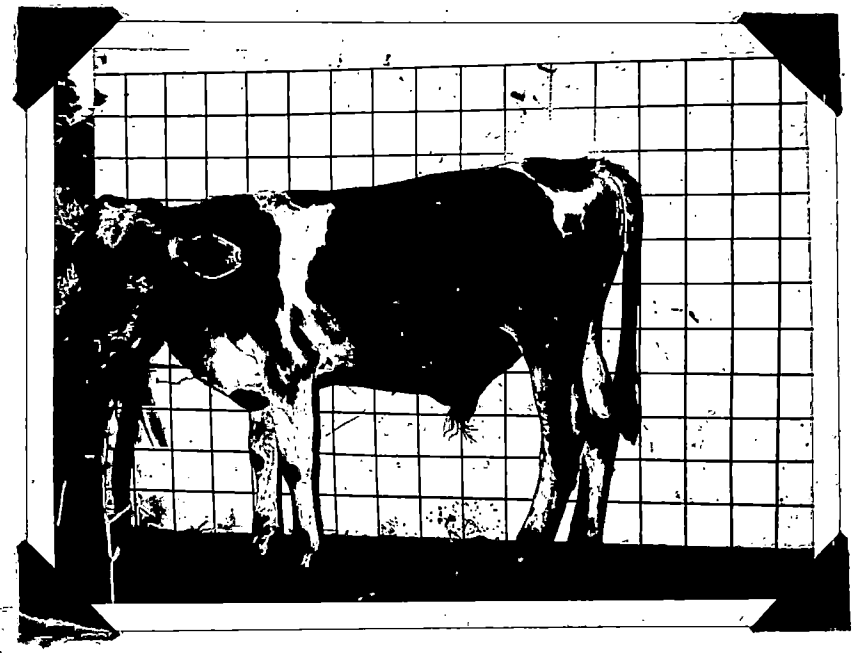


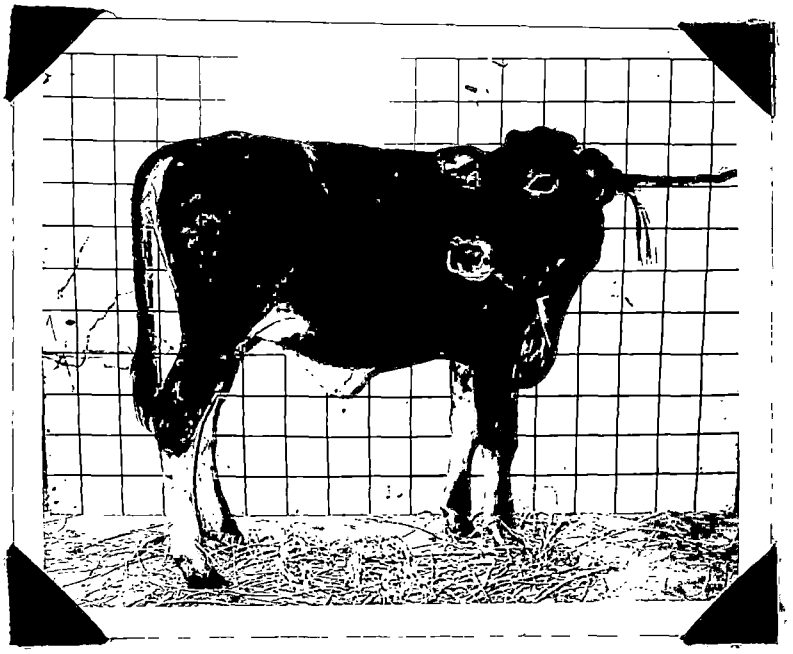


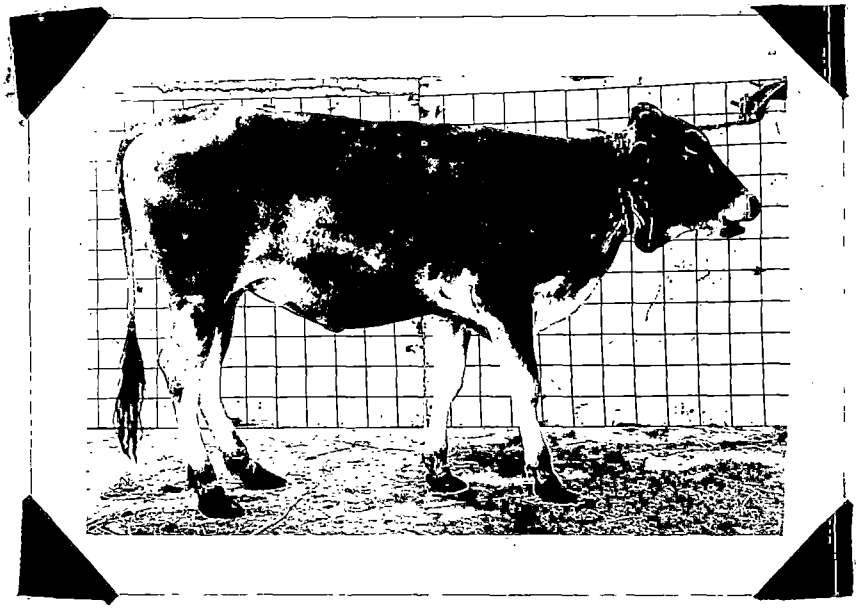


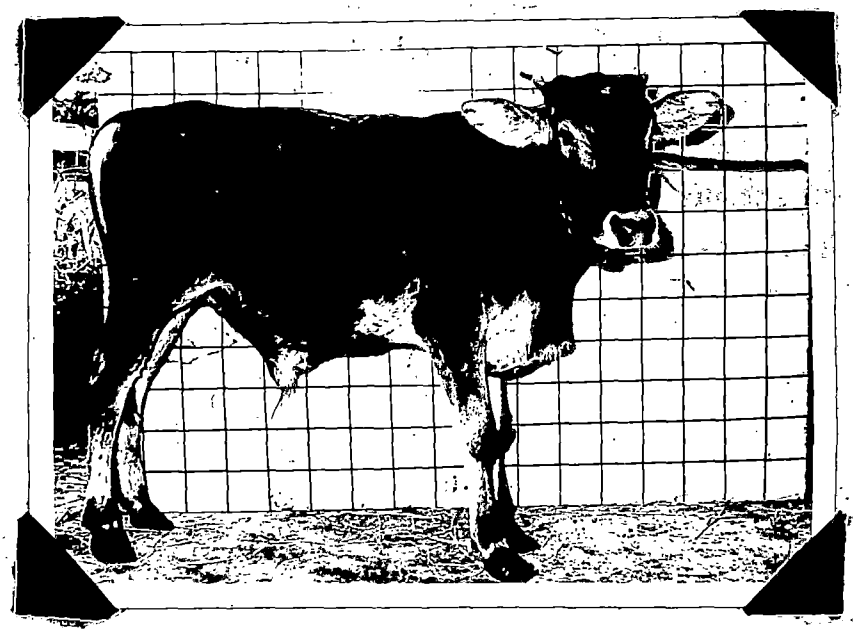


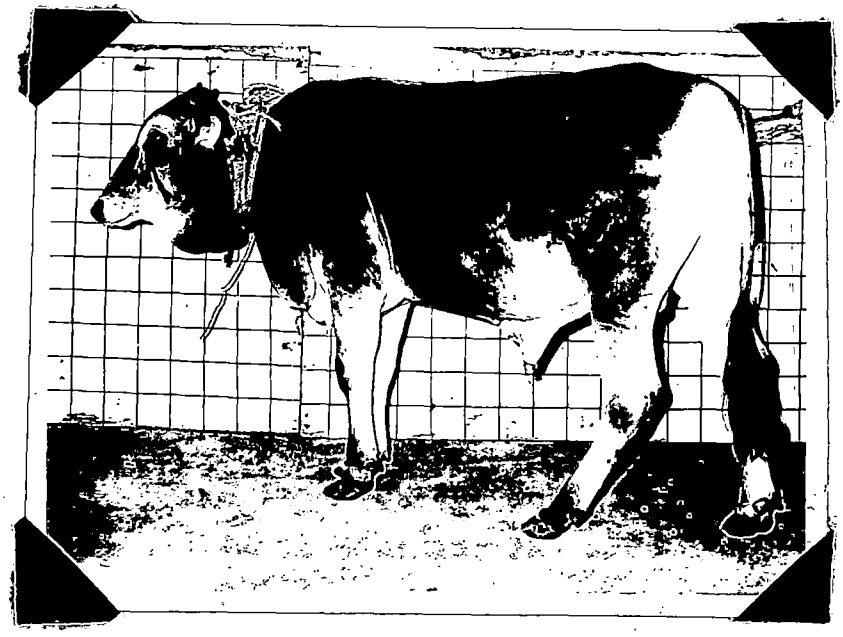












# DISCUSSION

## DISCUSSION

From the chemical composition of the concentrate mixtures presented in Table 2 it can be seen that they are almost identical in respect of the nutritional moities except for crude fibre and nitrogen-free extract and conform to the standards specified by ISI for compounded cattle feeds (ISI, 1968). The higher levels of rubber seed cake used in the mixtures $T_2$ and $T_3$ replacing equal amounts of cotton seed cake of higher fibre content evidently diminishes the crude fibre content of these mixtures. It can be observed that (Table 2) rubber seed cake is fairly rich in crude protein (24.6) and low in crude fibre (2.9). From the point of view of chemical composition it can be considered as a protein supplement comparable to coconut cake. The results also indicate that the hydrocyanic acid content of rubber seed cake used for the study was 8.7 mg/100 g as against the value of 9.5 mg/100 g reported previously (ICAR Report, 1976). Further, the animals receiving rations containing rubber seed cake at both 15 and 30 per cent levels did not exhibit any toxic symptoms during the period of the experiment. This is in agreement with the report of Radeleff (1970) that any plant material containing less than 20 mg of hydrocyanic acid per 100 g is not toxic to animals.

### Growth

From the summarised data presented in Table 3, represented in Fig. 1 and statistically analysed in Table 4, it will be seen

that the animals under treatment $T_3$ showed significantly higher overall weight gains ($P < 0.05$) than those under treatments $T_1$ and $T_2$, the average cumulative weight gains of the three groups during the experimental period of six months being 76 kg each for $T_1$ and $T_2$ and 89 kg for $T_3$. The average daily gains obtained for animals under the dietary treatments $T_1$ and $T_2$ were found to be 422 g each while that for $T_3$ was 494 g. Almost similar values have been obtained by Ranjhan (1977) for Jersey x Haryana cross-bred calves of 3-12 months of age. Average daily gains of 222 g for Sindhi calves of 6-12 months (Bhoreskar,1966), 270 g for Sahiwal (Mudgal, 1965b), 238 g for Tharparkar (Mudgal, 1965a), 420 g for Jersey calves of 6-12 months (Rajagopalan,1974) and 386 g for Sahiwal x Brown Swiss cross-bred calves (Bhatnagar et al. 1966) have been reported. The results obtained during the course of the present study also indicate that irrespective of the treatment differences, males gained significantly more weight than females ($P < 0.01$), the daily gains for males and females being 427 and 409 g for $T_1$, 435 and 405 g for $T_2$ and 543 and 442 g for $T_3$ respectively. The superior performance of male over female calves has been recorded by other workers (Mudgal, 1965b and Brody, 1965).

From the Tables 5-8, Figs. 2-4 and Plates 2-13, it can be seen that animals under the dietary treatment $T_3$ recorded significantly higher height ($P < 0.05$) and girth ($P < 0.01$) as compared to those under treatments $T_1$ and $T_2$. However, there was no significant difference in body length of animals on the three treatments.

Average increase in height, length and girth of the animals under the three treatments, $T_1$, $T_2$ and $T_3$ were found to be 10, 11 and 13 cm; 15, 18 and 20 cm and 21, 22 and 26 cm respectively. Higher body measurements recorded for animals under $T_3$ are commensurate with their increased body weights. Correlation between the increase in body size and mass has already been reported by Brody (1965).

Blood values

From the data presented in Table 9, it is evident that all the animals under the three dietary regimes maintained normal levels of haematological constituents such as RBC, haemoglobin, plasma protein, calcium and inorganic phosphorus suggesting that incorporation of rubber seed cake at 15 and 30 per cent level in the rations of growing calves appears to have no deleterious effect on the physiological well being and nutritional status of the animals.

Digestibilities of nutrients

Data given in Table 10 indicate that while the coefficients of digestibilities of the nutrients were almost similar in respect of treatments $T_1$ and $T_2$ and those for $T_3$, though not significant, were higher. When Red Sindhi calves of 18 months of age were fed on concentrate mixture along with paddy straw, a ration similar to the control ($T_1$) used in the present study,

Gupta and Saha (1977) obtained digestibility coefficients of 48.0, 50.9, 55.4, 65.9, 54.9 and 47.5 per cent for dry matter, organic matter, crude protein, ether extract, crude fibre and nitrogen-free extract respectively. When calculated indirectly, the DCP and TDN values of the three concentrate mixtures $T_1$, $T_2$ and $T_3$ containing rubber seed cake at 0, 15 and 30 per cent levels were found to be 15.5 and 66.7, 15.6 and 71.8 and 16.2 and 73.7 respectively. The markedly higher TDN value of the concentrate mixture $T_3$ may be responsible for the significantly higher weight gains obtained for the animals under the treatment $T_3$. Further it can be seen that with all the three rations the requirements of the animals in terms of DCP and TDN were met as per the standards prescribed by Sen and Ray (1971). The nutritive ratio for the treatments $T_1$, $T_2$ and $T_3$ were found to be 1: 3.3; 3.6 and 3.55 respectively.

Nitrogen and mineral balances

From the results presented in Table 10 it is observed that all animals maintained a positive balance for nitrogen, calcium and phosphorus. Further, there is a progressive increase in the balance of nitrogen in the treatment $T_1$, $T_2$ and $T_3$ respectively as the level of rubber seed cake increased from 0 to 30 per cent in the concentrate rations, the values being 16.5, 17.2 and 19.2 g of nitrogen per day respectively.

Calcium and phosphorus balances also showed almost a

similar trend without having any significant differences among the treatments. The respective values for $T_1$, $T_2$ and $T_3$ for calcium balance were 10.1, 9.7 and 11.2 g per day while those for phosphorus being 6.4, 6.3 and 7.0 g per day respectively.

Histopathological studies

Histopathological examination of internal organs such as liver, thyroid, pancreas, kidney, heart, spleen and adrenal of animals slaughtered at the end of the trial did not reveal any pathological changes suggesting that rubber seed cake can be safely incorporated in the rations of growing calves upto a level of 30 per cent. Garner (1961) has reported that hydrocyanic acid can be detected from muscles and tissues of animals showing symptoms of hydrocyanic acid toxicity. In the present study, muscle and liver tissues of the animals slaughtered were not found to contain any hydrocyanic acid thereby indicating the absence of hydrocyanic acid toxicity.

Feed efficiency and economics

From Table 12 and Figs. 5 and 6, it can be seen that the feed efficiency values expressed in terms of kg concentrate required per unit gain in body weight were found to be 5.05, 4.97 and 4.36 for treatments $T_1$, $T_2$ and $T_3$ respectively, while the respective figures for total ration being 10.85, 10.69 and 9.30. Further, the results presented in Table 12 and Fig. 6 indicate that the cost of ration per unit gain was Rs. 7.36,

Rs. 7.08 and Rs. 6.23, the concentrate alone amounting to Rs. 6.01, Rs.5.77 and Rs.4.99 respectively for the treatments $T_1$, $T_2$ and $T_3$. The differences obtained between the treatments in respect of biological and economic efficiency can be attributed to their difference in body weight gains and to the differences in the cost of rations. It can also be seen that even if the cost of concentrates is assumed to be the same, the treatment $T_3$ stands out as the most efficient ration to promote growth in calves.

From a critical evaluation of the results obtained during the course of the present investigation, it can be concluded that rubber seed cake can beneficially and economically be incorporated at 30 per cent level in the concentrate mixture for growing calves.

# S U M M A R Y

# S U M M A R Y

An investigation spread over a period of six months was carried out to evaluate the feeding value of rubber seed cake, using 24 Jersey x Sindhi cross-bred calves of 8-14 months of age, divided and distributed under three dietary treatments ($T_1$, $T_2$ and $T_3$), the animals on the different treatments being fed concentrate mixtures containing 0, 15 and 30 per cent levels of rubber seed cake respectively. The criteria for evaluation were growth rate, nutriture, digestibility coefficients of nutrients, toxic effects, feed efficiency and economics of rearing.

The salient observations made during the course of the investigation and the inferences drawn from the results obtained are given below:

1. Calves receiving concentrate mixture containing 30 per cent rubber seed cake showed significantly better overall weight gains than those fed mixtures containing 0 and 15 per cent rubber seed cake respectively.

2. Concentrate mixture incorporating rubber seed cake at 30 per cent level, on feeding, brought about significantly higher increase in height, length and girth in calves.

3. The physiological well being of the animals, as adjudged from their haematological values, is not influenced by

feeding rubber seed cake in the concentrate mixture even at a level of 30 per cent.

4. The digestibility coefficients of nutrients were found to be higher in animals receiving concentrate mixture with 30 per cent rubber seed cake.

5. Nitrogen, calcium and phosphorus balances of animals increased progressively as the level of rubber seed cake in the concentrate mixture increased from 0-30 per cent.

6. Rubber seed cake when incorporated at 30 per cent level in concentrate mixture did not exert any toxic effect on the animal, in as much as neither any pathological changes could be detected on histopathological examination of internal organs nor any hydrocyanic acid could be detected in any of the tissues.

7. Animals receiving concentrate mixture containing 30 per cent rubber seed cake had better feed efficiency values than those receiving 15 per cent and 0 per cent rubber seed cake in their concentrate mixture.

8. The cost of ration per kilogram gain was found to be highest in animals receiving the control ration, less in animals receiving 15 per cent rubber seed cake, and least in those receiving 30 per cent rubber seed cake in the concentrate mixture.

# REFERENCES

## REFERENCES


Anon (1929). Production of rubber seed oil. Ind. Eng. Chem. News Edn. Jan. 20 : p. 9 (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 12).

Anon (1948). Oil from rubber seeds. Indian Rubb. J. 115 : 553-554. (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 7).

Anon (1969). Rubber Cultivation Theory and Practice. Rubber Board, Kottayam, Kerala State. pp. 14.

A.O.A.C. (1970). Official Methods of Analysis. Association of Agricultural Chemists, Washington, D.C.

Azeemoddin, G. and Rao, S.D.T. (1962). Rubber seed and oil, Studies on Indian rubber seed oil. Rubb. Bd. Bull. 6 (2) : 67-68. (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 28).

Bhatnagar, D.S., Mudgal, V.D., Razdan, M.N. and Nair, P.G. (1966). Seminar on Animal Breeding. Haringhatta. Dec. 1966. ICAR, New Delhi (Cited by Rajagopalan, 1974).

Bhattacharya, P. (1976). New strategy in Animal Husbandry. Indian Dairyman. 28 (2) : 47-60.

Bhoreskar, M.R., Daniel, S.J. and Mullick, D.N. (1966). The growth rate of Red Sindhi, Sahiwal and Tharparkar female calves maintained under experimental feeding schedule. Indian J. Dairy Sci. 20 : 57.

Bhushan, D. (1958). Rubber seed and its oil. Indian Oil Seeds J. 2 : 35 (Cited by Nadarajah, 1969).

Bredemann, G. (1931). Danger of hydrocyanic acid content of Hevea seed products used for fodder. Tropenflanzer. 34 : 249. (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 32).

British Rubber Development Board (1948). New oil cake from rubber seed. Farmer and Stock Breeder. Dec. 14 (Rubber Research Institute of Malaysia. Bibliography on rubber seed oil. Number 10. Abstr. No. 33).

Brody, S. (1968). Bioenergetics and Growth. Hafner Publishing Co. Inc. New York. pp. 632.

Buvanendran, V. (1971). Effects of rubber seed meal on hatchability of hen's eggs. Trop. Agric. 77 (1&2) : 111-115.

Buvanendran, V. and Siriwardene, J.A. deS. (1970). Rubber seed meal in poultry diets. Ceylon Vet. J. 18 : 33-38.

Dawson, T.R. and Messenger, T.H. (1932). Produce from rubber seed 1. Preparation and properties 2. Application and Economics. R.A.B.R.M. Journal. 1 : 33-53. (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 41).

Ellett, W.B., Holdaway, C.W., Eheart, J.F. and Lasting, L.D. (1930). Feeding Hevea rubber seed meal for milk production. Virginia Agric. Exp. Sta. Tech. Bull. 41 (3) : 12 (Cited by Morrison, 1957).

Encyclopaedia Britannica, Ltd. London (1957). 19 : 602-604.

Farm Information Bureau (1977). Farm Guide. Government of Kerala. pp. 59.

Food and Agricultural Organisation of the U.N. and U.S. Department of Health, Education and Welfare. Food composition taken for use in East Asia (1972). Food Policy and Nutrition Division. FAO of U.N. 00100, Rome, Italy. (Cited by Orok and Bowland, 1974).

Garner, R.J. (1961). Veterinary Toxicology. Bailliere, Tindall and Cox. London. 2nd Ed. pp. 78.

George, J. (1970). Studies on the utilisation of rubber seed cake in swine ration. A dissertation. Submitted to Kerala Veterinary College and Research Institute, Mannuthy.

George, C.D.V., Greenstreet, V.R. and Gunn Lay Teik (1932). Storage of rubber seeds. Malay. Agric. J. 20 : 164-176. (Cited by Nadarajah, 1969).

Gorter, K. (1912). The glucoside of the seed of Hevea brasiliensis. Rec. Tror. Chim. 31 : 264. (Cited by Nair, P.G. 1969 A dissertation submitted to Kerala Veterinary College and Research Institute, Mannuthy).

Gupta, B.N. and Saha, R.C. (1977). Jute (Corchorous olitorius) leaf hay as a partial growth production feed substitute for Sindhi cattle. Indian J. Dairy Sci. 30 : 44-47.

Hattan, G.L. and Owen, F.G. (1970). Efficiency of total collection and chromic oxide techniques in short-term digestion trials. J. Dairy Sci. 53 (3) : 325-329.

Hyder Ali, M. (1970). Studies on the utilization of unconventional feeds/fodders in ruminant rations. M.Sc. Thesis. Submitted to the University of Calicut, Kerala.

I.C.A.R. Report (1971). Annual progress report on "All India Co-ordinated research project for investigation on agricultural by-products and industrial waste materials for evolving economic rations for livestock". Department of Nutrition, College of Veterinary and Animal Sciences, Mannuthy, for the year 1970-71.

I.C.A.R. Report (1972). Annual progress report on 'All India Co-ordinated research project for investigation on agricultural by-products and industrial waste materials for evolving economic rations for livestock'. Department of Nutrition, College of Veterinary and Animal Sciences, Mannuthy, for the year 1971-72.

I.C.A.R. Report (1976). Annual progress report on 'All India Co-ordinated research project for investigation on agricultural by-products and industrial waste materials for evolving economic rations for livestock'. Department of Nutrition, College of Veterinary and Animal Sciences, Mannuthy, for the year 1975-76.

Indian Standards Institute (1968). Indian standard specification for compounded feed for cattle. IS: 2052. 1st Revision. Manak Bhavan, 9, Bahadur Shah, Zafar Marg, New Delhi-6.

Kay, H.D. (1946). Report on Dairy Research, Dairy Education and Dairy Development in India. Government of India, Department of Agriculture, New Delhi. (Cited by Muniyappa M. 1972. Studies on silk cotton seed cake as a component of concentrate ration for milk production. M.Sc. Thesis. submitted to the Calicut University, Kerala).

Lauw Tjin Giok, M.D., Samsudin, M.D., Husaini, B.S. and Ignatius Tar Wotjo, M.S. (1967). Nutritional value of rubber seed protein. Am. J. Clin. Nutr. 20 (2) : 1300-1303.

Medical Research Institute, Ceylon (1950). Indian Rubb. J. 119 : 263. (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 39).

Morrison, F.B. (1957). Feeds and Feeding. The Morrison Publishing Co., Ithaca, New York. 22nd Ed. pp. 501.

Mudgal, V.D. and Ray, S.N. (1965a). Growth studies in Indian breeds of cattle. 1. Studies on growth of Tharparkar cattle. Indian J. Dairy Sci. 18 : 14.

Mudgal, V.D. and Ray, S.N. (1965b). Growth studies in Indian breeds of cattle. II. Studies on growth of Sahiwal cattle. Indian J. Dairy Sci. 18 : 65.

Nadarajah, M. (1969). The collection and utilisation of rubber seed in Ceylon. Rubb. Res. Inst. Ceylon Bull. 4 (3) : 23-32.

Nadarajah, M., Abeysinghe, A., Dayaratne, W.C. and Tharmalingam, R. (1975). The potentialities of rubber seed collection and its utilisation in Sri Lanka. (Rubber Research Institute of Ceylon).

National Academy of Sciences (1971). Rapid population growth. Baltimore, Md, Johns Hopkins Press. 2 Vols. (Cited by Krummel, C. and Dritchilo, 1977. Resource costs of animal protein production. World Animal Review No. 21 : 6-10).

National Commission on Agriculture (1976). Section 2, Chapter 28 Part VII (Animal Husbandry). (Cited in Indian Dairyman. 1976. 28 (9) : 423-432.

Nobori, H. and Takehara, M. (1948). Vegetable oils produced in the tropics VII. Oil of rubber seeds. Chem. Absts. 42 : 6139. (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 78).

Oluyemi, J.A., Fetuga, B.L. and Endely, H.N.L. (1976). The metabolizable energy value of some feed ingredients for young chicks. Poult. Sci. 55 (2) : 611-618.

Orok, E.J. and Bowland, J.B. (1974). Nigerian para rubber seed meal as an energy and protein source for rats fed soyabean meal or peanut meal supplemented diets. Can. J. Anim. Sci. 54 (2) : 239-246.

Orok, E.J. and Bowland, J.P (1974a). Composition of Nigerian yellow corn, sorghum and peanut meal (groundnut cake) with Canadian corn and soybean meal. Can. J. Anim. Sci. 54 : 217-218.

Oser, B.L. (1965). Hawks Physiological Chemistry. Tata McGraw-Hill Publishing Company Ltd. New Delhi. 14th Ed.

Pope, F.T. (1930). Use of rubber seed cake as a feed stuff. Comm. Rep. Sept. 8 : 617. (Rubber Research Institute of Malaysia, 1974. Bibliography on rubber seed oil. Number 10. Abstr. No. 83).

Radeleff, R.D. (1970). Veterinary Toxicology. Lea & Febiger, Philadelphia, pp. 51.

Rajagopalan, T.G. (1974). Study of some aspects of the performance of Jersey cattle. M.Sc. (A.H.) Thesis. Submitted to the Gujarat Agricultural University.

Rajaguru, A.S.B. (1971). Effects of rubber seed meal on the performance of mature chicken. J. National Agri. Soc. of Ceylon. 8: 38-47.

Rajaguru, A.S.B. and Vohra, P. (1975). Rubber seed meal as a potential feed ingredient for poultry. Indian Poult. Rev. 7 (1) : 73-74.

Rajaguru, A.S.B. and Wettimuny, S.G. deS. (1971). Rubber seed meal as a protein supplement in poultry feeding. J. National Agri. Soc. of Ceylon. 8 : 1-12.

Ranga-Rau, D.S. (1975). Report on review of livestock statistics in Asia. Current status and future needs. A regiona study. Food and Agricultural Organisation of the United Nations, Bangkok, Thailand. pp. 3.

Ranjhan, S.K. (1977). Animal Nutrition and Feeding Practices in India. Vikas Publishing Home. Pvt. Ltd. New Delhi. pp.210.

Rubber Research Institute of India (1977). Rubber Board, Kottayam, Kerala State (Personal communication).

Russell, W.S. (1975). The growth of Ayreshire cattle: An analysis of linear body measurements. Anim. Prod. 21 : 217-226.

Sankunny, T.R., Ramakrishnan, A. and Kunjukuttw, N. (1964). Studies on the nutritive value of certain unconventional feeds of special importance to Kerala. 2. Rubber seed and tapioca leaf. Kerala Vet. 3 (2) : 33-37.

Sen, K.C. (1952). Rubber seed kernel as cattle food. Indian Rubb. Bd. Bull. 3 : 36-37.

Sen, K.C. and Ray, S.N. (1971). Nutritive values of Indian Cattle feeds and the Feeding of Animals. Indian Council of Agricultural Research, New Delhi. 6th Ed. pp. 11.

Siqueira, R. de., Pechnik, E. and Guernelli, O. (1955). Investigation in applied biochemistry. Quimica. 9 : 13-19 (Cited by Lauw Tjin Giok et al. 1967).

Siriwardene, J.A. deS. and Nugara, D. (1972). Metabolizable energy of rubber seed meal in poultry diets. Ceylon Vet. J. 20 (3) : 61-63.

Snedecor, G.W. and Cochran, W.G. (1969). Statistical Methods. Oxford and I.B.H. Publishing Co., New Delhi. 6th Ed.

Swenson, M.J. (1970). Dukes Physiology of Domestic Animals. Comstock Publishing Associates. A division of Cornell University Press. Ithaca and London. 8th Ed.

Ulhas, P.H. (1976). Utilization of by-products to meet the feed needs of livestock. Proceedings of the Summer Institute on "Waste Management by Recycling". National Dairy Research Institute. Bombay Part II pp. 57.

Venkatachalar, M.C. (1976). Recycling of fodder waste and other poor quality materials as a nutritious cattle feed. Proceedings of the Summer Institute on "Waste Management by Recycling". National Dairy Research Institute. Bombay Part II. pp. 20.

Varghese, T.V. (1972). Kerala Khadi and Village Industries Board, Trivandrum (Personal communication).

Wright, N.C. (1937). Report on the Development of the Cattle and Dairy Industries in India. Manager of Publications, Delhi. (Cited by Hyder Ali, 1970).

# APPENDICES

APPENDIX I a

Data on fortnightly body weights (Kg) of calves maintained on the experimental rations.

Treatment $T_1$ (Control)

| Animal number | Sex | Age (days) | Fortnights | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 667 | Male | 381 | 108 | 115 | 122 | 133 | 143 | 151 | 157 | 172 | 176 | 186 | 186 | 200 | 211 |
| 551 | " | 283 | 79 | 82 | 84 | 90 | 98 | 100 | 104 | 113 | 120 | 123 | 124 | 132 | 138 |
| 666M | " | 384 | 80 | 84 | 90 | 96 | 105 | 109 | 118 | 127 | 132 | 137 | 141 | 153 | 158 |
| 566 | " | 234 | 74 | 77 | 80 | 84 | 90 | 92 | 102 | 115 | 118 | 120 | 127 | 138 | 142 |
| 664 | Female | 428 | 85 | 88 | 92 | 100 | 105 | 109 | 115 | 125 | 132 | 133 | 135 | 148 | 155 |
| 540 | " | 337 | 83 | 86 | 90 | 98 | 105 | 110 | 117 | 125 | 130 | 134 | 146 | 157 | 162 |
| 533 | " | 368 | 76 | 80 | 83 | 90 | 95 | 100 | 103 | 112 | 117 | 122 | 123 | 131 | 140 |
| 547 | " | 359 | 96 | 100 | 101 | 109 | 121 | 127 | 138 | 144 | 151 | 155 | 162 | 172 | 178 |
| Mean ± SE | | 347 ± 21.2 | 85 ±4.4 | 89 ±4.4 | 92 ±6.5 | 100 ±5.4 | 108 ±5.3 | 112 ±7.2 | 119 ± 7.4 | 129 ± 7.5 | 135 ± 5.6 | 139 ± 7.2 | 143 ± 7.7 | 155 ± 4.2 | 161 ± 7.2 |

APPENDIX I b

Treatment $T_2$ (15% Rubber seed cake)

| Animal number | Sex | Age (days) | Fortnights | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 670* | Male | 225 | 84 | 84 | 84 | 91 | 100 | Died on 4-11-1976 | | | | | | | |
| 555 | " | 279 | 83 | 85 | 86 | 96 | 106 | 111 | 122 | 133 | 139 | 145 | 156 | 165 | 174 |
| 659 | " | 404 | 88 | 92 | 93 | 102 | 112 | 114 | 123 | 132 | 140 | 143 | 146 | 151 | 156 |
| 663 | " | 394 | 85 | 91 | 94 | 102 | 111 | 115 | 124 | 139 | 144 | 145 | 162 | 166 | 166 |
| 527 | Female | 409 | 89 | 96 | 96 | 103 | 112 | 117 | 123 | 131 | 140 | 142 | 150 | 156 | 157 |
| 537 | " | 355 | 86 | 92 | 94 | 100 | 109 | 115 | 122 | 132 | 140 | 141 | 146 | 157 | 160 |
| 541 | " | 304 | 82 | 88 | 88 | 91 | 103 | 113 | 116 | 125 | 133 | 135 | 141 | 150 | 160 |
| 518 | " | 442 | 82 | 85 | 90 | 96 | 104 | 107 | 116 | 126 | 132 | 133 | 138 | 145 | 154 |
| Mean ± SE** | | 359 ± 20.4 | 85 ± 1.1 | 90 ± 1.4 | 92 ± 3.4 | 99 ± 3.4 | 108 ± 2.7 | 113 ± 2.6 | 121 ± 2.0 | 131 ±3.1 | 138 ±4.0 | 141 ±4.1 | 148 ±5.6 | 156 ±2.5 | 161 ±2.6 |

* Died on 4-11-1976.
** Average of seven animals only.

APPENDIX I c

Treatment $T_3$ (30% Rubber seed cake)

| Animal number | Sex | Age (days) | Fortnights | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 668 | Male | 366 | 102 | 110 | 120 | 136 | 141 | 150 | 159 | 175 | 187 | 197 | 206 | 218 | 223 |
| 535 | " | 366 | 95 | 100 | 102 | 110 | 118 | 123 | 140 | 146 | 151 | 163 | 170 | 181 | 187 |
| 565 | " | 235 | 73 | 78 | 80 | 89 | 100 | 106 | 117 | 130 | 139 | 145 | 156 | 166 | 176 |
| 553 | " | 275 | 76 | 76 | 79 | 89 | 98 | 101 | 110 | 121 | 130 | 134 | 146 | 150 | 151 |
| 666F | Female | 406 | 80 | 84 | 85 | 90 | 95 | 103 | 112 | 118 | 129 | 135 | 141 | 141 | 146 |
| 544 | " | 354 | 84 | 88 | 90 | 97 | 106 | 113 | 118 | 129 | 137 | 141 | 143 | 150 | 158 |
| 669 | " | 384 | 74 | 77 | 78 | 82 | 89 | 99 | 110 | 112 | 123 | 127 | 137 | 138 | 147 |
| 672 | " | 333 | 95 | 98 | 98 | 109 | 119 | 126 | 135 | 146 | 158 | 165 | 180 | 184 | 200 |
| Mean ± SE | | 340 ± 20.1 | 85 ± 3.5 | 89 ± 4.1 | 91 ± 6.3 | 100 ± 6.8 | 108 ± 6.6 | 115 ± 6.5 | 125 ± 6.6 | 135 ± 6.1 | 144 ± 8.0 | 151 ± 7.8 | 160 ± 8.1 | 166 ± 9.6 | 174 ± 8.6 |

APPENDIX II a

Data on linear body measurements of calves maintained on the experimental rations.

Treatment $T_1$ (Control)

| Animal number | Initial | | | At 3rd month | | | At 6th month | | |
|---|---|---|---|---|---|---|---|---|---|
| | Height (cm) | Length (cm) | Girth (cm) | Height (cm) | Length (cm) | Girth (cm) | Height (cm) | Length (cm) | Girth (cm) |
| 667 | 96 | 105 | 119 | 101 | 114 | 130 | 107 | 123 | 142 |
| 666M | 86 | 93 | 105 | 95 | 96 | 118 | 99 | 110 | 125 |
| 566 | 85 | 90 | 103 | 91 | 97 | 114 | 96 | 108 | 122 |
| 551 | 87 | 88 | 108 | 94 | 97 | 115 | 97 | 105 | 124 |
| 664 | 88 | 99 | 111 | 93 | 106 | 123 | 98 | 109 | 130 |
| 533 | 86 | 90 | 105 | 87 | 101 | 115 | 92 | 108 | 123 |
| 547 | 97 | 98 | 112 | 98 | 104 | 129 | 102 | 109 | 137 |
| 540 | 96 | 93 | 110 | 97 | 100 | 122 | 106 | 106 | 135 |
| Mean ± SE | 90 ± 2.6 | 95 ± 3.1 | 109 ± 2.7 | 95 ± 3.3 | 102 ± 1.0 | 121 ± 1.9 | 100 ± 2.7 | 110 ± 2.0 | 130 ± 1.5 |

APPENDIX II b

Treatment $T_2$ (15% Rubber seed cake)

| Animal number | Initial | | | At 3rd month | | | At 6th month | | |
|---|---|---|---|---|---|---|---|---|---|
| | Height (cm) | Length (cm) | Girth (cm) | Height (cm) | Length (cm) | Girth (cm) | Height (cm) | Length (cm) | Girth (cm) |
| 537 | 90 | 96 | 113 | 96 | 100 | 129 | 100 | 109 | 132 |
| 527 | 95 | 98 | 108 | 102 | 104 | 119 | 105 | 114 | 129 |
| 541 | 92 | 98 | 108 | 99 | 105 | 119 | 103 | 115 | 128 |
| 518 | 90 | 94 | 104 | 92 | 99 | 115 | 97 | 108 | 125 |
| 659 | 91 | 94 | 108 | 97 | 105 | 126 | 100 | 111 | 133 |
| 663 | 89 | 91 | 109 | 94 | 101 | 120 | 99 | 112 | 131 |
| 670* | 87 | 91 | 106 | Died on 4-11-1976 | | | | | |
| 555 | 85 | 95 | 103 | 95 | 109 | 116 | 100 | 121 | 131 |
| Mean ± SE** | 90 ± 3.2 | 95 ± 2.3 | 108 ± 3.7 | 96 ± 3.9 | 103 ± 3.4 | 121 ± 3.7 | 101 ± 3.7 | 113 ± 1.6 | 130 ± 2.3 |

* Died on 4-11-1976.
** Average of seven calves only.

APPENDIX II c

Treatment $T_3$ (30% Rubber seed cake)

| Animal number | Initial | | | At 3rd month | | | At 6th month | | |
|---|---|---|---|---|---|---|---|---|---|
| | Height (cm) | Length (cm) | Girth (cm) | Height (cm) | Length (cm) | Girth (cm) | Height (cm) | Length (cm) | Girth (cm) |
| 668 | 93 | 100 | 115 | 103 | 101 | 133 | 110 | 128 | 147 |
| 565 | 90 | 89 | 103 | 100 | 101 | 121 | 107 | 114 | 135 |
| 535 | 93 | 96 | 110 | 102 | 108 | 125 | 105 | 113 | 136 |
| 553 | 88 | 93 | 103 | 93 | 105 | 117 | 100 | 111 | 128 |
| 672 | 92 | 97 | 110 | 97 | 103 | 126 | 103 | 119 | 139 |
| 669 | 88 | 85 | 105 | 97 | 103 | 126 | 98 | 104 | 131 |
| 666F | 85 | 98 | 103 | 89 | 102 | 116 | 95 | 110 | 123 |
| 544 | 86 | 94 | 105 | 91 | 106 | 118 | 98 | 110 | 128 |
| Mean ± SE | 89 ± 3.3 | 94 ± 1.8 | 107 ± 2.3 | 96 ± 4.1 | 104 ± 4.2 | 122 ± 5.5 | 102 ± 1.8 | 114 ± 2.4 | 133 ± 4.6 |

APPENDIX III a (i)

Haematological values of the calves maintained on the experimental rations.

Initial values

Treatment $T_1$

| Animal number | RBC mill/ $mm^3$ | Haemaglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 667 | 6.97 | 8.6 | 9.2 | 11.9 | 7.3 |
| 551 | 7.11 | 9.0 | 8.4 | 12.9 | 9.2 |
| 666M | 8.47 | 9.4 | 8.4 | 12.9 | 7.4 |
| 566 | 8.10 | 9.0 | 7.6 | 13.9 | 7.8 |
| 664 | 8.78 | 9.6 | 8.8 | 11.9 | 7.7 |
| 540 | 9.05 | 9.2 | 8.8 | 12.1 | 7.2 |
| 533 | 8.22 | 8.8 | 8.0 | 10.3 | 8.0 |
| 547 | 7.92 | 8.4 | 8.0 | 13.1 | 7.4 |
| Mean ± SE | 8.08 ± 0.6 | 9.0 ± 0.1 | 8.4 ± 0.2 | 12.4 ± 0.2 | 7.8 ± 0.2 |

APPENDIX III a (ii)

Treatment $T_2$ (15% Rubber seed cake)

| Animal number | RBC mill/mm$^3$ | Haemaglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 670 | 6.14 | 7.4 | 8.0 | 12.1 | 7.7 |
| 555 | 8.04 | 8.2 | 9.6 | 12.7 | 7.7 |
| 659 | 6.75 | 9.2 | 11.2 | 12.1 | 6.4 |
| 663 | 5.76 | 8.0 | 8.8 | 12.9 | 9.6 |
| 527 | 6.87 | 9.0 | 9.2 | 13.3 | 7.2 |
| 537 | 8.33 | 8.2 | 8.8 | 13.1 | 7.3 |
| 541 | 10.17 | 8.2 | 8.4 | 13.1 | 7.7 |
| 518 | 7.86 | 8.0 | 8.0 | 12.7 | 8.0 |
| Mean ± SE | 7.68 ± 0.4 | 8.4 ± 0.5 | 9.1 ± 0.3 | 12.8 ± 0.4 | 7.7 ± 0.3 |

APPENDIX III a (iii)

Treatment $T_3$ (30% Rubber seed cake)

| Animal number | RBC mill/$mm^3$ | Haemaglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 668 | 8.56 | 8.6 | 10.0 | 11.9 | 8.3 |
| 535 | 7.15 | 9.0 | 9.6 | 11.3 | 7.4 |
| 565 | 8.67 | 8.6 | 8.8 | 12.3 | 6.9 |
| 553 | 7.19 | 7.6 | 8.8 | 13.9 | 10.9 |
| 666F | 5.35 | 7.4 | 8.4 | 11.9 | 6.9 |
| 544 | 6.18 | 7.2 | 10.0 | 13.3 | 4.2 |
| 669 | 9.14 | 9.6 | 8.4 | 12.1 | 6.9 |
| 672 | 7.35 | 8.2 | 8.4 | 12.7 | 8.0 |
| Mean ± SE | 7.44 ± 0.5 | 8.3 ± 0.2 | 9.1 ± 0.3 | 12.4 ± 0.4 | 7.4 ± 0.8 |

APPENDIX III b (i)

At 3rd month

Treatment $T_1$ (Control)

| Animal number | RBC mill/mm$^3$ | Haemaglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 667 | 8.19 | 9.8 | 10.2 | 12.5 | 5.5 |
| 551 | 6.41 | 9.8 | 10.7 | 12.8 | 6.4 |
| 666M | 9.50 | 10.4 | 8.4 | 12.6 | 8.0 |
| 566 | 8.36 | 10.6 | 8.9 | 12.2 | 8.3 |
| 664 | 7.93 | 10.6 | 10.7 | 12.4 | 8.7 |
| 540 | 8.58 | 9.8 | 9.8 | 12.6 | 7.4 |
| 533 | 7.08 | 10.2 | 10.2 | 12.5 | 7.2 |
| 547 | 7.88 | 10.0 | 9.8 | 14.3 | 7.5 |
| Mean ± SE | 7.99 ± 0.3 | 10.2 ± 0.4 | 9.8 ± 0.4 | 12.7 ± 0.4 | 7.4 ± 0.3 |

APPENDIX III b (ii)

Treatment $T_2$ (15% Rubber seed cake)

| Animal number | RBC mill/mm$^3$ | Haemoglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 670* | | | | | |
| 555 | 5.80 | 9.8 | 9.8 | 11.2 | 8.0 |
| 659 | 5.73 | 11.8 | 8.9 | 12.0 | 7.5 |
| 663 | 6.99 | 10.0 | 9.8 | 12.4 | 9.0 |
| 527 | 7.74 | 11.8 | 11.1 | 13.0 | 7.0 |
| 537 | 7.86 | 9.8 | 9.3 | 11.4 | 7.4 |
| 541 | 6.66 | 8.4 | 10.2 | 11.0 | 8.0 |
| 518 | 8.12 | 10.0 | 9.3 | 11.8 | 7.5 |
| Mean ± SE | 6.98 ± 0.4 | 9.9 ± 1.1 | 9.5 ± 1.0 | 11.8 ± 0.4 | 7.8 ± 0.1 |

* Died on 4-11-1976.

APPENDIX III b (iii)

Treatment $T_3$ (30% Rubber seed cake)

| Animal number | RBC mill/$mm^3$ | Haemoglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 668 | 6.69 | 10.0 | 10.2 | 12.5 | 8.6 |
| 535 | 7.55 | 10.0 | 9.8 | 12.4 | 6.7 |
| 565 | 8.19 | 10.4 | 9.8 | 13.6 | 8.8 |
| 553 | 6.60 | 10.4 | 11.1 | 12.8 | 7.0 |
| 666F | 6.24 | 9.2 | 10.2 | 12.6 | 6.1 |
| 544 | 6.96 | 9.6 | 10.7 | 12.9 | 7.2 |
| 669 | 7.76 | 10.0 | 9.3 | 12.8 | 8.0 |
| 672 | 8.01 | 9.8 | 9.3 | 12.4 | 8.3 |
| Mean ± SE | 7.30 ± 0.2 | 9.9 ± 0.3 | 10.05 ± 0.2 | 12.8 ± 0.4 | 7.6 ± 0.3 |

APPENDIX III c (i)

At 6th month

Treatment $T_1$ (Control)

| Animal number | RBC mill/mm$^3$ | Haemoglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 667 | 7.61 | 9.4 | 8.9 | 10.4 | 8.1 |
| 551 | 7.45 | 8.8 | 8.2 | 10.4 | 7.5 |
| 666M | 7.29 | 8.6 | 8.5 | 11.2 | 7.3 |
| 566 | 8.34 | 10.4 | 7.4 | 9.0 | 7.5 |
| 664 | 7.68 | 10.4 | 8.9 | 10.5 | 8.0 |
| 540 | 8.02 | 7.6 | 8.9 | 9.6 | 8.7 |
| 533 | 8.66 | 8.0 | 8.5 | 11.0 | 7.4 |
| 547 | 7.94 | 10.4 | 8.2 | 11.0 | 7.6 |
| Mean ± SE | 7.87 ± 0.2 | 9.2 ± 0.4 | 8.4 ± 0.3 | 10.4 ± 0.2 | 7.7 ± 0.4 |

APPENDIX III c (ii)

Treatment $T_2$ (15% Rubber seed cake)

| Animal number | RBC mill/mm$^3$ | Haemoglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 555 | 6.32 | 7.8 | 7.8 | 11.2 | 8.2 |
| 659 | 7.03 | 9.8 | 8.5 | 10.6 | 7.1 |
| 663 | 7.29 | 10.2 | 9.6 | 11.0 | 7.9 |
| 527 | 7.79 | 7.6 | 8.5 | 11.8 | 6.2 |
| 537 | 7.98 | 9.6 | 8.9 | 12.2 | 7.1 |
| 541 | 8.22 | 10.6 | 8.2 | 10.8 | 7.7 |
| 518 | 8.25 | 11.4 | 8.2 | 11.2 | 8.1 |
| Mean ± SE | 7.60 ± 0.2 | 9.6 ± 0.4 | 8.5 ± 0.4 | 11.3 ± 0.3 | 7.8 ± 0.3 |

APPENDIX III c (iii)

Treatment $T_3$ (30% Rubber seed cake)

| Animal number | RBC mill/$mm^3$ | Haemoglobin g/100 ml of blood | Plasma protein g/100 ml | Plasma calcium mg/100 ml | Plasma inorganic phosphorous mg/100 ml |
|---|---|---|---|---|---|
| 668 | 7.28 | 8.2 | 9.3 | 11.4 | 8.2 |
| 535 | 6.18 | 7.6 | 7.8 | 10.4 | 7.8 |
| 565 | 8.18 | 8.2 | 8.2 | 10.4 | 8.2 |
| 553 | 6.63 | 8.8 | 8.2 | 10.2 | 8.0 |
| 666F | 6.38 | 8.8 | 8.8 | 11.6 | 8.2 |
| 544 | 6.79 | 7.8 | 9.8 | 9.8 | 6.6 |
| 669 | 8.07 | 10.8 | 9.3 | 11.8 | 7.5 |
| 672 | 6.68 | 9.0 | 8.5 | 11.2 | 8.5 |
| Mean ± SE | 7.02 ± 0.3 | 8.7 ± 0.1 | 8.7 ± 0.4 | 10.9 ± 0.3 | 7.9 ± 0.4 |

APPENDIX IV a

Percentage chemical composition of dung collected during the metabolism trial.

Treatment $T_1$

| Nutritional moiety | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 667 | 551 | 666M | 566 | 664 | 540 | 533 | 547 |
| Dry matter | 21.0 | 23.2 | 22.2 | 22.1 | 22.8 | 23.7 | 22.6 | 21.9 |
| Organic matter | 81.4 | 81.1 | 81.6 | 82.5 | 81.6 | 81.2 | 82.1 | 82.1 |
| Crude protein | 9.6 | 10.8 | 11.6 | 11.1 | 12.5 | 10.4 | 12.8 | 11.4 |
| Ether extract | 2.5 | 1.7 | 2.8 | 1.9 | 2.6 | 3.3 | 2.9 | 3.2 |
| Crude fibre | 21.4 | 17.4 | 17.6 | 19.6 | 19.1 | 16.1 | 18.9 | 17.3 |
| N.F.E. | 47.9 | 51.2 | 49.6 | 49.9 | 47.4 | 51.4 | 47.5 | 51.2 |
| Total ash | 18.6 | 18.9 | 18.4 | 17.5 | 18.4 | 18.8 | 17.9 | 17.9 |
| Acid insoluble ash | 14.4 | 14.3 | 14.0 | 14.8 | 14.2 | 13.7 | 13.8 | 13.9 |
| Calcium | 0.76 | 0.68 | 0.72 | 0.88 | 0.81 | 0.76 | 0.78 | 0.98 |
| Phosphorous | 0.55 | 0.55 | 0.74 | 0.74 | 0.68 | 0.61 | 0.79 | 0.78 |

APPENDIX IV b

Treatment $T_2$ (15% Rubber seed cake)

| Nutritional moiety | Animal number | | | | | | |
|---|---|---|---|---|---|---|---|
| | 555 | 659 | 663 | 527 | 537 | 541 | 518 |
| Dry matter | 20.2 | 23.3 | 23.3 | 24.0 | 24.9 | 21.6 | 25.8 |
| Organic matter | 82.5 | 81.1 | 81.1 | 81.0 | 81.2 | 80.5 | 80.4 |
| Crude protein | 10.4 | 12.9 | 12.2 | 13.0 | 12.4 | 11.0 | 12.3 |
| Ether extract | 1.7 | 2.0 | 2.2 | 2.3 | 3.3 | 2.0 | 2.5 |
| Crude fibre | 15.8 | 17.5 | 19.3 | 17.2 | 17.3 | 19.2 | 20.2 |
| N.F.E. | 54.6 | 58.7 | 47.4 | 48.5 | 48.2 | 48.3 | 45.4 |
| Total ash | 17.5 | 18.9 | 18.9 | 19.0 | 18.8 | 19.5 | 19.6 |
| Acid insoluble ash | 14.1 | 14.3 | 15.1 | 14.2 | 14.2 | 15.8 | 14.7 |
| Calcium | 0.50 | 0.68 | 0.78 | 0.92 | 0.91 | 0.88 | 1.02 |
| Phosphorous | 0.42 | 0.56 | 0.44 | 0.91 | 0.89 | 0.67 | 0.82 |

APPENDIX IV c

Treatment $T_3$ (30% Rubber seed cake)

| Nutritional moiety | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 668 | 535 | 565 | 553 | 666F | 544 | 669 | 672 |
| Dry matter | 23.5 | 21.9 | 21.3 | 23.9 | 23.1 | 25.8 | 22.9 | 22.2 |
| Organic matter | 82.4 | 81.0 | 80.6 | 81.8 | 81.9 | 81.9 | 80.3 | 82.3 |
| Crude protein | 13.0 | 11.3 | 11.0 | 13.6 | 10.6 | 11.1 | 12.2 | 10.5 |
| Ether extract | 2.3 | 2.2 | 3.1 | 2.6 | 3.2 | 2.4 | 2.2 | 2.9 |
| Crude fibre | 17.5 | 14.4 | 14.9 | 13.9 | 14.7 | 15.9 | 15.0 | 15.0 |
| N.F.E. | 49.6 | 53.1 | 51.6 | 51.7 | 53.4 | 52.5 | 51.1 | 53.9 |
| Total ash | 17.6 | 19.0 | 19.4 | 18.2 | 18.1 | 18.1 | 19.7 | 17.7 |
| Acid insoluble ash | 13.9 | 14.4 | 14.7 | 14.3 | 14.9 | 12.7 | 14.6 | 14.0 |
| Calcium | 1.10 | 0.67 | 0.78 | 0.97 | 1.18 | 1.25 | 1.19 | 0.77 |
| Phosphorous | 0.59 | 0.58 | 0.64 | 0.34 | 0.81 | 0.89 | 0.77 | 0.61 |

APPENDIX V a

Digestibility coefficients of the nutrients in the three experimental rations.

Treatment $T_1$ (Control)

Dry matter

| | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 667 | 551 | 666M | 566 | 664 | 540 | 533 | 547 |
| Intake from concentrate | g | 2514 | 2057 | 2285 | 2057 | 2285 | 2285 | 2057 | 2285 |
| Intake from paddy straw | g | 3283 | 2720 | 2626 | 2533 | 2251 | 2157 | 2345 | 2814 |
| Total intake | g | 5797 | 4777 | 4911 | 4590 | 4536 | 4442 | 4402 | 5099 |
| Outgo in dung | g | 3185 | 2786 | 2474 | 1814 | 2224 | 2533 | 2192 | 2224 |
| Digested | g | 2612 | 1991 | 2437 | 2750 | 2312 | 1909 | 2210 | 2875 |
| Digestibility coefficient | | 45.0 | 41.6 | 49.6 | 59.9 | 50.9 | 42.9 | 50.2 | 56.3 |
| Mean ± SE | | | | | 49.6 ± 2.1 | | | | |

Organic matter

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 2275 | 1862 | 2068 | 1862 | 2068 | 2068 | 1862 | 2068 |
| Intake from paddy straw | g | 2761 | 2288 | 2208 | 2130 | 1893 | 1814 | 1972 | 2366 |
| Total intake | g | 5036 | 4150 | 4276 | 3992 | 3961 | 3882 | 3834 | 4434 |
| Outgo in dung | g | 2593 | 2259 | 2019 | 1518 | 1815 | 2057 | 1800 | 1824 |
| Digested | g | 2443 | 1891 | 2257 | 2474 | 2146 | 2056 | 2034 | 2610 |
| Digestibility coefficient | | 48.5 | 45.5 | 52.8 | 61.9 | 54.1 | 52.9 | 53.0 | 58.8 |
| Mean ± SE | | | | | 53.4 ± 2.0 | | | | |

(Contd.....)

APPENDIX V a (Contd.)

Crude protein

| | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 667 | 551 | 666M | 566 | 664 | 540 | 533 | 547 |
| Intake from concentrate | g | 563 | 461 | 512 | 461 | 512 | 512 | 461 | 512 |
| Intake from paddy straw | g | 128 | 106 | 102 | 99 | 88 | 85 | 90 | 110 |
| Total intake | g | 691 | 567 | 614 | 560 | 600 | 597 | 517 | 622 |
| Outgo in dung | g | 308 | 251 | 287 | 205 | 278 | 265 | 281 | 254 |
| Digested | g | 383 | 316 | 427 | 355 | 322 | 332 | 270 | 368 |
| Digestibility coefficient | | 55.4 | 55.7 | 69.5 | 63.4 | 53.7 | 55.6 | 49.0 | 59.1 |
| Mean ± SE | | | | | 57.7 ± 2.1 | | | | |

Ether extract

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 188 | 154 | 171 | 154 | 171 | 171 | 154 | 171 |
| Intake from paddy straw | g | 60 | 51 | 49 | 47 | 42 | 41 | 43 | 51 |
| Total intake | g | 248 | 205 | 220 | 201 | 213 | 212 | 197 | 222 |
| Outgo in dung | g | 81 | 47 | 66 | 44 | 57 | 83 | 63 | 70 |
| Digested | g | 167 | 158 | 154 | 157 | 156 | 129 | 134 | 152 |
| Digestibility coefficient | | 67.3 | 77.1 | 70.0 | 78.1 | 73.0 | 60.8 | 68.0 | 68.5 |
| Mean ± SE | | | | | 70.4 ± 1.7 | | | | |

(Contd.....)

APPENDIX V a (Contd.)

Crude fibre

| | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 667 | 551 | 666M | 566 | 664 | 540 | 533 | 547 |
| Intake from concentrate | g | 422 | 346 | 384 | 346 | 384 | 384 | 346 | 384 |
| Intake from paddy straw | g | 1024 | 849 | 819 | 790 | 702 | 673 | 732 | 878 |
| Total intake | g | 1446 | 1195 | 1203 | 1136 | 1086 | 1057 | 1078 | 1262 |
| Outgo in dung | g | 682 | 485 | 435 | 361 | 425 | 408 | 414 | 384 |
| Digested | g | 764 | 710 | 768 | 775 | 661 | 649 | 664 | 878 |
| Digestibility coefficient | | 52.8 | 59.4 | 63.8 | 68.2 | 60.8 | 61.4 | 61.5 | 69.5 |
| Mean ± SE | | | | | 62.2 ± 1.7 | | | | |

Nitrogen-free extract

| | | 667 | 551 | 666M | 566 | 664 | 540 | 533 | 547 |
|---|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 1101 | 901 | 1001 | 901 | 1001 | 1001 | 901 | 1001 |
| Intake from paddy straw | g | 1546 | 1281 | 1237 | 1193 | 1060 | 1016 | 1104 | 1325 |
| Total intake | g | 2647 | 2182 | 2238 | 2094 | 2061 | 2017 | 2005 | 2326 |
| Outgo in dung | g | 1526 | 1426 | 1227 | 918 | 1054 | 1301 | 1041 | 1138 |
| Digested | g | 1121 | 756 | 1011 | 1176 | 1007 | 716 | 964 | 1188 |
| Digestibility coefficient | | 42.3 | 34.6 | 45.2 | 56.1 | 48.8 | 35.4 | 48.0 | 51.0 |
| Mean ± SE | | | | | 53.4 ± 2.0 | | | | |

(Concl.)

APPENDIX V b

Treatment $T_2$ (15% Rubber seed cake)

Dry matter

| | | Animal number | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 555 | 659 | 663 | 527 | 537 | 541 | 518 |
| Intake from concentrate | g | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 |
| Intake from paddy straw | g | 2626 | 2814 | 2814 | 2814 | 2814 | 2814 | 2345 |
| Total intake | g | 4926 | 5114 | 5114 | 5114 | 5114 | 5114 | 4625 |
| Outgo in dung | g | 2771 | 2313 | 3006 | 2282 | 2195 | 2630 | 1961 |
| Digested | g | 2155 | 2801 | 2108 | 2832 | 2919 | 2484 | 2684 |
| Digestibility coefficient | | 43.7 | 54.7 | 41.2 | 55.3 | 57.0 | 48.5 | 57.8 |
| Mean ± SE | | | | | 51.2 ± 2.4 | | | |

Organic matter

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 2084 | 2084 | 2084 | 2084 | 2084 | 2084 | 2084 |
| Intake from paddy straw | g | 2208 | 2367 | 2367 | 2367 | 2367 | 2367 | 1972 |
| Total intake | g | 4292 | 4451 | 4451 | 4451 | 4451 | 4451 | 4056 |
| Outgo in dung | g | 2286 | 1876 | 2438 | 1848 | 1782 | 2117 | 1577 |
| Digested | g | 2006 | 2575 | 2013 | 2603 | 2669 | 2334 | 2479 |
| Digestibility coefficient | | 46.7 | 57.8 | 45.2 | 58.4 | 59.9 | 52.4 | 61.1 |
| Mean ± SE | | | | | 54.5 ± 2.5 | | | |

(Contd....)

APPENDIX V b (Contd.)

## Crude protein

| | | Animal number | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 555 | 659 | 663 | 527 | 537 | 541 | 518 |
| Intake from concentrate | g | 534 | 534 | 534 | 534 | 534 | 534 | 534 |
| Intake from paddy straw | g | 99 | 106 | 106 | 106 | 106 | 106 | 91 |
| Total intake | g | 633 | 640 | 640 | 640 | 640 | 640 | 625 |
| Outgo in dung | g | 289 | 298 | 306 | 247 | 271 | 291 | 243 |
| Digested | g | 344 | 342 | 334 | 393 | 369 | 349 | 382 |
| Digestibility coefficient | | 54.3 | 53.4 | 52.2 | 61.4 | 57.7 | 54.5 | 59.7 |
| Mean ± SE | | | | | 56.2 ± 1.1 | | | |

## Ether extract

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 190 | 190 | 190 | 190 | 190 | 190 | 190 |
| Intake from paddy straw | g | 47 | 51 | 51 | 51 | 51 | 51 | 44 |
| Total intake | g | 237 | 241 | 241 | 241 | 241 | 241 | 234 |
| Outgo in dung | g | 48 | 45 | 66 | 51 | 72 | 53 | 48 |
| Digested | g | 189 | 196 | 175 | 190 | 169 | 188 | 186 |
| Digestibility coefficient | | 79.7 | 81.3 | 72.6 | 78.8 | 70.1 | 78.0 | 79.5 |
| Mean ± SE | | | | | 77.1 ± 1.9 | | | |

(Contd.....)

APPENDIX V b (Contd.)

Crude fibre

| | | Animal number | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 555 | 659 | 663 | 527 | 537 | 541 | 518 |
| Intake from concentrate | g | 260 | 260 | 260 | 260 | 260 | 260 | 260 |
| Intake from paddy straw | g | 819 | 878 | 878 | 878 | 878 | 878 | 732 |
| Total intake | g | 1079 | 1138 | 1138 | 1138 | 1138 | 1138 | 992 |
| Outgo in dung | g | 438 | 405 | 580 | 393 | 380 | 505 | 396 |
| Digested | g | 641 | 733 | 558 | 745 | 758 | 633 | 596 |
| Digestibility coefficient | | 59.4 | 64.4 | 49.0 | 65.4 | 66.6 | 55.6 | 60.1 |
| Mean ± SE | | 60.1 ± 2.2 | | | | | | |

Nitrogen-free extract

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 1102 | 1102 | 1102 | 1102 | 1102 | 1102 | 1102 |
| Intake from paddy straw | g | 1237 | 1325 | 1325 | 1325 | 1325 | 1325 | 1104 |
| Total intake | g | 2339 | 2427 | 2427 | 2427 | 2427 | 2427 | 2206 |
| Outgo in dung | g | 1513 | 1126 | 1425 | 1107 | 1058 | 1270 | 890 |
| Digested | g | 826 | 1301 | 1002 | 1320 | 1369 | 1157 | 1316 |
| Digestibility coefficient | | 35.3 | 53.6 | 41.2 | 54.3 | 56.4 | 47.6 | 59.7 |
| Mean ± SE | | 49.7 ± 3.4 | | | | | | |

(Concl.)

APPENDIX V c

Treatment $T_3$ (30% Rubber seed cake)

Dry matter

| | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 668 | 535 | 565 | 553 | 666F | 544 | 669 | 672 |
| Intake from concentrate | g | 2514 | 2285 | 2285 | 2285 | 2285 | 2285 | 2285 | 2285 |
| Intake from paddy straw | g | 3283 | 2814 | 2814 | 2814 | 2345 | 2345 | 2814 | 2814 |
| Total intake | g | 5797 | 5099 | 5099 | 5099 | 4630 | 4630 | 5099 | 5099 |
| Outgo in dung | g | 2286 | 2921 | 2399 | 1877 | 2072 | 1988 | 1882 | 2768 |
| Digested | g | 3511 | 2178 | 2700 | 3222 | 2558 | 2642 | 3217 | 2331 |
| Digestibility coefficient | | 60.6 | 42.7 | 53.0 | 63.1 | 55.2 | 57.1 | 63.1 | 45.7 |
| Mean ± SE | | | | | | 55.1 ± 2.6 | | | |

Organic matter

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 2300 | 2091 | 2091 | 2091 | 2091 | 2091 | 2091 | 2091 |
| Intake from paddy straw | g | 2761 | 2367 | 2367 | 2367 | 2367 | 2367 | 2367 | 1972 |
| Total intake | g | 5061 | 4458 | 4458 | 4458 | 4458 | 4458 | 4458 | 4063 |
| Outgo in dung | g | 1884 | 2366 | 1934 | 1555 | 1697 | 1628 | 1511 | 2278 |
| Digested | g | 3177 | 2092 | 2524 | 2923 | 2761 | 2830 | 2947 | 1785 |
| Digestibility coefficient | | 62.8 | 46.9 | 56.6 | 65.6 | 61.9 | 63.5 | 66.1 | 43.9 |
| Mean ± SE | | | | | | 48.4 ± 3.1 | | | |

(Contd.....)

APPENDIX V c (Contd.)

## Crude protein

| | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 668 | 535 | 565 | 553 | 666F | 544 | 669 | 672 |
| Intake from concentrate | g | 568 | 516 | 516 | 516 | 516 | 516 | 516 | 516 |
| Intake from paddy straw | g | 128 | 110 | 110 | 110 | 91 | 91 | 110 | 110 |
| Total intake | g | 696 | 626 | 626 | 626 | 607 | 607 | 686 | 626 |
| Outgo in dung | g | 295 | 331 | 264 | 256 | 219 | 221 | 224 | 292 |
| Digested | g | 401 | 295 | 362 | 370 | 388 | 386 | 462 | 334 |
| Digestibility coefficient | | 57.6 | 47.1 | 57.8 | 59.1 | 63.9 | 63.6 | 67.3 | 53.4 |
| Mean ± SE | | | | | 58.7 ± 2.4 | | | | |

## Ether extract

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 158 | 143 | 143 | 143 | 143 | 143 | 143 | 143 |
| Intake from paddy straw | g | 61 | 52 | 52 | 52 | 44 | 44 | 52 | 52 |
| Total intake | g | 219 | 195 | 195 | 195 | 187 | 187 | 195 | 195 |
| Outgo in dung | g | 53 | 64 | 75 | 48 | 67 | 48 | 38 | 78 |
| Digested | g | 166 | 131 | 120 | 147 | 120 | 139 | 157 | 117 |
| Digestibility coefficient | | 75.8 | 67.2 | 61.5 | 75.4 | 64.2 | 74.3 | 80.5 | 60.0 |
| Mean ± SE | | | | | 69.9 ± 2.5 | | | | |

(Contd.....)

APPENDIX V c (Contd.)

## Crude fibre

| | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 668 | 535 | 565 | 553 | 666F | 544 | 669 | 672 |
| Intake from concentrate | g | 171 | 155 | 155 | 155 | 155 | 155 | 155 | 155 |
| Intake from paddy straw | g | 1024 | 878 | 878 | 878 | 732 | 732 | 878 | 878 |
| Total intake | g | 1195 | 1033 | 1033 | 1033 | 887 | 887 | 1033 | 1033 |
| Outgo in dung | g | 400 | 421 | 357 | 261 | 305 | 316 | 288 | 415 |
| Digested | g | 795 | 612 | 676 | 772 | 582 | 571 | 751 | 618 |
| Digestibility coefficient | | 66.5 | 59.2 | 65.4 | 74.7 | 65.6 | 64.4 | 72.7 | 59.8 |
| Mean ± SE | | | | | 66.0 ± 2.1 | | | | |

## Nitrogen-free extract

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Intake from concentrate | g | 1403 | 1275 | 1275 | 1275 | 1275 | 1275 | 1275 | 1275 |
| Intake from paddy straw | g | 1546 | 1325 | 1325 | 1325 | 1104 | 1104 | 1325 | 1325 |
| Total intake | g | 2949 | 2500 | 2500 | 2500 | 2379 | 2379 | 2500 | 2500 |
| Outgo in dung | g | 1134 | 1551 | 1239 | 970 | 1106 | 1044 | 962 | 1492 |
| Digested | g | 1815 | 949 | 1261 | 1530 | 1273 | 1335 | 1538 | 1008 |
| Digestibility coefficient | | 61.5 | 38.0 | 50.4 | 61.2 | 53.5 | 56.1 | 61.5 | 40.3 |
| Mean ± SE | | | | | 52.8 ± 3.9 | | | | |

(Concl.)

APPENDIX VI

Data on intake of digestible crude protein and total digestible nutrients.

| $T_1$ | | | $T_2$ | | | $T_3$ | | |
|---|---|---|---|---|---|---|---|---|
| Animal number | DCP (g) | TDN (g) | Animal number | DCP (g) | TDN (g) | Animal number | DCP (g) | TDN (g) |
| 667 | 383 | 2645 | 555 | 344 | 2236 | 668 | 401 | 3385 |
| 551 | 316 | 2138 | 659 | 342 | 2817 | 535 | 295 | 2151 |
| 666M | 427 | 2553 | 663 | 334 | 2287 | 565 | 362 | 2569 |
| 566 | 355 | 2659 | 527 | 393 | 2836 | 553 | 370 | 3003 |
| 664 | 322 | 2341 | 537 | 369 | 2876 | 666F | 388 | 2513 |
| 540 | 332 | 1987 | 541 | 349 | 2562 | 669 | 462 | 3104 |
| 533 | 270 | 2200 | 518 | 382 | 2713 | 544 | 386 | 2605 |
| 547 | 368 | 2776 | - | - | - | 672 | 334 | 2223 |
| Mean ± SE | 347±15.8 | 2412±102.6 | | 359±8.5 | 2625±104.6 | | 375±16.6 | 2694±153. |

APPENDIX VII a

Nitrogen balance g/day

Treatment $T_1$ (Control)

| Nitrogen (g) | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 667 | 551 | 666M | 566 | 664 | 540 | 533 | 547 |
| Intake from concentrate | 90.1 | 73.8 | 81.9 | 73.8 | 81.9 | 81.9 | 73.8 | 81.9 |
| Intake from paddy straw | 20.3 | 17.0 | 16.3 | 15.8 | 14.1 | 13.6 | 14.4 | 17.3 |
| Total intake | 110.4 | 90.8 | 98.2 | 89.6 | 96.0 | 95.5 | 88.2 | 99.2 |
| Outgo in dung | 49.1 | 40.2 | 45.9 | 32.8 | 44.5 | 42.4 | 45.0 | 40.6 |
| Outgo in urine | 44.6 | 37.4 | 37.8 | 40.6 | 36.8 | 27.4 | 30.5 | 40.4 |
| Total outgo | 93.7 | 77.6 | 83.7 | 73.4 | 81.3 | 69.8 | 75.5 | 81.0 |
| Balance | 16.7 | 13.2 | 14.5 | 16.2 | 14.7 | 25.7 | 12.7 | 18.2 |
| Mean ± SE | | | | 16.5 ± 1.4 | | | | |

APPENDIX VII b

Treatment $T_2$ (15% Rubber seed cake)

| Nitrogen (g) | Animal number | | | | | | |
|---|---|---|---|---|---|---|---|
| | 555 | 659 | 663 | 527 | 537 | 541 | 518 |
| Intake from concentrate | 85.4 | 85.4 | 85.4 | 85.4 | 85.4 | 85.4 | 85.4 |
| Intake from paddy straw | 15.8 | 17.0 | 17.0 | 17.0 | 17.0 | 17.0 | 14.6 |
| Total intake | 101.2 | 102.4 | 102.4 | 102.4 | 102.4 | 102.4 | 100.0 |
| Outgo in dung | 46.2 | 47.7 | 48.6 | 39.5 | 43.4 | 46.6 | 38.9 |
| Outgo in urine | 40.6 | 43.6 | 45.6 | 38.5 | 36.1 | 36.6 | 40.8 |
| Total outgo | 86.8 | 91.3 | 94.2 | 78.0 | 79.5 | 83.2 | 79.7 |
| Balance | 14.4 | 11.1 | 8.2 | 24.4 | 22.9 | 19.2 | 20.3 |
| Mean ± SE | | | | 17.2 ± 2.3 | | | |

APPENDIX VII c

Treatment $T_3$ (30% Rubber seed cake)

| Nitrogen (g) | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 668 | 535 | 565 | 553 | 666F | 544 | 669 | 672 |
| Intake from concentrate | 90.9 | 82.6 | 82.6 | 82.6 | 82.6 | 82.6 | 82.6 | 82.6 |
| Intake from paddy straw | 20.5 | 17.6 | 17.6 | 17.6 | 14.7 | 14.6 | 17.6 | 17.6 |
| Total intake | 111.4 | 100.2 | 100.2 | 100.2 | 97.2 | 97.2 | 100.2 | 100.2 |
| Outgo in dung | 47.2 | 53.0 | 42.0 | 41.0 | 35.0 | 35.4 | 35.8 | 46.7 |
| Outgo in urine | 49.4 | 32.2 | 44.9 | 48.6 | 32.9 | 35.4 | 38.9 | 34.6 |
| Total outgo | 96.6 | 86.2 | 87.1 | 89.6 | 67.9 | 70.8 | 74.7 | 81.3 |
| Balance | 14.8 | 14.0 | 13.1 | 10.6 | 29.3 | 26.4 | 26.5 | 18.9 |
| Mean ± SE | 19.2 ± 2.6 | | | | | | | |

## APPENDIX VIII a

### Mineral balance g/day

### Treatment $T_1$ (Control)

| Calcium | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 667 | 551 | 666M | 566 | 664 | 540 | 533 | 547 |
| Intake from concentrate | g | 18.1 | 14.8 | 16.5 | 14.8 | 16.5 | 16.5 | 14.8 | 16.5 |
| Intake from paddy straw | g | 20.7 | 17.1 | 16.5 | 16.0 | 16.4 | 13.6 | 14.8 | 17.7 |
| Total intake | g | 38.8 | 31.9 | 33.0 | 30.8 | 32.9 | 30.1 | 29.6 | 34.2 |
| Outgo in dung | g | 24.2 | 18.9 | 17.8 | 16.2 | 18.0 | 19.3 | 17.1 | 21.8 |
| Outgo in urine | g | 5.2 | 2.7 | 4.8 | 3.6 | 3.2 | 2.3 | 2.9 | 2.3 |
| Total outgo | g | 29.4 | 21.6 | 22.6 | 19.8 | 21.2 | 21.6 | 20.0 | 24.1 |
| Balance | g | 9.4 | 10.3 | 10.4 | 11.0 | 11.7 | 8.5 | 9.6 | 10.1 |
| Mean ± SE | | | | | 10.1 ± 0.4 | | | | |
| Phosphorous | | | | | | | | | |
| Intake from concentrate | g | 23.9 | 19.5 | 21.7 | 19.5 | 21.7 | 21.7 | 19.5 | 21.7 |
| Intake from paddy straw | g | 5.9 | 4.9 | 4.7 | 4.6 | 4.1 | 3.9 | 4.2 | 5.1 |
| Total intake | g | 29.8 | 24.4 | 26.4 | 24.1 | 25.8 | 25.6 | 23.7 | 26.8 |
| Outgo in dung | g | 17.5 | 15.3 | 18.3 | 13.6 | 15.1 | 15.5 | 17.3 | 17.3 |
| Outgo in urine | g | 6.3 | 2.0 | 3.7 | 5.8 | 3.2 | 0.9 | 1.3 | 2.6 |
| Total outgo | g | 23.8 | 17.3 | 22.0 | 19.4 | 18.3 | 16.4 | 18.6 | 19.9 |
| Balance | g | 6.0 | 7.1 | 4.4 | 4.7 | 7.5 | 9.2 | 5.1 | 6.9 |
| Mean ± SE | | | | | 6.4 ± 0.5 | | | | |

APPENDIX VIII b

Treatment $T_2$ (15% Rubber seed cake)

| Calcium | | Animal number | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 555 | 659 | 663 | 527 | 537 | 541 | 518 |
| Intake from concentrate | g | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 |
| Intake from paddy straw | g | 16.5 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 14.8 |
| Total intake | g | 29.8 | 35.0 | 35.0 | 35.0 | 35.0 | 35.0 | 32.1 |
| Outgo in dung | g | 13.9 | 15.7 | 23.4 | 21.2 | 20.0 | 21.0 | 20.0 |
| Outgo in urine | g | 10.3 | 6.8 | 6.0 | 2.1 | 2.5 | 3.1 | 2.9 |
| Total outgo | g | 24.2 | 22.5 | 29.4 | 23.3 | 22.5 | 24.1 | 22.9 |
| Balance | g | 5.6 | 12.5 | 5.6 | 11.7 | 12.5 | 10.9 | 9.2 |
| Mean ± SE | | 9.7 ± 1.2 | | | | | | |
| Phosphorous | | | | | | | | |
| Intake from concentrate | g | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 |
| Intake from paddy straw | g | 4.7 | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 | 4.2 |
| Total intake | g | 26.3 | 26.7 | 26.7 | 26.7 | 26.7 | 26.7 | 25.8 |
| Outgo in dung | g | 11.6 | 13.0 | 13.2 | 20.8 | 19.5 | 17.6 | 17.3 |
| Outgo in urine | g | 8.8 | 2.9 | 4.4 | 1.4 | 1.9 | 2.7 | 1.8 |
| Total outgo | g | 20.4 | 15.9 | 17.6 | 22.2 | 21.4 | 20.3 | 19.1 |
| Balance | g | 5.9 | 10.8 | 9.1 | 4.5 | 5.3 | 6.4 | 6.7 |
| Mean ± SE | | 6.3 ± 0.6 | | | | | | |

## APPENDIX VIII c

### Treatment $T_3$ (30% Rubber seed cake)

| Calcium | | Animal number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 668 | 535 | 565 | 553 | 666F | 544 | 669 | 672 |
| Intake from concentrate | g | 20.6 | 18.7 | 18.7 | 18.7 | 18.7 | 18.7 | 18.7 | 18.7 |
| Intake from paddy straw | g | 20.7 | 17.7 | 17.7 | 17.7 | 14.8 | 14.8 | 17.7 | 17.7 |
| Total intake | g | 41.3 | 36.4 | 36.4 | 36.4 | 33.5 | 33.5 | 36.4 | 36.4 |
| Outgo in dung | g | 25.1 | 19.6 | 18.7 | 18.2 | 25.1 | 24.9 | 22.3 | 21.3 |
| Outgo in urine | g | 3.4 | 5.0 | 3.1 | 5.8 | 1.0 | 2.2 | 3.3 | 2.0 |
| Total outgo | g | 28.5 | 24.6 | 21.8 | 23.6 | 26.1 | 27.1 | 25.6 | 23.3 |
| Balance | g | 12.8 | 11.8 | 14.6 | 12.8 | 7.4 | 6.4 | 10.8 | 13.1 |
| Mean ± SE | | | | | 11.2 ± 1.0 | | | | |
| Phosphorous | | | | | | | | | |
| Intake from concentrate | g | 21.9 | 19.9 | 19.9 | 19.9 | 19.9 | 19.9 | 19.9 | 19.9 |
| Intake from paddy straw | g | 5.9 | 5.1 | 5.1 | 5.1 | 4.2 | 4.2 | 5.1 | 5.1 |
| Total intake | g | 27.8 | 25.0 | 25.0 | 25.0 | 24.1 | 24.1 | 25.0 | 25.0 |
| Outgo in dung | g | 13.5 | 16.9 | 10.4 | 6.4 | 16.8 | 17.7 | 14.5 | 16.9 |
| Outgo in urine | g | 7.5 | 3.2 | 4.9 | 8.6 | 2.1 | 1.1 | 3.3 | 2.0 |
| Total outgo | g | 20.0 | 20.1 | 15.3 | 15.0 | 18.9 | 18.8 | 17.8 | 18.9 |
| Balance | g | 7.8 | 4.9 | 9.7 | 10.0 | 5.2 | 5.3 | 7.2 | 6.1 |
| Mean ± SE | | | | | 7.0 ± 0.8 | | | | |

APPENDIX IX a

Data on feed consumption, efficiency and economy.

Treatment $T_1$ (Control)

| Animal number | Total feed intake | | Total weight gain (kg) | Feed efficiency (kg conc./kg gain) | Cost of concentrate for raising a year old calf for a period of six months (Rs) | Cost of concentrate per kg gain (Rs) | Cost of concentrate for 100 kg gain (Rs) |
|---|---|---|---|---|---|---|---|
| | Concentrate mixture (kg) | Paddy straw (kg) | | | | | |
| 667 | 437 | 532 | 103 | 4.24 | 519.29 | 5.04 | 501.00 |
| 551 | 371 | 442 | 59 | 6.28 | 440.86 | 7.47 | 747.00 |
| 666M | 378 | 439 | 78 | 4.84 | 449.18 | 5.76 | 576.00 |
| 566 | 371 | 437 | 68 | 5.45 | 440.86 | 6.48 | 648.00 |
| 664 | 378 | 403 | 70 | 5.40 | 449.18 | 6.42 | 642.00 |
| 540 | 378 | 437 | 79 | 4.78 | 449.18 | 5.69 | 569.00 |
| 533 | 371 | 407 | 64 | 5.79 | 440.86 | 6.89 | 689.00 |
| 547 | 389 | 437 | 82 | 4.74 | 462.25 | 5.64 | 564.00 |
| Average | 384 | 441 | 76 | 5.05 | 456.46 | 6.01 | 601.00 |

APPENDIX IX b

Treatment $T_2$ (15% Rubber seed cake)

| Animal number | Total feed intake | | Total weight gain | Feed efficiency (kg conc./kg gain) | Cost of concentrate for raising a year old calf for a period of six months | Cost of concentrate per kg gain | Cost of concentrate for 100 kg gain |
|---|---|---|---|---|---|---|---|
| | Concentrate mixture | Paddy straw | | | | | |
| | (kg) | (kg) | (kg) | | (Rs) | (Rs) | (Rs) |
| 555 | 378 | 440 | 91 | 4.15 | 437.88 | 4.81 | 481.00 |
| 659 | 378 | 440 | 68 | 5.55 | 437.88 | 6.44 | 644.00 |
| 663 | 378 | 441 | 81 | 4.66 | 437.88 | 5.41 | 541.00 |
| 527 | 378 | 436 | 68 | 5.55 | 437.88 | 6.44 | 644.00 |
| 537 | 378 | 441 | 74 | 5.10 | 437.88 | 5.92 | 592.00 |
| 541 | 378 | 443 | 78 | 4.84 | 437.88 | 5.61 | 561.00 |
| 518 | 378 | 401 | 72 | 5.25 | 437.88 | 6.08 | 608.00 |
| Average | 378 | 435 | 76 | 4.97 | 437.88 | 5.77 | 577.00 |

APPENDIX IX c

Treatment $T_3$ (30% Rubber seed cake)

| Animal number | Total feed intake | | Total weight gain | Feed efficiency (kg conc./kg gain) | Cost of concentrate for raising a year old calf for a period of six months | Cost of concentrate per kg gain | Cost of concentrate for 100 kg gain |
|---|---|---|---|---|---|---|---|
| | Concentrate mixture | Paddy straw | | | | | |
| | (kg) | (kg) | (kg) | | (Rs) | (Rs) | (Rs) |
| 668 | 437 | 432 | 121 | 3.61 | 446.61 | 4.32 | 432.00 |
| 535 | 389 | 440 | 92 | 4.23 | 433.98 | 5.19 | 519.00 |
| 565 | 378 | 436 | 103 | 3.67 | 433.98 | 4.66 | 466.00 |
| 553 | 378 | 436 | 75 | 5.04 | 433.98 | 5.86 | 586.00 |
| 666F | 378 | 403 | 66 | 5.73 | 433.98 | 7.11 | 711.00 |
| 544 | 378 | 400 | 72 | 5.25 | 433.98 | 6.57 | 657.00 |
| 669 | 378 | 437 | 73 | 5.18 | 433.98 | 6.77 | 677.00 |
| 672 | 389 | 533 | 105 | 3.70 | 446.61 | 5.02 | 502.00 |
| Average | 388 | 440 | 89 | 4.36 | 445.46 | 4.99 | 499.00 |

# EVALUATION OF FEEDING VALUE OF RUBBER SEED CAKE FOR PROMOTING GROWTH IN CALVES

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ABSTRACT OF A THESIS
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# ABSTRACT

A detailed investigation was carried out to assess the value of rubber seed cake as an ingredient in the concentrate mixture of calves to study the growth rate, nutriture, feed efficiency and economics of rearing. Twenty four, Jersey x Sindhi cross-bred calves of 8-14 months of age belonging to the University Livestock Farm, Mannuthy were divided into three equal groups and distributed under three dietary treatments, $T_1$, $T_2$ and $T_3$, the animals being fed concentrate mixtures containing 0, 15 and 30 per cent levels of rubber seed cake respectively for a period of six months. Paddy straw served as the sole roughage. Rubber seed cake at 30 per cent level promoted better weight gains, body size and feed efficiency. Incorporation of rubber seed cake in the concentrate mixture improved the digestibility coefficients of nutrients as also the balance of nitrogen, calcium and phosphorus in the animals. Animals fed rubber seed cake maintained perfect health as evidenced from their haematological values and were free from any toxic effect as adjudged from the histopathological examination of the internal organs and their carcass quality.

The cost of feed was found to be 14 per cent lower for kg body weight gain when rubber seed cake was incorporated at 30 per cent level in the concentrate mixture of growing calves. The overall results obtained during the course of the present investigation indicate that rubber seed cake can be incorporated in the concentrate mixture for growing calves at 30 per cent level to achieve both biological and economic efficiency.