GROWTH AND CARCASS CHARACTERISTICS OF PIGS MAINTAINED ON RATIONS CONTAINING DIFFERENT LEVELS OF DRIED TAPIOCA CHIPS

BY

SASIKALA DEVI, K. A.

THESIS

Submitted in partial fulfilment of the
requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Animal Nutrition
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy - Trichur

1981

DECLARATION

I hereby declare that this thesis entitled "GROWTH AND CARCASS CHARACTERISTICS OF PIGS MAINTAINED ON RATIONS CONTAINING DIFFERENT LEVELS OF DRIED TAPIOCA CHIPS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Mannuthy, Signature of the candidate: Sasikala Devi

31-7-1981. Name of the candidate: SASIKALA DEVI, K.A.

CERTIFICATE

Certified that this thesis, entitled "GROWTH AND CARCASS CHARACTERISTICS OF PIGS MAINTAINED ON RATIONS CONTAINING DIFFERENT LEVELS OF DRIED TAPIOCA CHIPS" is a record of research work done independently by Smt. Sasikala Devi, K.A. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Name of the Guide: Dr.C.T.Thomas
(Chairman, Advisory Board)

Mannuthy,

Designation: Associate Professor of Animal Nutrition

31-7-1981.

ACKNOWLEDGEMENT

I feel pleasure in expressing my sincere gratitude to :

Dr.C.T.Thomas, Associate Professor, Department of Animal Nutrition, Major advisor and Chairman of the Advisory Committee, for his valuable guidance and persistent encouragement throughout the course of the study.

Dr.R.Sivaraman, Professor and Head of the Department of Animal Nutrition for his timely advice and generous help in the execution of the present project.

Dr.C.K.Thomas, Professor of Farms and Dr. (Mrs) N.Kunjikutty, Associate Professor, Department of Animal Nutrition, members of the Advisory Committee, for their continous help and valuable suggestions in completing the present study and presentation of this thesis.

Dr.P.G.Nair, former Dean and Dr.M.Krishnan Nair, Dean, Faculty of Veterinary and Animal Sciences, for providing the necessary facilities to undertake the study.

Staff of the Department of Animal Nutrition for their persistent encouragement and help in carrying out the study.

Dr.M.Soman, Associate Professor, and all staff of the Department of Veterinary Public Health for their timely help and co-operation rendered during the period of the investigation.

Dr.P.U.Surendran, Professor and Smt.S.C.Ammamma, Junior Assistant Professor, Department of Statistics for their valuable suggestions and help in the statistical analysis of the results.

Dr.P.C.Saseendran, Assistant Professor, University Pig Breeding Farm, Mannuthy, for his generous help in the implementation of the present project.

Sri.T.K.Prabhakaran, for the pains taken in typing the manuscript.

Kerala Agricultural University for providing financial assistance in the form of fellowship.

Sasikala Devi, K.A.

DEDICATED TO MY LOVING PARENTS

TABLE OF CONTENTS

INTRODUCTION

INTRODUCTION

The food problem of any country is undoubtedly of very great importance in her national development and the animal industry plays a very significant role in solving this vital problem. In India, the per capita availability of animal proteins is only about 1/10th to 1/5th of that available in countries which are agriculturally and industrially well developed. This deficiency is mainly due to the low productivity of milk, meat, eggs and other animal products of our live-stock. It is well known that animal proteins rank high from the stand point of utilisation in the human body. Production of foods of animal origin is gaining more importance at present due to the fact that protein deficiency is one of the most common nutritional disorders observed among the people in India. The development of pig industry offers great possibilities and has great potentialities in this regard.

Pigs stand second to beef cattle in the production of meat. Of the world total meat production of 95 million metric tonnes in 1969-70, pork formed 35.3 per cent as against 41.0 per cent and 15.2 per cent respectively by beef and chicken (Borgstrom, 1973). The total production of pork in India was estimated to be 53,000 tonnes in 1973 and pork constituted 7.4 per cent of the total meat production during the three years from 1971 to 1973. (National Commission Report, 1976). The annual contribution in the form of pork and pork products to the national economy, on a conservative basis, can be placed at more than Rs.150 million. In addition, 0.34 million kg of bristles, a valuable export commodity worth Rs.15 million, are also reported to be produced annually by the pig industry (ICAR Report, 1977).

In India, pig farming has a special significance as it can play an important role in improving the socio-economic status of a sizeable section of the weaker rural community. For a long time, the major part of the pig rearing and pork industry was in the hands of people belonging to the lowest economic status having very limited means to undertake intensive pig farming with good production stock, proper housing, feeding and management. They were compelled to follow old and primitive methods with common village hogs which could properly be designated as scrub animals. These small sized animals did not have any definite characteristics, grew slowly and produced small litters and the meat produced by them was of inferior quality. Pig farming remained neglected for long because of a general apathy against this occupation mainly due to a religious concept and on account of the general way these animals were maintained. Further more, many constraints like insufficient availability of high quality breeding stock, lack of balanced feeds at economic prices and absence of favourable market conditions also hampered pig production. With the adoption of improved pig rearing practices applicable even under rural conditions, there has been a significant increase in the income of some of the poorest people in the country who traditionally rear pigs. But, pig farming as a commercial venture is still to be established in the country. However, under the national five year plans, pig industry has developed to a great extent in the country. The proper development of pig industry on scientific and profitable lines as followed in other progressive countries of the world will, not only help to solve the country's food problem to a great extent but also improve the nutritional standards of our growing population.

The pig population in the country was estimated to be only 64.56 lakhs according to 1972 census. Among the important pork producing states, Uttar Pradesh is the foremost followed by West Bengal, Madhya Pradesh, Andhra Pradesh, Assam and Tamilnadu. In a survey conducted in 1974 by the Progressive Agro-Industrial Consultants, it was observed (National Commission Report, 1976) that in metropolitan cities like Bombay, Calcutta and Delhi, there has always been a sharp increase in the consumption of pork and its products. In Kerala, the total population of pig was estimated to be 1.29 lakhs (Livestock Census, 1972) with the highest percentage in Kottayam and Ernakulam and lowest in Malappuram district. About 93 per cent of the total population of pigs is found to be concentrated in the rural areas of the state.

The rearing of pigs requires comparatively very little investment in regard to housing and other equipments. Labour requirement is also less when compared to those in dairy and poultry production. The returns from hog production come much more quickly than do from many other enterprises. Pig is a very prolific breeder and a quick grower. It can consume more feed per unit body weight and excels all other farm animals in the economy with which it can convert farm by-products and other vegetable matter into edible flesh of high nutritive value yielding maximum returns. One kilogram of pork can be produced from as little as 3.0 to 3.5 kg of feed. Maynard (1946) has reported that the average percentages of the gross energy in the feed which can be converted to human food are 20 per cent for pork, 15 per cent for milk, 7 per cent for egg, 5 per cent for chicken and 4 per cent each for beef and mutton. With better feeding, proper breeding and management pork production can be made more remunerative than is at present.

Profitable raising of pigs depends largely on a carefully planned and efficient feeding programme. Since more than 60 to 70 per cent of the cost of swine production is accounted for by feeds, economic formulation of swine rations assumes paramount importance. It is also well known that adoption of improved methods of feeding can produce much better carcass at a much earlier age and with greater financial returns.

Swine being monogastric, are in direct competition with man for cereal grains like maize, oats and sorghum. Maize is one of the chief sources of energy in pig rations. The shortage of grains is at present very adversely affecting the livestock and poultry farming. In view of the scarcity of foods for human consumption, it is necessary to avoid or minimize the use of feeds required for human diets and utilize other subsidiary feeds to the maximum extent. It is well known that many by-products of animal and plant origin, garbage and subsidiary crops like tapioca can be used in swine rations without adversely affecting the performance. The use of such feeds will help not only in lowering the cost of animal feeds but also in relieving the pressure on cereal grains.

Cassava (Manihot esculenta, crantz) or Tapioca, the world's seventh most important food crop, is the principal source of carbohydrates for about 300 million people, most of them in the developing countries of the tropics. In India, tapioca cultivation is confined mostly to Kerala where it is used mostly as a supplementary food for the common people. The annual production of tapioca in Kerala is around 41 lakh tonnes, more than 60 per cent of which is used as food for man and animals. Tapioca is richer in calorific value compared to other tubers such as potato and is almost of the same value as that of cereals. It can be used as fresh, dried or ensiled products in the feeding of animals. Results of many experiments with pig (Pond and Maner, 1974; Coursey and Halliday, 1974; Phillips, 1979 and Gomez, 1979) indicate that tapioca tuber is an excellent source of energy when properly supplemented with proteins, minerals and vitamins. In addition to its low protein content, the use of tapioca in both human and animal diets is constrained by the presence of cyanogenetic glycosides which on hydrolysis yield hydrocyanic acid or prussic acid. The concentration of cyanogenetic glycosides present in tapioca roots varies widely. But proper treatments such as cooking in water, chopping, mixing sundrying etc. are found to be effective methods of reducing hydrocyanic acid content (Cunha, 1977). There are many studies (Oyenuga, 1961; Manickam <u>et al</u>. 1976; Omaghese and Bowland, 1977 and Ramachandran, 1977) indicating that dried tapioca chips can be profitably incorporated at relatively higher levels in swine rations without having any deleterious effect on the production performance of the animal. On the contrary, there are reports of reduced growth rates and feed efficiency in pigs when fed on rations containing higher levels of tapioca (Hew and Hutagalung, 1972; Muller and Nah, 1975 and Swan and Lewis, 1976). Further, there are restrictions in several countries on the use of tapioca in livestock feeds at relatively higher levels (Coursey and Halliday, 1974).

The foregoing considerations clearly indicate that more detailed and systematic studies are warranted to find out the desirable levels of inclusion of tapioca in swine rations, as the chief source of energy in place of conventional energy supplements as cereal grains. As such, this investigation was taken up to assess the effects of isoprotemic rations containing different levels of dried tapioca chips replacing equal quantities of maize on growth and carcass characteristics of pigs and thereby to establish the desirable levels of inclusion of dried tapioca chips in practical swine rations for optimum performance.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Profitable raising of pigs depends primarily on formulation of economically balanced rations exploiting all the locally available feed resources to the maximum possible extent. This is more important in view of the scarcity of conventional cereal grains even for human consumption. The knowledge of the nutritional requirements of our animals in their various physiological states is obviously a prerequisite in any scheme of feeding the animals on a scientific basis.

Providing an adequate supply of protein is the most important prerequisite for optimum performance in swine. Influence of varying protein levels on growth rate and feed efficiency in swine was extensively investigated. The National Research Council recommendation (NRC, 1968) in respect of total protein in swine rations is found to be 22 per cent at body weights of around 10 kg and 13 per cent at 60 kg. Most of the available literature indicate that the growth rate and feed efficiency in swine are positively correlated with dietary protein levels during the growth period (Smith and Lucas, 1957; Meade et al. 1969; Barber et al. 1971; Cunningham et al. 1973; Fetuga et al. 1975; Menge and Frobish, 1973; Luce et al. 1976; Ramachandran, 1977; Seve and

Aumaitre, 1978 and Pond et al. 1980). Robinson et al. (1964) in their studies on growing pigs maintained on diets containing protein levels of 19, 16, 14 and 12 per cent found significant differences in growth response with varying protein levels only during the early stages of growth. Cole and Luscombe (1969) reported a significant increase in growth rate in pigs of 50 to 120 pound body weight over those above 120 pounds with dietary protein levels ranging from 10.3 to 17.1 per cent. Pay and Davies (1973) obtained positive growth response and feed efficiency up to 55 kg live weight and negative response beyond 55 kg with increasing levels of dietary protein in the diet.

Morgan et al. (1959) reported significantly better growth rates and feed efficiency in swine with higher levels of protein at all stages of growth with the greatest difference being only after 100 pounds live weight. Bellis (1965) and Davey (1976) also reported beneficial results on higher dietary levels of protein throughout the growing and fattening periods. Auman et al. (1961) could not find any significant difference in daily gains of weaner pigs on rations with protein levels of 14, 16 and 18 per cent from weaning to 125 pound body weight. Similar results were reported by

Whitelaw et al. (1966) in their studies using piglets of 21 to 56 days of age. In similar experiments, Newport (1979) did not notice any significant improvement in performance of piglets during 2 to 28 days of age on diets containing protein levels of 21, 24 and 27 per cent.

Boomgardt and Baker (1973) stated that the expression of amino acid requirement as a percentage of dietary protein is preferable to that as a percentage of total diet. The above authors have recorded the tryptophane requirements of growing swine as 0.71, 0.67 and 0.66 per cent respectively at dietary protein levels of 10, 14 and 18 per cent. Baker et al.(1975) reported that the amino acid requirements are affected by the protein levels in the diet. Studies on the effect of varying dietary lysine levels on growth rate in swine were carried out by Magruder et al. (1961); Blair et al. (1969); Brown et al. (1973) and Katz et al. (1973). Kobayashi et al. (1980) while observing the effects of different lysine levels in the diets of finishing pigs reported that the average daily gains and feed conversion efficiency were higher on a diet with 0.74 per cent lysine than those on a diet containing only

0.42 per cent of the same.

The reports on the effects of different levels and sources of energy on growth rates and feed efficiency in swine are many and varied. The Agricultural Research Council Recommendations (ARC, 1965) in respect of energy requirements of swine vary from 3.00 Mcal of digestible energy for pigs of 20 kg body weight with daily average gains of 500 g to 7.5 Mcal for those of 60 kg with daily gains of 790 g. The National Research Council (NRC, 1968) specification for energy is shown to be 3500 Kcal digestible energy per kg of feed for animals weighing up to 20 kg and 3300 Kcal for finishing pigs. Campbell <u>et al</u>. (1975) reported the optimum digestible energy level as 3640 Kcal per kg of feed till the animals attained the body weight of 20 kg. Robinson <u>et al</u>. (1964) while comparing the effects of three energy levels of 3,300, 3080 and 2640 Kcal at 18 per cent total protein and 2860 Kcal at 20 per cent protein, did not notice any significant difference either in growth rate or in feed efficiency due to varying energy levels. Metz <u>et al</u>. (1980) in their studies on pigs weighing from 25 to 110 kg body weight, observed that a difference in daily energy intake by 20 per cent caused a reduction of 15 per cent in live weight gain and 12 per cent in nitrogen retention. Reddy et al. (1980) while comparing the effects of three energy levels (3.1, 3.3 and 3.5 Mcal DE/kg) and three protein levels (16, 18 and 20 per cent) in the diets of growing pigs found that a diet with 18 per cent protein and 3.1 or 3.3 Mcal of digestible energy per kg was superior in terms of average daily gain and feed conversion efficiency.

Energy protein inter-relationship in the diets of pig was well established. The need for a higher dietary protein level with increased energy content in the diet was emphasized by many workers (Sewell et al. 1961; Clawson et al. 1962; Allee et al. 1971 and Leibbrandt et al. 1975). Costain and Morgan (1961) reported that pigs could tolerate a wider energy protein ratio at the finishing period of 100 to 200 pounds body weight than during any earlier growth period. Clawson et al. (1962) in a study with isocaloric diets and graded levels of protein, observed that growth rate was significantly increased by a narrow energy protein ratio only in the early period of growth. Clawson et al. (1962) also reported that a narrow protein energy ratio supported the most rapid gains during the first 28 days. According to Reddy and Agarwala (1975), there was no significant difference either in growth rate or in feed efficiency of growing Yorkshire pigs with three energy protein ratios of 1 : 168, 1 : 133 and 1 : 110.

Braude *et al.* (1958) observed that feed conversion efficiency in pigs was higher with restricted feeding regime when compared with *ad libitum* feeding. Similar results were reported by Barber *et al.* (1957); Plank and Berg (1963); Biswas *et al.* (1966) and Vanschoubroek *et al* (1967). In experiments on pigs of 50 to 100 pounds body weight, Blair *et al.* (1969) reported higher feed conversion efficiency with increased feeding level. Cole *et al.* (1968) observed only slower growth rate in pigs of 23 to 50 kg body weight maintained on restricted levels of feeding. Veum *et al.* (1970) also recorded similar results. The above authors further observed a linear reduction in growth rate and feed efficiency with increasing degrees of feed restriction. Burlacu *et al.* (1978), on the other hand, reported that *ad libitum* or restricted feeding at 80 per cent of the former did not have any marked influence on feed utilisation in swine.

Influence of environmental temperature on growth rate and feed efficiency in swine was shown by many authors (Capstick and Wood, 1922; Moustgaard, 1959;

Mount, 1959; Pfeiffer and Ender, 1973 and Seerley *et al.* 1975). Decreased growth rate and lowered feed efficiency in swine reared at very low atmospheric temperature were recorded by Pearson *et al.* (1966); Fuller and Boyne, (1971); Stahly *et al.* (1979) and Verstegen *et al.* (1979). Houghton *et al.* (1964) concluded that energy requirements of pigs in humid tropics were lower than of those in temperate regions. Holmes (1973) obtained reduced growth rate in pigs exposed to continually high ambient temperature. Close and Mount (1978) inferred from their studies that the optimum temperature for normal body weight gain in swine was more dependent on the metabolisable energy intake of the animals.

Sex is another factor reported to have marked influence on growth rate and feed efficiency in swine. Morgan *et al.* (1959) and Hansson (1974) in their experiments with pigs of 50 to 100 pounds body weight observed that males grew significantly faster and utilised feed more efficiently than females. Blair and English (1965) recorded 14.9 per cent higher daily gain and 9.5 per cent better feed efficiency in males compared to females from 120 to 150 pounds body weight. Higher feed efficiency was reported for boars compared to barrows (Charette, 1961; and Pay and

Davies, 1973). Faster growth rate and higher feed consumption rate were reported in barrows than in gilts (Clawson *et al.* 1962; Laird, 1964; Hale *et al.* 1967, 1968; Baird *et al.* 1970 and Cunningham et al. 1973). Cunningham et al. (1973) observed higher protein requirements in gilts than in barrows.

There are several reports on the effects of breed of the animal on growth rate and efficiency in swine (Lucas and Calder, 1956; Aunan *et al.* 1961 and Cole and Wangsness, 1978). Lucas and Calder (1956) did not observe any significant effect of breed on growth rate and feed efficiency in swine. On the other hand, Aunan *et al.* (1961) showed that daily gain in pigs was markedly affected by the breed of the animal.

The role of feed additives in swine rations was extensively investigated. There are many reports of improved feed efficiency and rate of gain in pigs by the inclusion of antibiotics in the rations (Smith and Lucas, 1957; Speer, 1962; Dvořák, 1963; Smith *et al.* 1964 and Moulick *et al.* 1965). Morgan *et al.* (1958) did not observe any improvement either in growth rate or in feed efficiency by the inclusion of aureomycin in the diets of pigs of 120 to 150 pounds body weight.

Caldor *et al.* (1959) in their experiments with pigs of 6 to 40 pounds body weight observed that while the growth rate was improved, there was no significant effect on feed efficiency by the inclusion of antibiotics in the diets. In similar experiments with pigs of 50 to 200 pounds, Morgan *et al.* (1959) also did not notice any influence of antibiotics on growth rate and feed efficiency in pigs. According to Holme and Robinson (1965), though penicillin had no beneficial effect zinc bacitracin promoted better growth rates in animals. Solneve and Vasilanko (1968) observed a reduced growth stimulatory effect on continuous feeding of antibiotics to pigs. Rey (1978) reported that among the common antibiotics, aureomycin and terramycin are more effective than penicillin, bacitracin and streptomycin. There are also many reports on the effects of inclusion of other additives as arsenicals and copper sulphate in swine rations (Stuckey *et al.* 1962; Speer, 1962; Barber *et al.* 1965; Moulick *et al.* 1965 Braude and Ryder, 1973 and Prince *et al.* 1979).

The need for suitable energy feed ingredients in the rations of growing and finishing swine was well established. Maize is one of the most commonly used grains in swine rations because of its high digestability and palatability. Maize provides a DCP of 7.0, D.E. of 3488 Kcal per kg and TDN of 79 per cent (Crampton and Harris, 1969). Baker _et al_. (1969) indicated that tryptophane is the first limiting amino acid in corn protein. Anni _et al_. (1980) also reported that when compared to other cereal grains like sorghum, tryptophan content is the lowest in maize. Katz _et al_. (1973) showed that while addition of lysine to a corn soyabean meal based diet increased the rate of gain and feed conversion efficiency in swine, methionine had no such effect. Beneficial effects of lysine supplementation in cereal based rations were also shown by Brown _et al_. (1973). On a comparison of different varieties of maize, Mahajan _et al_. (1974) reported a higher biological value for opaque-2 variety of maize when compared to local (Desi), Punjab maize I and normal maize (Vijay) varieties. Similar results were also reported by Sihombing _et al_. (1969); Baker _et al_. (1970) and Moroquin _et al_. (1973).

Robinson _et al_. (1965), in their studies on the energy values of different cereal grains, recorded digestible energy values of 2880, 3300, 3430, and 3300 Kcal/kg respectively for barley, wheat, maize and milo. While comparing the feeding values of various cereal grains as energy sources in swine rations Handlin _et al._ (1961) observed that hogs finished on rations based on maize gained faster than those on rations containing barley, milo and oats. Myers (1963) observed higher efficiency of feed conversion in pigs of 43 to 200 pounds as the proportion of maize was increased from 45 to 75 per cent. In similar experiments using pigs of 25 to 110 kg body weight Jucker _et al._ (1966) did not observe any significant difference either in weight gain or in feed efficiency on diets containing 20, 40 and 60 per cent maize. In a feeding experiment to compare diets based on maize, barley and wheat, Gill _et al._ (1966) reported higher daily gains and feed efficiency in pigs fed on diets based on maize. Cole _et al._ (1969) while comparing the different cereal grains as barley, wheat and maize, found that the performance of pigs from weaning to 120 pounds live weight was not significantly affected by the type of cereal used. On the other hand, after 120 pounds body weight, pigs fed on maize diets gained more than those on barley or wheat diets. Similar results were also reported by Lawrence (1968). According to the National Commission Report (1976), maize can be replaced to the extent of 50 per cent by smaller millets as energy source. Sharda et al. (1978) reported that maize could be replaced to the extent of 25 per cent by ground barley in the diets of growing pigs without adversely affecting the daily gain and feed efficiency.

Lawrence (1967) reported that grinding the cereals produced better results in terms of digestibility and digestible energy in swine. Growth rates and feed conversion efficiency were reported to be higher on diets containing ground maize or sorghum than on those with crimped grain (Lawrence, loc. cit). Lawrence (1973) observed that the apparent digestibility of dry matter and nitrogen was improved by micronising the grains. Lawrence (1977) observed that diets containing ground maize or barley were superior to those containing micronised form of the same for pigs.

Cassava or Tapioca is one of the most abundantly used feed ingredient in place of conventional energy sources such as cereal grains. Chemical composition and nutritive value of tapioca have been studied by many workers (Barrios and Bressani, 1967; Ketika and Oyenuga, 1972; Coursey and Halliday, 1974; Longe, 1978; Oke, 1978 and Raja et al. 1979). Ketika and Oyenuga

(1972) in a study to find out the effect of age of plant on starch content in tapioca tubers, reported average starch contents of 67.2 to 81.0 per cent of total dry matter during five to nine months of plant maturity with the highest percentage at the age of eight months. It was also shown that the starch content tended to fall after the age of eight months at a rate of 3.2 to 5.4 per cent.

Carbohydrates constitute 80 to 90 per cent of total dry matter of tapioca roots, 78 to 90 per cent of which being starch (Raja et al. 1979). The digestibility of tapioca protein is reported to be equal to that of rice protein with a biological value of 48 per cent. The essential amino acids in cassava protein have been identified as arginine, histidine, threonine, tryptophan and methionine. It contains about 0.46 per cent fat, the principal fatty acids being palmitic, oleic, linoleic and linolenic. The calcium and phosphorus contents are shown to be 0.13 and 0.15 per cent respectively (Raja et al. loc. cit). Tapioca protein is relatively poor in quality due to a very low content of sulphur containing amino acids (Oke, 1978).

Presence of varying proportions of cyanogenetic glycosides has been reported in tapioca roots. Oyenuga and Amazigo (1957) reported that fresh tubers contain hydrocyanic acid in the range of 21 to 213 milligram per kilogram. Coursey and Halliday (1974) recorded a range of 15 to 400 mg of hydrocyanic acid per kilogram of fresh roots. Hydrocyanic acid content in tapioca peels is found to be five to ten times greater than that in tubers (Oyenuga and Amazigo, 1957 and Coursey, 1973). Several factors such as genetic, climatic and agronomic conditions are found to influence the concentration of cyanogenetic glycosides in tapioca roots (Coursey and Halliday, 1974; Oyefeso, 1976 and Raja *et al.* 1979). Obligbesan (1977) observed a definite influence of potassium application in the soil on the cyanide content of tubers.

The feeding value of tapioca tubers as an energy source was extensively investigated. Oyenuga (1961) showed that the yield of energy per hectare of land was about 13 times more with tapioca cultivation than with either maize or guinea corn. In a study on comparative calorific values of various tubers, Achaya (1975) and Nestle (1976) reported that 100 g each of tapioca, yam, taro, potato and sweet potato provides

109, 90, 86, 70 and 97 calorie respectively of energy on fresh basis. Raja *et al.* (1979) compared the energy value of tapioca with those of the common cereal grains. According to him 100 g of each of wheat flour, parboiled rice, maize flour and cassava meal provides 332 to 334, 359, 356 and 338 calorie respectively.

Coursey and Halliday (1974) observed that supplementation of tapioca containing mixed diets with iodine in addition to methionine largely eliminated the goitrogenic activity due to thiocyanate production from hydrocyanic acid. Philips (1979) concluded that on account of the low protein content, any substitution of dried tapioca for cereals in mixed feeds must be compensated by an increased level of protein supplements such as oil cakes or other protein sources.

Reports on the effects of inclusion of tapioca in the rations of animals are many and varied. According to the studies conducted at the Hawai Experimental Research Station in 1935 (Krider and Caroll, 1956). Cassava meal was worth about 45 per cent as much as barley in the rations of growing and finishing swine. Both raw and boiled cassava based diets were shown to be equal to corn based diets for growing and finishing swine by Jones (1959). According to Oyenuga (1961) raw cassava produced better results than boiled cassava in the diets of growing pigs if the quantity of cassava in the diet did not exceed 42 per cent of the total dry matter. It was also concluded that raw cassava at a level of 42 per cent of the diet tended to show better retention of nitrogen than did boiled cassava. But the diet containing raw cassava had lower apparent digestibility and showed the highest net absorption of calcium and phosphorus. Buitrago (1964) reported that the intake of cassava by the animals was increased significantly by giving a protein supplement in a separate feeder ad libitum.

There are many reports of reduced growth rate and feed efficiency when tapioca was included at higher levels in swine rations. Gomez (1979) observed that gilts fed sweet cassava grew more slowly than those fed maize. Similar results were also reported by Maner (1972). There are also restrictions and regulations in several countries with regard to the levels of inclusion of tapioca chips in livestock rations. In Federal Republic of Germany the permissible levels of inclusion of tapioca in swine rations vary from 10 to 40 per cent. Cooperatives in Netherland have recommended maximum inclusion rates of only 15 per cent in pig rations. In Belgium, the normal level of inclusion of tapioca meal in mixed feeds was recommended to be only 5 per cent (Coursey and Halliday, 1974).

But there are many studies indicating that tapioca can be included at fairly higher levels in swine rations provided the ration is properly supplemented with protein, minerals and vitamins. Maner (1972) showed that fresh cassava could be successfully included in swine rations if properly supplemented with methionine. On the other hand, Onaghese and Bowland (1977) did not find any beneficial effect by the addition of methionine. Pond and Maner (1974) stated that cassava, if properly processed to eliminate toxicity from hydrocyanic acid, is an excellent source of energy for the pig. The energy digestibility in tapioca was similar to that of grains. They concluded that cassava meal can be included up to 40 per cent in the rations of growing and finishing pigs with beneficial results. But higher levels of inclusion reduced growth rate and feed efficiency and necessitated supplementation of methionine and other nutrients for better performance. Similar results were also reported by Onaghese and Bowland (1977). In a study to find out the effect of replacing barley with tapioca meal at a level of 45 per cent in the rations of early weaned pigs, Arambawela et al. (1975) did not observe any deleterious effect on growth rate and feed efficiency in animals. Manickam et al. (1976) could include dried tapioca chips up to 60 per cent replacing maize in swine rations without showing any ill effects on the animals. Further, the above authors observed a higher, though not significant, feed efficiency on tapioca containing diets. Gomez (1979) reported that the total consumption of fresh chopped cassava by growing and finishing swine varied depending on the protein content of the supplement used. The daily average consumption of tapioca throughout the growing and finishing stage was greater with higher levels of protein in the diet. It was also shown that fresh roots could be safely fed to gestating and lactating pigs with an adequate supplementation with protein, minerals, and vitamins.

Several factors, both nutritional and environmental have been found to influence carcass quality in swine. Higher levels of protein in the diet were reported to enhance lean growth (Morgan et al. 1959; Robinson et al. 1964; Cole and Luscombe, 1969; Blair et al. 1969;

Stahly and Wahlstrom, 1973; Fetuga *et al.* 1975; Luce *et al.* 1976 and Davey, 1976) and decreased back fat (Morgan *et al.* 1959 and Stahly and Wahlstrom, 1973). On the other hand, Whitelaw *et al.* (1966); Meade *et al.* (1969) and Ramachandran, (1977) could not notice any significant difference on carcass characteristics with different dietary protein levels. Meade *et al.* (1969) reported that dressing percentage, cross sectional area of loin-eye muscle and percentage yield of ham and loin were not markedly affected by two different dietary protein levels viz. 20 and 17 per cent, during the early growth period. Kobayashi *et al.* (1980) did not observe any significant difference in carcass length, dressing percentage or in backfat thickness in animals fed on diets containing lysine levels of 0.42 and 0.74 per cent.

There are varying reports on the effects of dietary levels of energy on carcass characteristics in swine. Robinson *et al.* (1964) observed that carcass quality was significantly influenced by variation in the energy levels of the diets. Robinson (1965) recorded a positive correlation between energy intake and carcass length in swine. Body protein content was reported to be lower with energy restricted diets (Babatunda *et al.* 1967). Cole *et al.* (1968) observed relatively lower dressing percentages for animals fed on low energy diets. Brooks (1972) recorded increased backfat thickness at higher levels of dietary energy. Robinson and Lewis, (1964) and Baird *et al.* (1970) did not observe any beneficial effect on carcass quality with higher energy levels in the ration. With higher dietary levels of energy, Blair *et al.* (1969) obtained fatter carcass at all live weights. Robinson (1965) could not find any significant effect of energy level on any of the carcass characteristics except carcass length.

Braude *et al.* (1958) recorded a lower dressing percentage for pigs maintained on a restricted feeding regime. Vanschoubroek *et al.* (1967) reported that on an average feed restriction of 15 per cent could result in a reduction of backfat thickness by 7.63 per cent with 0.53 per cent reduction for each one per cent restriction in feed. Barber *et al.* (1972) and Fuller and Livingstone (1978) also observed similar results and concluded that backfat thickness decreased with intensity of feed restriction. Reddy and Agarwala (1975) could not find any significant difference in dressing percentage, carcass length and backfat thickness in animals fed on diets with energy protein ratios of 1 : 168, 1 : 133 and 1 : 110.

Merkel *et al.* (1958) recorded a positive correlation between percentage of crude fibre in the diet fed and length of lean carcass obtained. Cameron (1960) observed an improved carcass quality with decreased dressing percentage at higher levels of crude fibre in the diet. Baird *et al.* (1975) reported that low fibre diets produced leaner carcasses when compared to high fibre diets.

The effects of different sources of energy feed ingredients on carcass quality were studied by many workers. In a comparison of different cereal grains as sources of energy in finisher rations, Myers (1963) observed that dressing percentage was increased with increasing proportion of maize in the diet. Gill *et al.* (1966) observed higher backfat thickness in pigs fed on maize when compared to those fed on barley on wheat. Jucker *et al.* (1966) and Forbes and Holme (1968) recorded higher iodine values for the backfat collected from animals fed on diets containing maize compared to those on other cereal based diets. Lawrence (1968) could not find any significant difference in carcass length with diets containing higher levels of different cereals such as barley, maize or sorghum. Lawrence (1973) in his studies with diets containing either ground or micronised cereals recorded higher dressing percentages with micronised diets. Carcass length was also found to be increased on micronised diets.

Totsuka *et al.* (1978) could not notice any significant change in carcass quality by inclusion of cassava up to 20 per cent levels in the finishing diets. Manickam *et al.* (1976) reported similar values for carcass length, backfat thickness, loin-eye area and dressing percentage with diets containing either maize or tapioca at a level of 60 per cent. Ramachandran (1977) in his studies on the effects of different energy and protein levels did not report any adverse effect on carcass characteristics by the inclusion of dried tapioca chips at relatively higher levels in the grower and finisher rations.

Body weight at slaughter is another factor influencing carcass characteristics. Agarwala (1963) and Narayana Rao *et al.* (1964) observed a positive correlation between dressing percentage and live weight. Bellis and Taylor (1961) and Laverentjeva *et al.* (1970) recorded increased carcass length at higher body weights. Backfat thickness was also found positively correlated with live weight (Ramachandran, 1977 and Neely et al. 1978). Deo et al. (1980) could not find any significant differences in any of the carcass characteristics by the age and weight of the animal at the slaughter weight.

Sex of the animal is also found to influence the carcass quality. Gilts are reported to yield better carcasses with lesser backfat (Braude et al. 1961; Robinson, 1965 and Blair et al. 1969) larger eye-muscle area (Hale et al. 1967; Wong et al. 1968; Cunningham et al. 1973; Gilster and Wahlstrom, 1973 and Mervin et al 1975) and higher percentage of primal cuts (Buck, 1962; Blair and English, 1965; Blair et al. 1969; and Gilster and Wahlstrom, 1973) than barrows. Prescott and Lamming (1964) and Fay and Davies (1973) reported leaner carcasses with larger eye-muscle area and decreased backfat thickness in boars than in barrows. Morgan et al. (1959) could not find any influence of sex on carcass measurements. Shanmuganatham and Ranganathan (1973) also reported similar results.

There are also many reports on the effects of enviromnmental factors like temperature, season and climate on carcass characteristics in swine (Moody et al. 1961; Bruner et al. 1969 and Kempster, 1978). Stahly and

Cromwell, (1979) and Stahly <u>et al</u>. (1979) reported that carcass length and percentages of lean cuts were lower for pigs reared in cold (10°C) than for those kept in a warm (35°C) environment. Deo <u>et al</u>. (1980) observed that the season of birth of the piglets markedly influenced carcass weight and dressing percentage in swine.

MATERIALS AND METHODS

MATERIALS AND METHODS

Animals

Eighteen large White Yorkshire weanling pigs maintained at the University Pig Breeding Farm, Mannuthy, formed the experimental subjects for the present study. The animals were divided into three groups (Group I, II and III) of six animals each as uniformly as possible in regard to litter, sex, age and weight. The males and females of all the experimental groups were housed separately in closed fully roofed well-ventilated pens of 11.1 sq. metres with facilities for feeding and watering. The animals were dewormed and sprayed against ectoparasites sufficiently before the commencement of the experiment.

Diets

The percentage ingredient composition and chemical composition of the experimental diets (Diet A, B and C) fed to the respective groups (Group I, II and III) are given below:

Percentage ingredient composition of the experimental diets

Ingredients	Total protein levels								
	18%			16%			14%		
	A	B	C	A	B	C	A	B	C
Maize	40.0	20.0	..	40.0	20.0	..	40.0	20.0	..
Dried Tapioca chips	..	20.0	40.0	..	20.0	40.0	..	20.0	40.0
Deoiled groundnut cake	11.0	14.0	17.0	13.0	16.0	19.0	8.0	11.0	15.0
Deoiled coconut cake	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Dried fish (unsalted)	15.0	15.0	15.0	10.0	10.0	10.0	9.0	9.0	9.0
Wheat bran	23.0	20.0	17.0	26.0	23.0	20.0	32.0	29.0	25.0
Mineral mixture	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Calculated ME Mcal/kg	2.96	2.97	2.97	2.95	2.96	2.97	2.91	2.93	2.94
Cost per kg(Rs)	1.57	1.53	1.49	1.58	1.54	1.50	1.53	1.50	1.47

Salt and vitamin B_2 D_3 were added at the rate of 2.5 kg and 100 g respectively per metric tonne in all the diets.

Percentage chemical composition of the experimental diets

Composition	Total protein levels								
	18%			16%			14%		
	A	B	C	A	B	C	A	B	C
Moisture	8.2	9.9	10.0	7.1	8.9	10.3	8.2	11.0	11.1
Crude protein	18.3	18.4	17.8	16.8	16.2	16.4	14.5	15.0	14.4
Crude fibre	3.9	4.0	4.9	4.3	4.0	4.0	5.7	4.4	4.2
Ether extract	2.8	4.0	3.2	4.6	3.8	4.2	3.7	4.6	4.3
Total ash	14.2	13.5	13.0	13.0	12.7	11.3	13.7	13.3	12.1
Nitrogen free extract	60.8	60.1	61.1	61.3	63.3	64.1	62.4	62.7	65.0
Calcium	1.40	1.30	1.21	1.04	1.02	1.06	1.43	1.36	1.05
Phosphorus	0.61	0.71	0.79	0.79	0.71	0.70	0.80	0.63	0.80

Methods

The animals in the three groups I, II and III were maintained on the respective diets A, B and C with 18 per cent total protein up to an average live weight of 20 kg (Phase I), with 16 per cent total protein up to 50 kg (Phase II) and with 14 per cent total protein till they attained an average body weight of 70 kg.

All the experimental animals were fed semi - ad libitum allowing access to the feed for one hour every day in the morning as well as in the evening. Water was provided ad libitum. Records of daily feed intake and fortnightly body weights and body measurements were maintained. A record of the daily room temperature (minimum and maximum) was also maintained throughout the course of the experiment.

Towards the end of the phase II of the experiment, when the average feed consumption was almost uniform for each group, data on total feed intake and faecal output in respect of each group were gathered during a collection period of 4 days. Faeces was collected as and when it was voided taking all precautions to avoid contamination with urine and dirt. The faeces collected each day was weighed accurately, mixed well and representative samples at the rate of 1/10th of the total quantity was stored in a refrigerator. The aliquots of faeces taken during the collection period of four days were pooled and preserved for the proximate analysis. All the feed samples as well as the faecal samples collected during the digestion trial were analysed for proximate principles by standard procedures (A.O.A.C. 1970).

Analysis of the blood constituents viz., haemoglobin, packed cell volume, plasma protein, plasma calcium and inorganic phosphorus, was carried out by standard procedures to assess the nutritional status of the animals. Haemoglobin was estimated by Cyanmethaemoglobin method (Benjamin, 1974), plasma protein by Biuret method (Gornall et al. 1949), Plasma calcium by Clark and Collip modification (1925) of Kramer-Tisdall method (1921) and inorganic phosphorus by Fiske and Subba Row (1925) method.

Two males and two females from all the three experimental groups were slaughtered when they attained the body weight of 70 kg for gathering data on carcass characteristics. The dressed weight of the carcass without head was recorded, the head being removed at the allanto occipital region. Weight of the head was also recorded. Length of carcass was measured from the anterior aspect of the first rib to the anterior aspect of the aitch bone. Backfat thickness was measured at three sites viz., at the region of the first rib, last rib and last lumbar vertebra. Leaf fat was removed and the weight was recorded. The fore-trotters and hind-trotters were removed from the knee joint and hock joint respectively. The shoulder (Boston butt and picnic shoulder) was separated from the rest of the carcass by cutting between the second and third rib leaving first one and half ribs with the shoulder. The boston butt and picnic shoulder were separated by sawing across the scapula just above its juncture with the humerus and parallel to the brest side of the shoulder, approximately one inch below the posterior edge of the scapula perpendicular to the outer skin surface of the carcass. The breast flap was removed from the picnic. Removed the ham by cutting at a point approximately 2½ inches from the most anterior point of the aitch bone by sawing through the sacral vertebra and shaft of the ilium. Separated the loin from the side and spare ribs by cutting on a curved line from the lower edge of the tender loin muscle at the leg end on the loin, to a point just below the tender loin at the last rib. Then saw the ribs from a point as close to the chine bone of the third thoracic vertebra as possible to the point just below the tender loin muscle at the last rib. Weights of all cuts were recorded. The cross sectional area of the eye-muscle was calculated from its measurements taken at the region of the tenth rib.

Representative sample from the subcutaneous fat and leaf fat were collected and preserved for the determination of fat constants. Melting point, iodine number and saponification value were determined by the methods described in A.O.A.C. (1970).

Statistical analysis of the results was carried out by following the method described by Snedecor and Cochran (1967).

The data on animal number 3/178 in Group III were not included during the IInd and IIIrd phases of the experiment since the animal had to be removed from the group considering its very low growth rate compared to its mates.

RESULTS

RESULTS

Results on growth rate and feed conversion efficiency of animals in the three groups I, II and III under the respective dietary treatments A, B and C are set out in tables 1 to 14 and represented in figures 1 to 3. Tables 15 to 23 show data on body measurements of animals recorded at fortnightly intervals till the end of the experiment. Table 24 presents a consolidated data on gains in body weight and body measurements up to eighth fortnight. Digestibility coefficients of nutrients in the three diets determined at the end of the second phase of the feeding experiment are shown in table 25. Results of haematological studies are presented in tables 26 to 33.

Data on carcass characteristics of animals slaughtered at an average body weight of 70 kg are detailed in tables 34 to 36 and statistically analysed in tables 37 to 45. Data on fat constants in respect of both subcutaneous and leaf fat collected from the animals at the time of slaughter are set out in tables 46 to 55. Details of production cost of animals under the three dietary treatments are presented in tables 56 and 57 and represented in figure 4.

Table 1. Fortnightly body weights (kg) of pigs maintained on the three dietary treatments

Diet A - Group I

Animal number	Sex	Fortnights													
		0	1	2	3	4	5	6	7	8	9	10	12	13	14
4/178	M	12.0	15.5	20.5	21.5	25.5	30.0	34.0	39.0	45.5	52.0	58.5	70.0		
2/179	M	10.5	15.0	20.0	24.0	31.5	37.5	43.0	51.0	60.0	71.0				
2/178	M	15.5	19.5	25.0	30.0	38.0	42.5	44.5	56.0	70.0					
7/178	F	13.5	16.5	17.5	20.0	22.0	23.0	28.5	33.5	37.5	43.0	47.5	58.5	66.0	73.5
10/176	F	12.5	15.5	19.0	22.5	26.0	31.0	36.0	46.0	51.5	60.5	71.0			
7/176	F	13.5	16.0	19.0	22.0	23.0	25.0	29.5	33.0	38.0	41.0	45.5	56.5	64.0	71.5
Average		12.9	16.3	20.2	23.3	27.7	31.5	36.2	43.1	50.4	53.5	55.6	61.7	65.0	72.5
S.E.		±0.7	±0.7	±1.1	±1.4	±2.5	±3.0	±2.8	±3.9	±5.2	±5.6	±5.9	±4.2	±1.0	±1.0

Table 2. Diet B - Group II

Animal number	Sex	Fortnights													
		0	1	2	3	4	5	6	7	8	9	10	12	13	14
1/176	M	13.0	15.5	18.5	24.5	27.0	37.5	45.5	53.0	57.5	65.5				
3/176	M	13.5	15.5	18.0	21.5	27.0	28.5	34.0	38.0	41.5	45.0	50.5	58.5	67.5	71.0
1/178	M	12.5	14.0	16.5	18.0	22.0	24.5	31.0	34.5	38.5	43.0	47.5	55.0	64.5	74.0
8/176	F	13.5	16.5	20.5	24.0	30.5	35.0	43.0	49.0	56.0	62.5	65.5			
3/179	F	10.0	12.5	15.5	20.0	27.5	29.0	40.0	48.5	55.5	64.5	71.0			
6/178	F	14.5	17.5	19.0	24.5	28.5	33.0	38.5	44.5	50.0	60.5	67.0			
Average		12.8	15.2	18.0	22.1	27.1	31.2	38.7	44.6	49.8	56.8	60.3	56.7	66.0	72.5
S.E.		±0.6	±0.7	±0.7	±1.1	±1.2	±2.0	±2.2	±2.9	±3.3	±4.1	±4.7	±1.7	±1.5	±1.5

Table 3. Diet C - Group III

Animal number	Sex	Fortnights														
		0	1	2	3	4	5	6	7	8	9	10	12	13	14	15
5/178	M	15.5	20.5	27.5	33.5	42.5	47.0	58.5	66.0	73.0						
1/179	M	11.5	16.0	21.5	26.0	32.5	36.0	44.0	49.5	54.0	60.5	65.5				
3/178	M	11.5	13.0	16.5	..	..	..	..	..	..	..	..				
9/176	F	13.5	17.0	21.5	24.0	28.5	32.0	40.0	46.5	52.0	57.0	63.5				
9/178	F	15.5	19.0	23.0	27.0	33.5	36.0	45.0	51.5	57.5	65.0					
5/176	F	10.0	13.5	16.5	18.5	22.5	25.5	29.5	34.0	35.5	40.0	42.5	51.0	56.0	63.0	70.0
Average		12.9	16.5	21.1	25.8	31.9	35.3	43.4	49.5	54.4	55.6	57.2	51.0	56.0	63.0	70.0
S.E.		±0.5	±1.2	±1.1	±2.4	±3.3	±3.5	±4.7	±5.1	±6.0	±5.5	±7.4				

Table 4. Fortnightly average feed intake (kg), body weight gain (kg) and feed conversion efficiency of pigs maintained on the three dietary treatments

Diet A - Group I

	Fortnights												
	1	2	3	4	5	6	7	8	9	10	12*	13	14
Average weight gain	3.42	3.92	3.08	4.33	3.83	4.71	6.83	7.33	7.00	6.50	11.17	7.50	7.50
Average feed intake	10.16	10.54	13.86	16.50	13.52	19.97	24.52	22.80	23.03	23.27	44.23	29.25	25.50
Feed efficiency	2.97	2.69	4.50	3.81	3.53	4.24	3.59	3.11	3.29	3.58	3.96	3.90	3.40

* Values given include that of 11th fortnight also since data for the 11th fortnight could not be gathered.

Table 5 Diet B - Group II

	Fortnights												
	1	2	3	4	5	6	7	8	9	10	12*	13	14
Average weight gain	2.42	2.75	4.08	5.00	4.17	7.42	5.92	5.25	7.00	5.20	7.75	9.25	6.5
Average feed intake	9.46	10.09	13.59	16.50	13.76	24.49	25.34	23.52	23.52	24.02	33.71	28.58	26.71
Feed efficiency	3.91	3.67	3.33	3.30	3.30	3.30	4.28	4.48	3.36	4.62	4.35	3.09	4.11

Table 6. Diet C - Group III

	Fortnights													
	1	2	3	4	5	6	7	8	9	10	12*	13	14	15
Average weight gain	3.58	4.58	3.80	6.10	3.40	8.10	6.10	4.90	5.88	4.67	8.50	5.00	7.00	7.00
Average feed intake	10.31	11.50	14.40	19.28	14.14	23.65	25.13	21.85	23.99	19.61	35.10	15.80	22.89	23.80
Feed efficiency	2.88	2.51	3.79	3.16	4.16	2.92	4.12	4.46	4.08	4.20	4.13	3.16	3.27	3.40

Table 7. Average cumulative daily gain (g) and number of days to attain slaughter weight for animals maintained on the three dietary treatments

Diet A - Group I

Animal number	Sex	Initial body weight (kg)	Body weight at slaughter (kg)	No. of days under experiment	Total weight gain (kg)	Average daily gain (g)
4/178	M	12.0	70.0	168	58.0	354.2
2/179	M	10.5	74.0	134	63.5	473.9
2/178	M	15.5	71.5	120	56.0	466.7
7/178	F	13.5	73.5	195	60.0	307.7
10/176	F	12.5	74.0	148	61.5	415.5
7/176	F	13.5	71.5	195	58.0	297.4
Average		12.9	72.4	160	59.5	335.9
S.E.		±0.7	±0.7	±13	±1.1	±31.7

Table 8. Diet D - Group II

Animal number	Sex	Initial body weight (kg)	Body weight at slaughter (kg)	No. of days under experiment	Total weight gain (kg)	Average daily gain (g)
1/176	M	13.0	69.5	134	56.5	421.6
3/176	M	13.5	71.0	195	57.5	294.9
1/178	M	12.5	74.0	195	61.5	315.4
8/176	F	13.5	70.5	148	57.0	385.1
3/179	F	10.0	74.0	148	64.0	432.4
6/178	F	14.5	69.0	152	54.5	358.6
Average		12.8	71.3	162	58.5	368.0
S.E.		±0.6	±0.9	±11	±1.4	±22.8

Table 9. Diet C - Group III

Animal number	Sex	Initial body weight (kg)	Body weight at slaughter (kg)	No. of days under experiment	Total weight gain (kg)	Average daily gain (g)
5/178	M	15.5	73.5	120	58.0	483.3
1/179	M	11.5	69.0	152	57.5	378.3
9/176	F	13.5	67.5	152	54.0	355.3
9/178	F	15.5	68.5	134	53.0	395.5
5/176	F	10.0	70.0	208	60.0	288.5
Average		13.2	69.7	153	56.5	380.2
S.E.		±1.1	±1.0	±15	±1.3	±31.6

Table 10. Sexwise data on average daily weight gain and number of days to to attain 70 kg for animals maintained on the three diretary treatments

Sex	Diets					
	A		B		C	
	Average daily weight gain (g)	Number of days to attain 70 kg (extrapolated)	Average daily weight gain (g)	Number of days to attain 70 kg (extrapolated)	Average daily weighat gain (g)	Number of days to attain 70 kg (extrapolated)
Male	431.6 ±38.7	135 ±17	344.0 ±39.3	172 ±19	430.8 ±52.5	132 ±25
Female	340.2 ±37.8	174 ±18	392.0 ±21.6	147 ± 6	346.4 ±31.2	166 ±22

Table 11. Summarised data on body weight gain, number of days to attain 70 kg, feed intake and feed efficiency of animals maintained on the three dietary treatments

Diets	Average initial weight (kg)	Average final weight (kg)	Average weight gain (kg)	Average daily gain (g)	Days taken to attain 70 kg body weight (extrapolated)	Average feed intake (kg)	Feed efficiency
A	12.9 ±0.7	72.4 ±0.7	59.5 ±1.1 *(160 ± 13)	385.9 ±31.7	155 ±14	213.4	3.59
B	12.8 ±0.6	71.3 ±0.9	58.5 ±1.4 *(162 ± 11)	368.0 ±22.8	160 ±10	212.0	3.62
C	13.2 ±1.1	69.7 ±1.0	56.5 ±1.3 *(153 ± 15)	380.2 ±31.6	153 ±17	201.9	3.57

* Figures in paranthesis indicate the average number of days to attain this much gain.

FIGURE - 1

AVERAGE DAILY WEIGHT GAINS OF THE ANIMALS ON THE DIFFERENT DIETARY TREATMENTS

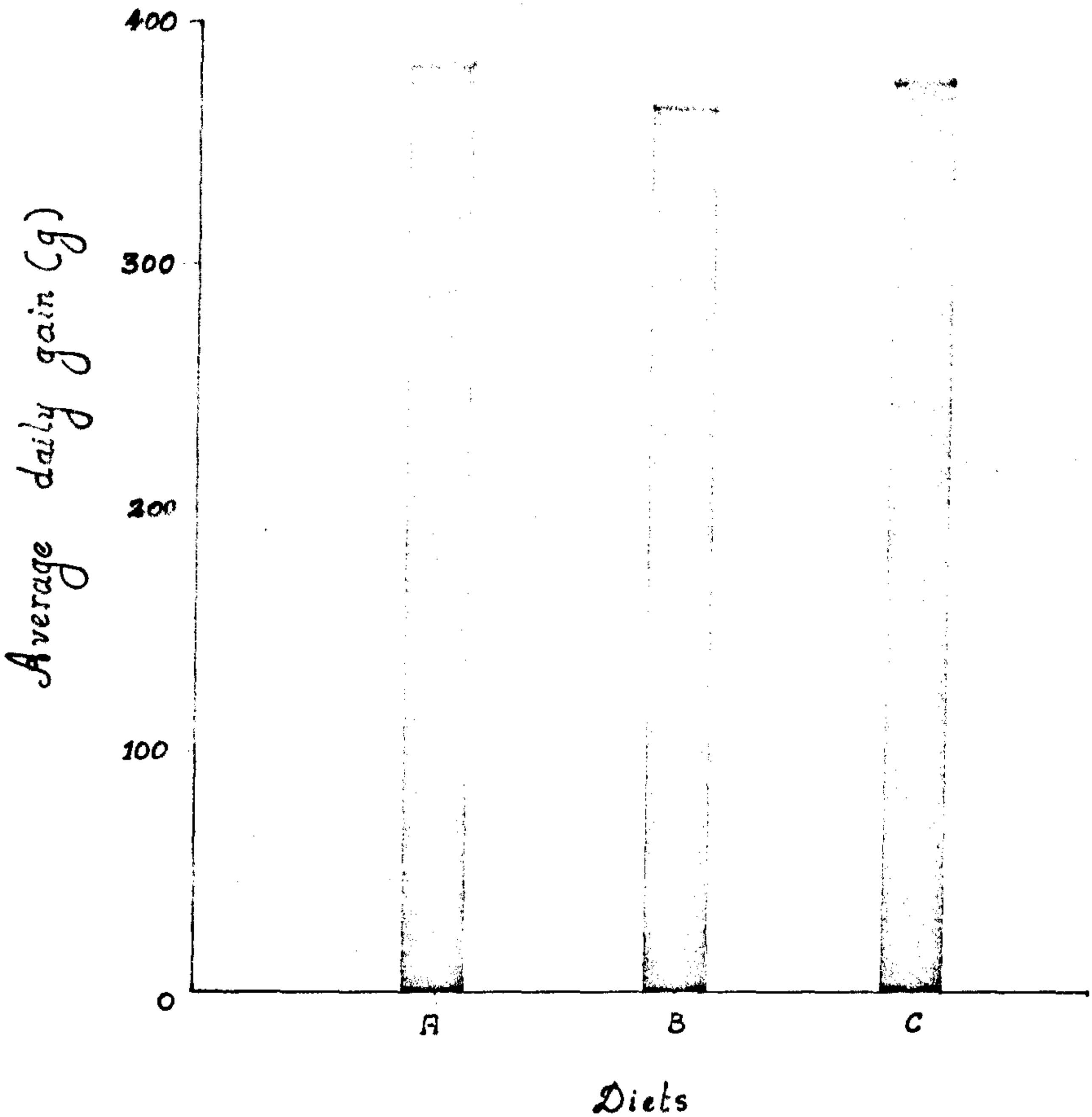


FIGURE-2

AVERAGE FORTNIGHTLY FEED EFFICIENCY OF ANIMALS ON THE DIFFERENT DIETARY TREATMENTS

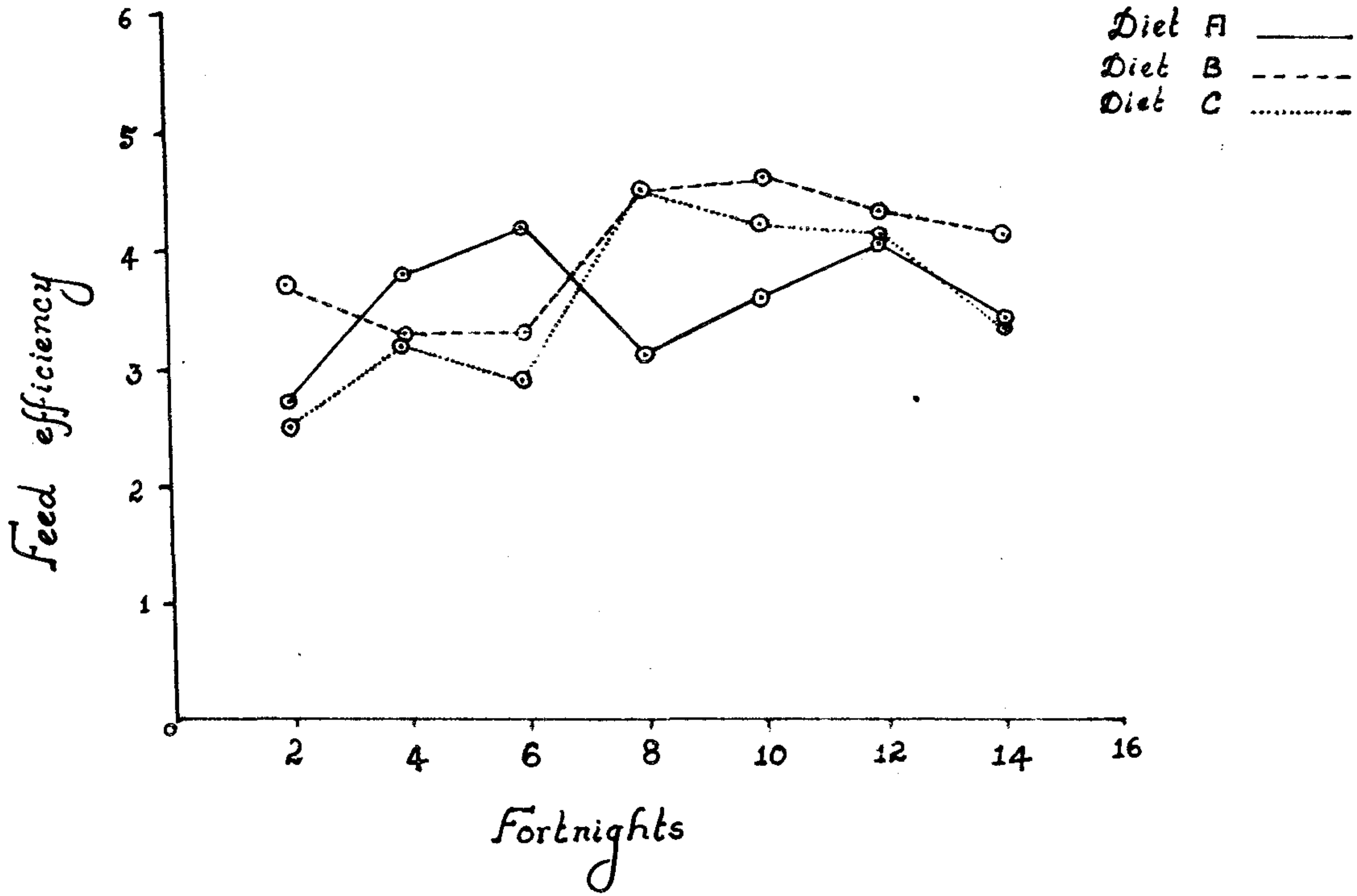


FIGURE - 3

AVERAGE CUMULATIVE FEED EFFICIENCY OF ANIMALS ON THE DIFFERENT DIETARY TREATMENTS

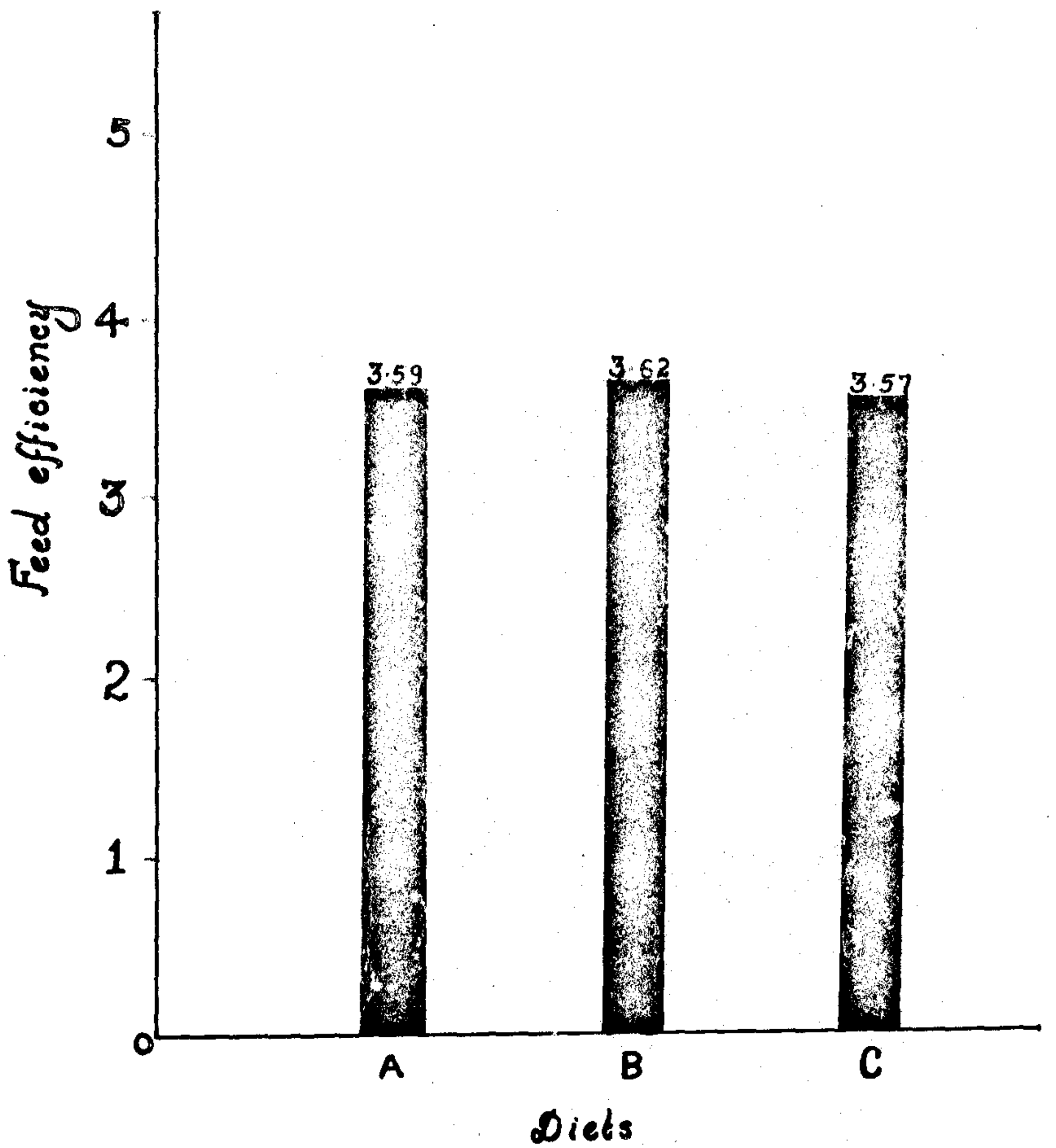


Table 12. Analysis of variance - Average daily gain (g)

Sources	df	SS	MSS	F
Treatments	2	998.6325	499.3162	0.11
Error	14	65527.9262	4680.5662	
Total	16	66526.5586		

Table 13. Analysis of variance - Average daily gain (g) (Sex wise)

Sources	df	SS	MSS	F
Sex	1	6434.8184	6434.8184	1.61
Error	15	60091.7402	4006.1160	
Total	16	66526.5586		

Table 14. Analysis of variance - Fortnightly feed efficiency

Soource	df	SS	MSS	F
Treatments	2	0.2969	0.1485	0.53
Periods	12	4.7416	0.3951	1.41
Error	24	6.7202	0.2800	
Total	38	11.7351		

Table 15. Body measurements (fortnightly values) of pigs maintained on the three dietary treatments

Body length (cm)

Diet A - Group I

Animal number	Sex	Fortnights														
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
4/178	M	60	65	74	78	80	84	90	101	102	104	110	116	117		
2/179	M	59	64	67	72	76	80	94	108	110	112					
2/178	M	67	69	79	82	83	84	104	110	114						
7/178	F	63	67	73	77	80	82	90	97	98	102	105	116	119	119	121
10/176	F	62	69	69	78	80	85	94	102	104	105	109				
7/176	F	64	71	76	79	83	87	89	98	100	100	104	113	115	120	122
Average		62.5	67.5	73.0	77.7	80.3	83.7	93.5	102.7	104.7	104.6	107.0	115.0	117.0	119.5	121.5
S.E.		±1.2	±1.1	±1.8	±1.3	±1.1	±1.0	±2.3	±2.2	±2.5	±2.0	±1.5	±1.0	±1.2	±0.5	±0.5

Table 16. Diet B - Group II

Animal number	Sex	Fortnights 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1/176	M	62	66	71	80	81	82	98	102	108	110					
3/176	M	63	66	68	77	80	86	94	100	101	102	103	113	118	122	122
1/178	M	63	67	72	73	78	81	84	95	99	99	102	106	110	118	119
8/176	F	65	69	70	74	85	89	97	101	103	104	113				
3/179	F	57	62	69	72	80	85	91	104	109	110	116				
6/178	F	62	72	73	76	84	89	93	95	100	103	106				
Average		62.0	67.0	70.5	75.3	81.3	85.3	92.8	99.5	103.3	104.7	108.0	109.5	114.0	120.0	120.5
S.E.		±1.1	±1.4	±0.8	±1.2	±1.1	±1.4	±2.1	±1.5	±1.7	±1.8	±2.8	±3.5	±4.0	±2.0	±1.5

Table 17. Diet C - Group III

nimal umber	Sex	Fortnights 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
/178	M	71	75	81	85	90	95	104	107	114							
/179	M	60	64	71	74	78	88	90	92	93	95	102					
/178	M	62	66	66	..	..	..	..	..	..	..	..					
/176	F	66	71	76	78	84	90	94	95	96	103	110					
/178	F	69	73	75	78	87	97	99	102	104	109						
/176	F	56	58	67	70	77	79	83	90	98	100	101	109	112	117	124	126
verage		64.0	67.8	72.6	77.0	83.2	89.8	94.0	97.2	101.0	101.7	104.3	109.0	112.0	117.0	124.0	126.0
.E.		±2.3	±2.6	±2.3	±2.5	±2.5	±3.2	±3.6	±3.2	± 3.7	±2.9	±2.8					

Table 18. Chest Girth (cm)
Diet A - Group I

Animal number	Sex	Fortnights														
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
4/178	M	51	56	60	63	65	67	69	76	82	84	85	90	92		
2/179	M	50	52	59	69	71	72	78	88	90	94					
2/178	M	56	60	69	71	75	77	84	93	94						
7/178	F	54	56	60	61	63	65	69	74	76	78	80	85	88	92	95
10/176	F	54	57	61	63	68	72	78	80	87	89	93				
7/176	F	54	61	66	66	67	69	71	75	77	79	79	85	86	90	93
Average		53.2	57.0	62.5	65.5	68.2	70.3	74.8	81.0	84.3	84.8	84.2	86.7	88.7	91.0	94.0
S.E.		±0.9	±1.3	±1.6	±1.6	±1.8	±1.7	±2.5	±3.2	±3.0	±3.0	±3.2	±1.7	±1.8	±1.0	±1.0

Table 19. Diet B - Group II

Animal number	Sex	Fortnights														
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1/176	M	51	54	60	67	70	74	76	84	93	93					
3/176	M	53	56	62	64	66	68	68	76	80	80	80	84	86	95	97
1/178	M	51	54	57	62	64	66	68	73	77	78	79	83	88	93	97
8/176	F	55	59	61	69	72	74	80	86	86	87	91				
3/179	F	47	52	56	61	69	71	80	87	91	91	94				
6/178	F	56	59	63	66	70	73	76	81	83	91	92				
Average		52.2	55.7	59.8	64.8	68.5	71.0	74.7	81.2	85.0	86.7	87.2	83.5	87.0	94.0	97.0
S.E.		±1.3	±1.2	±1.1	±1.2	±1.2	±1.4	±2.2	±2.3	±2.5	±2.6	±3.2	±0.5	±1.0	±1.0	

Table 20. Diet C - Group III

imal mber	Sex	Fortnights															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
'178	M	59	61	66	72	78	82	86	93	94							
'179	M	48	55	59	69	71	74	82	83	85	85	91					
'178	M	50	52	58	..	..	..	..	..	..	..	..					
'176	F	54	57	65	66	70	75	77	82	87	89	93					
'178	F	55	58	64	68	70	74	84	85	88	90						
'176	F	48	52	57	61	64	68	70	74	74	75	77	81	83	89	89	91
erage		52.3	55.8	61.5	67.2	70.6	74.6	79.8	83.4	85.6	84.7	87.0	81.0	83.0	89.0	89.0	91.0
.E.		±1.8	±1.4	±1.7	±1.8	±2.2	±2.2	±2.9	±3.0	±3.3	±2.4	±5.0					

Table 21. Height at Withers (cm)

Diet A - Group I

Animal number	Sex	Fortnights														
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1/178	M	31	36	36	40	42	43	45	49	55	56	58	64	68		
2/179	M	31	42	42	44	44	45	56	56	58	69					
2/178	M	36	37	39	42	44	45	50	53	54						
7/178	F	30	34	34	40	42	44	47	48	48	54	55	60	61	61	63
10/176	F	34	35	39	40	41	43	46	50	51	58	60				
7/176	F	31	36	37	39	41	42	46	48	49	51	52	60	60	60	60
Average		32.2	36.7	38.[illegible]	40.8	42.3	43.7	48.3	50.7	52.5	57.6	56.2	61.3	63.0	60.5	61.5
S.E.		±0.9	±1.1	±1.1	±0.7	±0.6	±0.5	±1.7	±1.3	±1.6	±3.1	±1.7	±1.3	±2.5	±0.5	±1.5

Table 22. Diet B - Group II

Animal number	Sex	Fortnights														
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1/176	M	35	37	39	40	45	47	50	50	52	60					
3/176	M	35	36	39	40	42	43	43	48	48	53	54	62	62	64	64
1/178	M	31	38	38	39	41	42	42	47	48	52	53	55	59	59	64
8/176	F	34	38	42	43	45	47	48	49	50	50	54				
3/179	F	30	32	35	38	40	43	47	48	51	54	56				
6/178	F	35	37	40	41	43	45	47	48	49	49	50				
Average		33.3	36.3	38.8	40.2	42.7	44.5	46.2	48.3	49.7	53.0	53.4	58.5	60.5	61.5	64.0
S.E.		±0.9	±0.9	±0.9	±0.7	±0.8	±0.9	±1.2	±0.4	±0.7	±1.6	±1.0	±3.5	±1.5	±2.5	

Table 23. Diet C - Group III

nimal umber	Sex	Fortnights															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
/178	M	35	36	43	43	44	46	51	54	56							
/179	M	33	37	39	40	42	44	46	50	51	52	53					
/178	M	32	37	40	..	..	..	..	..	..	..	..					
/176	F	38	39	40	41	43	45	48	49	52	52	53					
/178	F	36	40	41	42	42	43	45	52	58	60						
/176	F	32	37	37	38	40	43	47	47	48	49	50	55	57	58	58	60
verage		34.3	37.7	40.0	40.8	42.2	44.2	47.4	50.4	53.0	53.2	52.0	55.0	57.0	58.0	58.0	60.0
.E.		±1.0	±0.6	±0.8	±0.9	±0.7	±0.8	±1.0	±1.2	±1.8	±2.4	±1.0					

Table 24. Consolidated data showing average values of gains in body weight and body measurements up to eighth fortnight

Gain	Group I (Diet A)	Group II (Diet B)	Group III (Deit C)
Body weight (kg)	37.5 ±5.2	36.2 ±3.2	41.2 ±5.1
Body length (cm)	42.2 ±2.5	41.3 ±2.6	36.6 ±2.5
Heart girth (cm)	31.2 ±3.1	32.8 ±3.3	32.8 ±1.9
Height at withers (cm)	20.3 ±1.7	16.3 ±1.2	18.2 ±1.5

Table 25. Average digestibility coefficients of nutrients in the three experimental diets

Diets	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract	Total digestible nutrients
Diet A	81.8	80.3	66.9	40.0	90.1	77.0
Diet B	79.6	73.0	68.7	37.1	86.3	74.9
Diet C	82.4	78.4	69.9	39.2	90.1	79.4

Table 26. *Data on blood constituents of animals maintained on the three dietary treatments

Diet A - Group I

Animal number	Haemoglobin g/100 ml	Packed cell volume (%)	Plasma protein g/100 ml	Plasma calcium mg/100 ml	Plasma inorganic phosphorus mg/100 ml
2/179	13.5	34	7.11	14.10	5.53
2/178	14.5	38	8.32	12.61	4.81
10/176	14.2	36	7.80	12.00	5.14
7/176	13.6	36	6.48	12.60	5.73
Average	13.9	36	7.43	12.82	5.30
S.E.	±0.2	±0.8	±0.40	±0.45	±0.20

* Blood values of animals slaughtered were only included

Table 27.   Diet B - Group II

Animal number	Haemoglobin g/100 ml	Packed cell volume (%)	Plasma protein g/100 ml	Plasma calcium mg/100 ml	Plasma inorganic phosphorus mg/100 ml
1/176	14.5	38	7.89	12.20	5.07
3/176	13.0	35	7.94	10.81	5.33
3/179	14.8	38	8.30	13.00	5.52
6/178	13.6	36	6.60	12.70	5.91
Average	14.0	36.7	7.68	12.17	5.46
S.E.	±0.4	±0.7	±0.37	±0.49	±0.18

Table 28. Diet C - Group III

Animal number	Haemoglobin g/100 ml	Packed cell volume (%)	Plasma protein g/100 ml	Plasma calcium mg/100 ml	Plasma inorganic phosphorus mg/100 ml
5/178	13.6	34	7.78	12.20	5.13
1/179	13.5	34	7.35	12.51	5.91
9/176	14.6	38	7.65	13.20	5.57
9/178	13.5	38	7.36	14.25	4.94
Average	13.8	36.0	7.53	13.04	5.39
S.E.	±0.3	±1.2	±0.11	±0.46	±0.22

Table 29. Analysis of variance - Haemoglobin (g/100 ml)

Source	df	SS	MSS	F
Treatments	2	0.0717	0.0358	0.09
Error	9	3.5975	0.3997	
Total	11	3.6692		

Table 30. Analysis of variance -Packed cell volume (%)

Source	df	SS	MSS	F
Treatments	2	1.5000	0.7500	0.22
Error	9	30.7500	3.4167	
Total	11	32.2500		

Table 31. Analysis of variance - Plasma protein (g/100 ml)

Source	df	SS	MSS	F
Treatments	2	0.1312	0.0656	0.16
Error	9	3.7344	0.4149	
Total	11	3.8656		

Table 32. Analysis of variance - Plasma calcium (mg/100 ml)

Source	df	SS	MSS	F
Treatments	2	1.6154	0.8077	0.94
Error	9	7.7419	0.8602	
Total	11	9.3573		

Table 33. Analysis of variance - Plasma inorganic phosphorus (mg/100 ml)

Source	df	SS	MSS	F
Treatments	2	0.0482	0.0241	0.15
Error	9	1.4514	0.1613	
Total	11	1.4996		

Table 34. Carcass characteristics of animals maintained on the three dietary treatments

Diet A - Group I

Animal No.	2/179	2/178	10/176	7/176	Average S.E.
Sex	M	M	F	F	
Live body weight (kg)	74.0	71.5	74.0	71.5	72.7 ±0.7
Dressed weight without head (kg)	46.0	45.0	47.8	46.0	46.2 ±0.6
Dressing percentage without head	62.1	62.9	64.6	64.3	63.5 ±0.6
Carcass length (Cm)	75.5	75.0	76.0	77.5	76.0 ±0.5
Average backfat thickness (cm)	2.2	2.3	2.3	2.0	2.2 ±0.1
Eye-muscle area (cm^2)	20.88	29.98	27.44	28.25	26.64 ±2.0
Weight of leaf fat (g)	950	900	840	835	881.2 ±27.3
Weight of shoulder (kg)	11.3	10.5	10.6	12.2	11.2 ± 0.9
Percentage of shoulder against live weight	15.2	14.7	14.3	17.1	15.3 ±0.6
Weight of loin (kg)	11.4	10.5	10.6	10.4	10.7 ±0.3
Percentage of loin against live weight	15.4	14.7	15.7	14.5	15.1 ±0.3
Weight of side and spare ribs (kg)	8.4	8.5	9.5	8.2	8.6 ±0.3
Percentage of side and spare ribs against live weight	11.3	11.9	12.8	11.5	11.9 ±0.3

/Contd.../

Table 34 (contd)

	Animal No.	2/179	2/178	10/176	7/176	Average S.E.
	Sex	M	M	F	F	
Weight of ham (kg)		11.2	10.5	12.1	11.8	11.4 ±0.4
Percentage of ham against live weight		15.1	14.7	16.3	16.5	15.7 ±0.4
Weight of picnic shoulder (kg)		6.0	5.8	6.3	6.5	6.2 ±0.1
Weight of boston butt (kg)		4.7	4.3	3.9	4.9	4.5 ±0.2

Table 35. Diet B - Group II

Animal No.	1/175	3/176	3/179	6/176	Average S.E.
Sex	M	M	F	F	
Live body weight (kg)	69.5	71.0	74.0	69.0	70.9 ±1.1
Dressed weight without head(kg)	42.7	44.3	49.0	47.8	46.0 ±1.5
Dressing percentage without head	61.4	62.4	66.2	63.7	63.4 ±1.0
Carcass length (cm)	73.0	77.0	76.5	75.0	75.4 ±0.9
Average backfat thickness(cm)	2.4	2.1	2.5	2.5	2.4 ±0.1
Eye-muscle area (cm^2)	24.28	25.50	29.90	22.30	25.49 ±1.62
Weight of leaf fat (g)	1050	860	1430	1270	1152.5 ±124.8
Weight of shoulder (kg)	11.6	12.0	12.1	9.9	11.4 ±0.5
Percentage of shoulder against live weight	16.7	16.9	16.3	13.2	15.8 ±0.9
Weight of loin (kg)	10.1	10.2	10.9	12.1	10.8 ±0.5
Percentage of loin against live weight	14.5	14.4	14.7	16.1	14.9 ±0.4
Weight of side and spare ribs (kg)	9.2	7.9	10.0	10.4	9.4 ±0.6
Percentage of side and spare ribs against live weight	13.2	11.1	13.5	13.9	12.9 ±0.6
Weight of ham (kg)	10.6	10.5	12.4	11.9	11.4 ±0.5
Percentage of ham against live weight	15.2	16.5	16.7	15.9	16.1 ±0.3
Weight of picnic shoulder(kg)	5.5	6.5	6.7	5.6	6.0 ±0.3
Weight of boston butt (kg)	3.3	4.7	3.8	3.8	3.9 ±0.3

Table 36. Diet C - Group III

Animal No.	5/178	1/179	9/176	9/178	Average S.E.
Sex	M	M	F	F	
Live body weight (kg)	73.5	69.0	67.5	68.5	69.6 ±1.3
Dressed weight without head(kg)	47.5	44.4	43.4	44.0	44.8 ±0.9
Dressing percentage without head	64.6	64.3	64.1	64.2	64.3 ±0.1
Carcass length (cm)	78.0	71.5	76.0	75.5	75.3 ±1.4
Average backfat thickness (cm)	2.7	2.2	2.3	2.6	2.5 ±0.1
Eye-muscle area (cm^2)	24.68	23.86	23.98	21.94	23.61 ±0.6
Weight of leaf fat (g)	1300	1290	995	1370	1238.7 ± 83.2
Weight of shoulder (kg)	10.3	11.3	10.6	9.2	10.4 ±0.4
Percentage of shoulder against live weight	14.0	16.4	15.8	13.8	14.9 ±0.7
Weight of loin (kg)	10.9	11.0	9.6	10.4	10.5 ±0.3
Percentage of loin against live weight	14.8	15.9	14.3	15.2	15.1 ±0.4
Weight of side and spare ribs (kg)	9.9	7.8	9.4	9.8	9.2 ±0.5
Percentage of side and spare ribs against live weihgt	13.5	11.3	13.9	14.3	13.2 ±0.7
Weight of ham (kg)	11.0	11.0	10.7	10.5	10.8 ±0.1
Percentage of ham against live weight	15.0	15.9	15.8	15.3	15.5 ±0.2
Weight of picnic shoulder (kg)	5.3	6.2	6.0	4.8	5.6 ±0.3
Weight of boston butt(kg)	4.4	4.6	3.8	3.5	4.1 ±0.2

Table 37. Analysis of variance - Dressing percentage without head

Source	df	SS	MSS	F
Treatments	2	1.9940	0.9970	0.82
Sex	1	7.2840	7.2840	5.97*
Error	8	9.7650	1.2206	
Total	11	19.0430		

* Significant at 5 per cent level

Table 38. Analysis of variance - Carcass length (cm)

Source	df	SS	MSS	F
Treatments	2	1.2920	0.6460	0.16
Sex	1	3.5210	3.5210	0.88
Error	8	31.8850	3.9857	
Total	11	36.7300		

Table 39. Analysis of variance - Average backfat thickness (cm)

Source	df	SS	MSS	F
Treatments	2	0.1317	0.0659	1.60
Sex	1	0.0075	0.0075	0.18
Error	8	0.3300	0.0413	
Total	11	0.4692		

Table 40. Analysis of variance - Eye-muscle area (Cm^2)

Source	df	SS	MSS	F
Treatments	2	18.6235	9.3118	0.91
Sex	1	1.7710	1.7710	0.17
Error	8	81.4498	10.1812	
Total	11	101.8443		

Table 41. Analysis of variance - Weight of leaf fat

Source	df	SS	MSS	F
Treatments	2	0.2784	0.1392	4.18
Sex	1	0.0127	0.0127	0.38
Error	8	0.2662	0.0333	
Total	11	0.5573		

Table 42. Analysis of variance - Percentage of shoulder against live weight

Source	df	SS	MSS	F
Treatments	2	1.4550	0.7275	0.32
Sex	1	1.1101	1.1101	0.50
Error	8	17.9192	2.2399	
Total	11	20.4843		

Table 43. Analysis of variance - Percentage of loin against live weight

Source	df	SS	MSS	F
Treatments	2	0.0470	0.0235	0.04
Sex	1	0.0520	0.0520	0.10
Error	8	4.2377	0.5297	
Total	11	4.3367		

Table 44. Analysis of variance - Percentage of side and spare ribs against live weight

Source	df	SS	MSS	F
Treatments	2	4.0754	2.0377	2.47
Sex	1	4.7375	4.7375	5.74*
Error	8	6.6047	0.8256	
Total	11	15.4176		

* Significant at 5 per cent level

Table 45. Analysis of variance - Percentage of ham against live weight

Source	df	SS	MSS	F
Treatments	2	0.7002	0.3501	0.96
Sex	1	1.4421	1.4421	3.93
Error	8	2.9322	0.3665	
Total	11	5.0745		

Table 46. Body fat characteristics of pigs maintained on the three dietary treatments

Diet A - Group I

Animal number	Sex	Subcutaneous fat			Leaf fat		
		Melting point (°C)	Saponification value	Iodine number	Melting point (°C)	Saponification value	Iodine number
2/179	M	40.0	198.80	62.43	41.5	202.77	51.84
2/178	M	37.5	204.61	59.50	44.5	202.49	53.87
10/176	F	38.5	206.53	63.00	42.0	198.30	52.09
7/176	F	39.0	196.45	61.46	45.0	191.96	49.22
Average		38.7	201.60	61.60	43.2	198.88	51.75
S.E.		±0.5	± 2.38	±0.77	±0.9	± 2.52	±0.96

Table 47. Diet B - Group II

Animal number	Sex	Subcutaneous fat			Leaf fat		
		Melting point (°C)	Saponification value	Iodine number	Melting point (°C)	Saponification value	Iodine number
1/176	M	38.5	202.47	57.88	41.0	192.51	47.94
3/176	M	40.0	201.61	58.20	44.0	205.82	50.21
3/179	F	39.5	203.26	58.79	43.5	197.70	51.79
6/178	F	41.0	205.70	61.09	42.5	204.69	50.63
Average		39.7	203.26	58.99	42.7	200.18	50.14
S.E.		±0.5	± 0.88	±0.72	±0.7	± 3.12	±0.81

Table 48. Diet C - Group III

Animal number	Sex	Subcutaneous fat			Leaf fat		
		Melting point (°C)	Saponification value	Iodine number	Melting point (°C)	Saponification value	Iodine number
5/178	M	36.5	196.05	59.44	43.5	198.03	55.08
1/179	M	38.5	202.97	56.99	41.0	204.02	47.78
9/176	F	39.9	198.04	57.88	43.0	199.27	46.61
9/178	F	41.0	202.71	54.36	41.5	205.28	51.34
Average		38.9	199.96	57.17	42.2	201.65	50.22
S.E.		±0.9	± 1.73	±1.06	±0.6	± 1.77	±1.90

Table 49. Analysis of variance - Melting point - subcutaneous fat

Source	df	SS	MSS	F
Treatments	2	2.3750	1.1875	0.62
Error	9	17.1875	1.9097	
Total	11	19.5625		

Table 50. Analysis of variance - Saponification value - subcutaneous fat

Source	df	SS	MSS	F
Treatments	2	22.0116	11.0058	0.88
Error	9	112.6235	12.5137	
Total	11	134.6351		

Table 51. Analysis of variance - Iodine number - subcutaneous fat

Source	df	SS	MSS	F
Treatments	2	39.6606	19.8303	5.62*
Error	9	26.9701	2.9967	
Total	11	66.6307		

Treatments	A	B	C
Mean	61.60	58.99	57.17

C.D. of treatments at 5 per cent level 2.77

C.D. of treatments at 1 per cent level 3.98

* Indicate significance at 5% level

Table 52. Analysis of variance - Melting point - Leaf fat

Source	df	SS	MSS	F
Treatments	2	2.0000	1.0000	0.48
Error	9	18.7500	2.0833	
Total	11	20.75		

Table 53. Analysis of variance - Saponification value - Leaf fat

Source	df	SS	MSS	F
Treatments	2	15.3400	7.6700	3.35
Error	9	231.0900	25.6767	
Total	11	246.4300		

Table 54. Analysis of variance - Iodine number -leaf fat

Source	df	SS	MSS	F
Treatments	2	6.6853	3.3427	0.48
Error	9	62.6848	6.9650	
Total	11	69.3701		

Table 55. Comparison between subcutaneous fat and leaf fat using 't' test.

Fat constants	't' value
Melting point	5.6365**
Saponification value	0.9526
Iodine number	9.5936**

* indicates significance at 5 per cent level

** indicates significance at 1 per cent level

Table 56. Details of calculation of other costs (in rupees) of pigs maintained on the three experimental rations

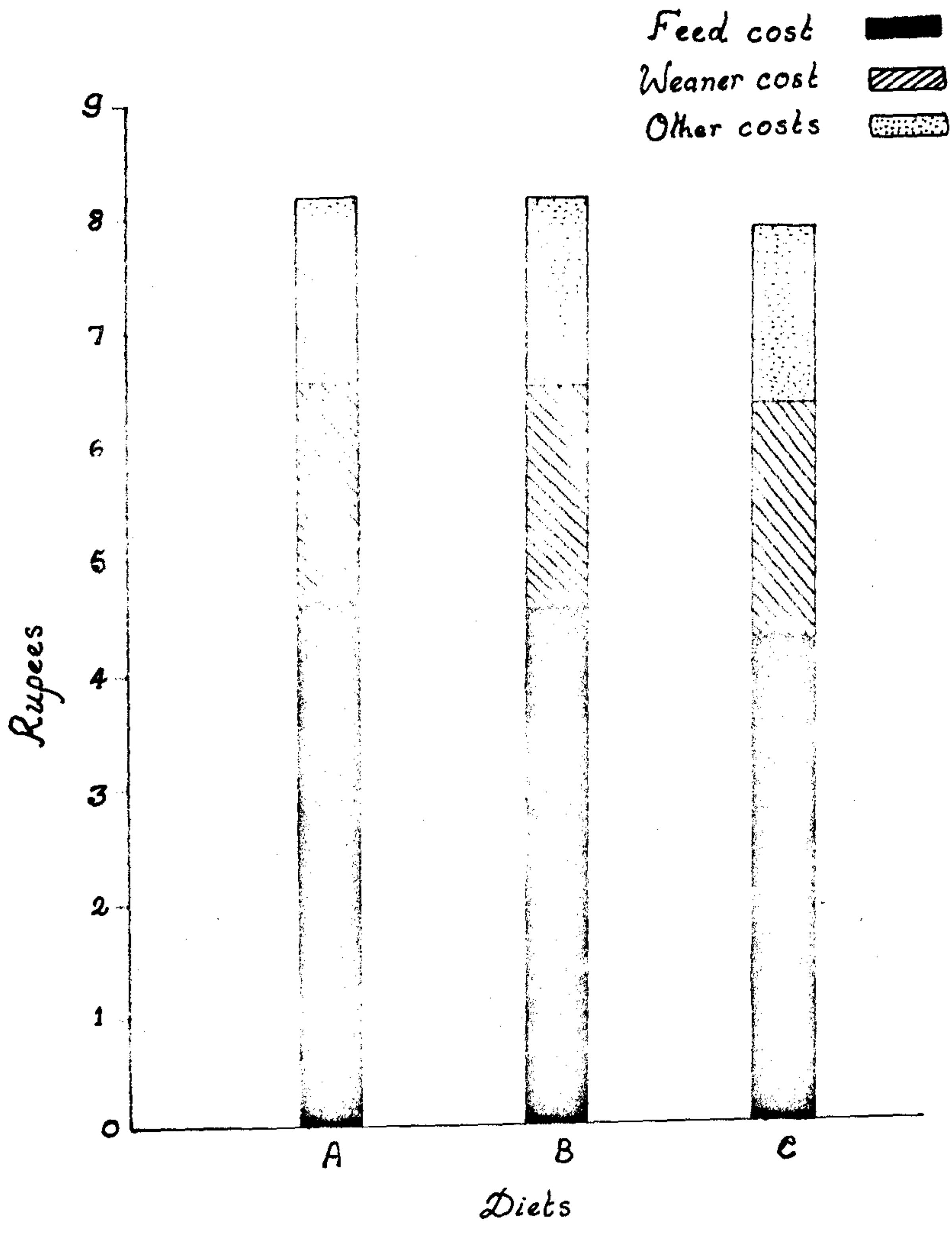
Diets	A	B	C
Number of days under experiment	160	162	153
Initial cost per pigling (Rupees)	141.90	140.80	141.90
Feed cost per pig	332.01	323.21	300.77
Details of other costs			
Veterinary aid per pig	1.50	1.50	1.50
Labour charges @ 29 paise per pig per day ie. 2 labourers for 100 pigs @ Rs.14.50 per day	46.40	46.98	44.37
Water and electricity charges @ one paise per pig per day ie. 30 lit. per day per pig @ 25 paise per 1000 lit.	1.60	1.62	1.53
Interest for veterinary aid, labour and water charges @ 6%	1.29	1.32	1.18
Interest for feed cost @ 6%	8.73	8.61	7.56
Interest @ 12% for the initial cost of piglings @ Rs.11/- per kg live weight	7.46	7.50	7.30
Interest @ 12% for the cost of building @ Rs.20/- per sq. feet at the rate of 35 sq.ft. per pig	36.82	37.28	35.21
Depreciation for building @ 5 per cent	15.34	15.53	14.67
Total other costs per pig	119.14	120.34	113.32

Table 57. Details of production cost per kilogram live weight of pigs maintained on the three dietary treatments

Diets		A	B	C
Average initial cost of pigling @ Rs.11/-per kg	Rs.	141.90	140.80	141.90
Total feed cost per pig		332.01	323.21	300.77
Total other costs per pig		119.14	120.34	113.32
Total cost per pig		593.05	584.35	555.99
Average weight at slaughter (kg)		72.4	71.3	69.7
Cost of production per kg live weight	Rs.	8.20	8.19	7.98
<u>Breakup of production cost per kg liveweight</u>				
Initial cost of pigling		1.96	1.97	2.04
Feed cost		4.59	4.53	4.32
Other costs		1.65	1.69	1.63
Total		8.20	8.19	7.99

FIGURE-4

COST OF PRODUCTION PER KILOGRAM BODY WEIGHT ON THE THREE DIETARY TREATMENTS



DISCUSSION

DISCUSSION

Growth

From the results presented in tables 1 to 3 it will be seen that the animals maintained on the three dietary treatments gained weight satisfactorily and at comparable rates during the entire period of the experiment or till they attained the slaughter weights of around 70 kg. Results set out in tables 4 to 6 indicate that with all the three diets there was a similar increase in daily gain, the rate of gain being higher from 50 to 70 kg body weight when compared to those in earlier periods. There are reports of similar rate of increase in live weight gain in pigs (Blair et al. 1969 and Bhagwat and Sahasrabudhe, 1971). Statistical analysis of the results on growth (Tables 7 to 13) indicate that there were no significant differences in growth rate of animals on the three dietary treatments, A, B and C, the overall average daily gains being 385.9, 368.0 and 380.2 g respectively for the three groups I, II and III. The total average food intake of the animals were also similar, the values being 213.4, 212.0 and 201.9 kg for the three dietary treatments A, B and C respectively (Table 11.). The above results indicate that the three rations were of similar palatability and produced comparable growth response in grower pigs. The similar values for total protein and calculated metabolisable energy for the three rations coupled with the above findings help in concluding that the rations were isocaloric in addition to being isoproteinic. Tapioca is richer in calorific value compared to other tubers (Nestle, 1976; Achaya, 1976 and Oyenuga and Fetuga, 1975) and is almost of the same value as that of cereals (Raja et al. 1979). Rey (1978) reported metabolisable energy values of 3.08 and 3.13 Mcal/kg respectively for tapioca and maize. Omaghese and Bowland (1977) reported overall daily gains of only 290, 280 and 260 g respectively with three diets containing tapioca chips at levels of 0,20 and 40 per cent. Ramachandran (1977) in his studies on the effects of different energy protein levels on growth and carcass characteristics in swine, observed an average daily gain of 418 g under a similar dietary protein regime and using tapioca as the major energy source. While Bhagwat and Sahasrabudhe (1971) reported an average daily gain of 453 g, Rao et al. (1978) recorded only 295 g in pigs of Large White Yorkshire breed. Though the results obtained in the present investigation indicate that dried tapioca chips is almost similar in feeding value as that of maize in isoproteinic rations, Manickam et al.

(1976) recorded relatively higher overall daily gains, though not statistically significant with diets containing tapioca at a level of 60 per cent in complete replacement of maise as an energy source. Almost similar results were also reported by Oyenuga (1961) in his studies using raw and boiled cassava in place of guinea corn. The widely varying reports on growth rates of pigs under almost similar dietary regimes might be due to several other factors like genetic and environmental besides nutritional, influencing growth in animals.

As regards the time taken by the experimental animals to attain the slaughter weight of 70 kg, data presented in tables 10 and 11 indicate that it was essentially the same with all the three dietary treatments. This observation is supported by the similar rates of growth shown by the animals in all the three groups.

The results of the present study also indicate that though generally males grew faster than females, there were no significant differences in respect of sex (Tables 10 to 13). Morgan <u>et al.</u> (1959) and Hansson, (1974) also reported similar results. On the other hand, Robinson and Lewis (1964) and Blair and English (1965) did not observe any influence of sex on growth rate in swine.

Tables 15 to 23 present data on body measurements of animals recorded at fortnightly intervals during the entire period of experiment. Consolidated data on gains in body weight and body measurements up to the eighth fortnight are set out in table 24. These results indicate that gains in body measurements take place parallel to gains in body weight. Thus, the conclusions drawn on the basis of observations on body weights have been validated by those on body measurements. An over all evaluation of the above results indicate that there was no significant difference in the growth response produced by isoproteinic diets in which tapioca replaced maize at 0, 50 and 100 per cent levels. Bardoloi et al. (1978) observed that body weights and body measurements like body length, chest girth and height at withers have positive and significant coefficients of correlation among the major growth traits at various ages. There are limited number of reports on the use of body measurements for the estimation of live body weights in pigs (Gonzales, 1952 and Eusebio and Sanes, 1970).

Feed efficiency

From the results set out in tables 4 to 6, 11 and 14 and represented in figures 2 and 3 it will be seen that all the animals showed almost similar overall feed conversion efficiency, the average values being 3.59, 3.62 and 3.57 for the three groups I, II and III respectively. The data on fortnightly feed efficiency (Tables 4 to 6) indicate a trend of decreased feed efficiency with advancing age though almost similar values were obtained during the second and third phases of the experiment with all the three dietary treatments. Ranjhan et al.(1972) obtained an average feed efficiency of 3.0 up to 50 kg and 4.3 from 50 to 70 kg body weight in pigs. Kumar et al. (1974) recorded feed efficiency values of 3.4, 4.0 and 4.5 for body weights of 50 kg, 50 to 70 kg and 70 to 90 kg respectively. While Bhagwat and Sahasrabudhi (1971) reported an overall feed efficiency value of 4.2, Saseendran (1979) recorded values of 3.94 for males and 3.53 for females with pigs of Large White Yorkshire breed. The results obtained during the present study are in agreement with those reported by Onaghese and Bowland (1977). Ramachandran (1977) recorded an overall feed efficiency of only 4.18 under a similar dietary regime. Manickam et al. (1976), on the other hand, reported higher feed efficiency values on tapioca based diets than on maize based diets though the results were not statistically significant.

Results of the digestion experiments conducted towards the end of the second phase of the experiment (Table 25) indicate that there were no marked differences in the average digestibility coefficients of nutrients in the three diets. The almost uniform values obtained in regard to the digestibilities of protein, ether extract, crude fibre and nitrogen free extract in all the three diets clearly reveal that dried tapioca chips was as efficiently utilised as maize by the growing and finishing swine. A trend of lower values for digestibility coefficients of nutrients excepting for ether extract was evident with the group II. This was also reflected in their average daily gains (Table 11). This finding cannot be explained on the basis of the present data. Data on digestibilities of nutrients in rations containing dried tapioca chips at higher levels as used in the present study are scanty in literature. The results obtained for the digestibility coefficients of nutrients in maize diets are almost similar to those reported by Hale et al. (1978). The similar values for the digestibility coefficients of nutrients in maize and tapioca based diets further support the results on growth and feed efficiency that dried tapioca is of almost same feeding value as that of maize at the levels used in the present study. The average calculated TDN values of the three diets A, B and C were found to be 77.0, 74.9 and 79.4 respectively.

Blood values

In tables 26 to 28 are presented data on blood constituents of animals recorded at the end of the feeding regime. Statistical analysis of the results on haematological studies (Tables 29 to 33) indicate that there were no significant differences among the three diets in respect of any of the variables studied. Further, it can be seen that all the values recorded in the present study fall within the normal range for the species as reported in literature. While Doxey (1971) and Coffin (1973) observed almost similar values for haemoglobin, Dukes (1955) and Kunjikutty et al. (1977) reported relatively lower average values of 11.95 and 8.20 respectively. PCV values recorded for the animals in the three groups I, II and III were found to be 36.0, 36.7 and 36.0 respectively. Dukes (1955); Schalm (1961) and Doxey (1971) reported average PCV values of 41.5, 38.5 and 42.0 respectively in pigs. The plasma protein concentrations recorded in the present study are in agreement with the values reported by most of the workers (Cornelius and Kaneko, 1963; Doxey, 1971; Sebastian, 1972 and Kunjikutty *et al.* 1977). The plasma calcium levels of 12.82, 12.17 and 13.04 obtained for animals in the three groups I, II and III respectively are found to be higher when compared to those reported by Cornelius and Kaneko (1963); Ullery *et al.* (1967); Doxey, (1971) and Sebastian (1972) and almost similar to those reported by Dukes (1955). The plasma inorganic phosphorus concentrations recorded in respect of animals of the three groups I, II and III were shown to be 5.30, 5.46 and 5.39 respectively. Dukes (1955) reported a range of 5 to 8 mg per cent for plasma inorganic phosphrus concentration in pigs. Ullery *et al.* (1967); Sebastian (1972) and Kunjikutty *et al.* (1977) reported average inorganic phosphorus values of 7.10, 6.06 and 7.70 respectively. On the other hand, Cornelius and Kaneko (1963) reported higher values of 10.94 in pigs at the age of 6 months. An overall evaluation of the results on haematological studies indicates that the animals under all the three dietary treatments keep normal nutritional status and inclusion of dried tapioca chips in place of maise even at a level of 40 per cent in the rations of growing and finishing swine does not exert any deleterious effect on the physiological well being of the animals in as much as all the values for blood constituents recorded in the present study fall within the normal range for the species.

Carcass characteristics

Data on carcass characteristics presented in tables 34 to 36 and their statistical analysis in tables 37 to 45 indicate that there were no significant differences among the three dietary treatments in as much as the average values in regard to the different parameters studied were almost similar in animals of all the three groups. The average values for dressing percentage without head recorded for the animals in the groups I, II and III were 63.5, 63.4 and 64.3 respectively. Manickam *et al.* (1976) reported similar values for dressing percentages with diets containing either maize or tapioca at a level of 60 per cent. Ramachandran (1977) in his studies with a similar dietary protein regime and using tapioca as the major source of energy, reported an average dressing percentage of 70.2 for animals slaughtered at a body weight of 70 kg. Kunjikutty *et al.* (1977) also reported similar values of dressing percentage for animals maintained on diets containing 42 per cent tapioca chips and slaughtered at a body weight of around 50 kg.

Results of the present study showed that dressing percentages were higher with females than with males, the differences being statistically significant ($P < 0.05$). Similar results were reported by Blair and English (1965) and Deo et al. (1980). On the other hand, Shanmughanatham and Ranganathan (1972) did not find any influence of sex on dressing percentage in swine. Zobrisky et al. (1959) has pointed out that the dressing percentage is a valuable single measure of live hog value.

It can be seen from tables 34 to 36 that the carcass length recorded in respect of animals in the three groups I, II and III were similar and found to be 76.0, 75.4 and 75.3 cm respectively. The above results are in agreement with those of Manickam et al. (1976) who also could not observe any difference in carcass length between animals maintained on diets containing either maize or tapioca chips and slaughtered at a body weight of 70 kg. Ramachandran (1977) reported values almost similar to those obtained in the present study. Sebastian (1972) recorded an average value of 77.0 in pigs slaughtered at a body weight of 70 kg. Robinson (1965) observed a positive correlation between energy intake and carcass length in swine. The results on the influence of sex on body length obtained in the present study are in keeping with those reported by Morgan et al. (1959), but at variance with those recorded by Deo et al. (1980).

The backfat thickness was not found to be significantly influenced by variation either in dietary treatments or in sex of the animals in as much as similar values of 2.2, 2.4 and 2.5 were obtained for the groups I, II and III respectively. But, there appears to be a trend of higher fat deposition when tapioca replaces maize at a higher level. This doubt is reinforced by the observations on leaf fat content described in the following paragraph. Manickam et al. (1976) recorded comparatively higher but uniform values of 3.54 and 3.44 in animals maintained on maize and tapioca based diets respectively and slaughtered at a body weight of 70 kg. Ramachandran (1977) reported an average value of 2.98 under a similar dietary regime as used in the present study. While Blair et al. (1969) reported higher backfat thickness in males compared to those in females, Deo et al.(1980) did not notice any influence of sex in this regard.

A comparison of the diets in respect of fat accumulated around the internal organs clearly reveals that inclusion of tapioca tended to promote higher deposition of fat in swine. The average quantities of leaf fat recorded with the tapioca based diets were markedly higher, though not statistically significant, compared to those with diets containing similar levels of maize, the values for the three diets A, B and C being 881.2, 1152.5 and 1238.7 g respectively. While comparing the feeding value of tapioca with that of guinea corn, Oyenuga and Opeke (1957) observed a greater accumulation of fat around the kidney and other internal organs in animals maintained on tapioca based diets. In studies on albino rats to assess the influence of type of carbohydrates on protein utilisation Thomas and Chandran (1974) also observed a greater deposition of internal fat in animals fed on tapioca starch diets.

The data on loin-eye area did not reveal any significant difference either due to variation in dietary treatments or in sex. Manickam et al. (1976) also reported similar results. While Sebastian (1972) recorded a similar value of 26.9 as obtained in the present study, Ramachandran (1977) reported an average value of 30.3 with animals at similar slaughter weights. Though

Deo et al. (1980) observed a positive influence of sex on eye-muscle area, Blair et al. (1969) recorded contradictory results.

The percentages of all the important prime cuts Viz., shoulder, loin, side and spare ribs, and ham against live body weights, were almost similar with all the three diets. Though a trend of higher percentages for prime cuts in females than in males was observed with all the three diets, there was significant difference in this regard only with respect to side and spare ribs. Blair et al. (1969) and Gilster and Wahlstrom (1973) reported higher percentages for all prime cuts in females than in males. On the other hand, Morgan et al. (1959) and Shanmuganathan and Ranghanathan (1973) did not observe any influence of sex on the percentages of prime cuts in swine.

Data on fat constants presented in tables 46 to 55 clearly reveal that the diets did not seem to influence the melting point, since the same in respect of both subcutaneous and leaf fat were similar with all the three dietary treatments. Melting points recorded in the present study also fall within the normal range of values as reported in literature (Maynard and Loosli, 1969; McDonald, 1973 and Ramachandran, 1977). The above results also indicate that there was marked difference between subcutaneous and leaf fat in regard to melting point, the values obtained for the subcutaneous fat being significantly lower when compared to those for leaf fat with all the three diets. The variation in the nature of fat depending upon the location in the body has been well established, the subcutaneous fat being softer and more unsaturated than deep fat (Maynard and Loosli, 1969; Lister et al. 1974; and McDonald, 1975). Body fat synthesied from carbohydrate is harder and more saturated in type (Maynard and Loosli, 1969). Henriques and Hansen (1901) suggested that temperature differences between subcutaneous and internal regions could explain the difference in unsaturation. The increased unsaturation of subcutaneous fat relative to internal depots is mainly due to an increase in oleic acid at the expense of stearic acid (Lister et al. 1974).

Saponification value of body fat was not found to be influenced by variation in dietary treatments and in location in the body in as much as similar values were obtained for both subcutaneous and leaf fat with all the three dietary treatments. A similar range of values for saponification number as obtained in the present study was also reported by many other workers (Maynard and Loosli, 1969; Sebastian, 1972; McDonald, 1975 and

Ramachandran, 1977).

Iodine number of fat was found to be influenced both by dietary variations and by differences in their location in the body. On a perusal of the data on iodine values of subcutaneous fat, it is seen that though the differences between diets A and B and between B and C were not significant, the same between diets A and C was significant ($P < 0.05$). The higher iodine values for subcutaneous fat compared to leaf fat only support the previous observation with respect to melting point. In regard to both subcutaneous and leaf fat iodine number was found to be higher with maize based diets though there was significant difference only with respect to subcutaneous fat. Jucker et al. (1966) and Forbes and Holme (1968) recorded higher iodine values for backfat collected from animals fed on diets containing maize compared to those on other cereal based diets. The iodine values obtained with the tapioca based diets in the present study are similar to those reported by Ramachandran (1977) in his experiments using a similar dietary regime. A relatively higher percentage of unsaturated fat in maize can possibly account for the higher iodine values recorded for the diets with maize compared to those with tapioca.

From the tables 56 and 57 and figure 4, it can be seen that the cost of production calculated per kilogram live weight of the animals in the three groups I, II and III under the respective dietary treatments A, B and C were found to be Rs.8.20, 8.19 and 7.99 respectively, clearly indicating that dried tapioca chips can be included at a level of 40 per cent replacing maize with monetary benefit.

An overall critical evaluation of the results obtained in the present study indicates that dried tapioca chips is a suitable substitute for conventional cereal grains like maize in swine rations in as much as similar growth rates, feed conversion efficiency and carcass characteristics were obtained with three isoproteinic rations containing 0, 20 and 40 per cent levels of dried tapioca chips in partial or complete replacement of maize.

SUMMARY

SUMMARY

An investigation was carried out to assess the effects of isoproteinic rations containing dried tapioca chips in partial or complete replacement of maize, on growth and carcass characteristics in swine. Eighteen Large White Yorkshire weanling pigs were divided into three groups (Group I, II and III) of six animals each as uniformly as possible in regard to litter, sex, age and weight and were allotted to the dietary treatments A, B and C with 0, 20 and 40 per cent levels respectively of tapioca chips in partial or complete replacement of maize. All the animals were maintained on the respective diets with 18 per cent total protein up to an average live weight of 20 kg, with 16 per cent protein up to 50 kg and with 14 per cent protein, till they attained a body weight of around 70 kg.

Records of daily feed intake and fortnightly body weights and body measurements were maintained throughout the period of experiment. Towards the end of the second phase of the experiment, a digestion trial was carried out to find out the digestibility coefficients of nutrients in the three rations. Two males and two females each from all the three experimental groups were slaughtered when they attained the body weight of 70 kg for gathering data

on carcass characteristics. Representative samples from subcutaneous and leaf fat were collected for the determination of fat constants. Analysis of blood constituents was also carried out to assess the nutritional status of the animals.

Animals under all the three dietary treatments gained weight satisfactorily and at similar rates throughout the course of the experiment, the overall average daily gains being 385.9, 368.0 and 380.2 g for the three groups, I, II and III respectively. The three diets were of similar palatability and the total food intake of the animals were similar, the average values being 213.4, 212.0 and 201.9 kg for the three dietary treatments A, B and C respectively. The time taken by the animals in the three groups to attain 70 kg body weight was also found to be similar. The data on body measurements indicated that gains in body measurements took place parallel to gains in body weights. As regards feed conversion efficiency, there were no significant differences among the three dietary treatments, the values being 3.59, 3.62 and 3.57 respectively for the three groups I, II and III. Results of digestion experiments indicated that there were no significant differences in digestibility coefficients of nutrients in the three rations suggesting that dried tapioca chips was as efficiently utilised as maize by growing and finishing swine. The calculated TDN values of the three diets A, B and C were found to be 77.0, 74.9 and 79.4 respectively.

Results of haematological studies indicated that the blood constituents viz., haemoglobin, packed cell volume, plasma protein, plasma calcium and inorganic phosphorus levels recorded for the animals in all the three groups were within the normal range without any significant difference between the diets indicating that the animals maintained normal nutritional status and inclusion of dried tapioca chips up to 40 per cent in place of maize did not exert any deleterious effect on the physiological well being of the animals.

Data on carcass characteristics indicated that there were no significant differences among the three dietary treatments in regard to the different parameters studied. The average values for dressing percentages without head for the animals in the three groups I, II and III were similar and found to be 63.5, 63.4 and 64.3 respectively. Dressing percentages were significantly higher in females than in males. The carcass length recorded in respect of animals in the three groups I, II and III were shown to be 76.0, 75.4 and 75.3 respectively. Inclusion of tapioca chips at higher levels tended to promote greater fat deposition in the body. The average quantities of leaf fat recorded with tapioca based diets were markedly higher, though not significant, the values for the three diets A, B and C being 881.2, 1152.5 and 1238.7 g respectively. Backfat thickness also reflected a similar trend, but less clearly, the average values for the groups I, II and III being 2.2, 2.4 and 2.5 respectively. The data on loin-eye area did not reveal any significant difference either due to variation in dietary treatments or in sex. The average values for the three groups I, II and III were found to be 26.64, 25.49 and 23.61 cm respectively. The percentages of all the important prime cuts viz., shoulder, loin, side and spare ribs and ham were almost similar with all the three diets. Though a trend of higher percentages for prime cuts in females than in males was observed, there was significant difference only with respect to side and spare ribs.

The diets did not seem to influence melting point since the same in respect of both subcutaneous and leaf fat were similar with all the three dietary treatments and were within the normal range for the species. There was significant difference between subcutaneous and leaf fat in regard to melting point, the values obtained for subcutaneous fat being lower than those for leaf fat, indicating the greater unsaturation of subcutaneous fat compared to leaf fat. Saponification values of body fat were almost similar with all the three dietary treatments in regard to both subcutaneous and leaf fat. Iodine number of fat was influenced both by dietary variations and by differences in the location in the body. With respect to both subcutaneous and leaf fat, iodine number was shown to be higher with maize based diets though there was significant difference only in regard to subcutaneous fat.

The cost of production arrived at per kilogram live weight of animals in the groups I, II and III were found to be Rs.8.20, 8.19 and 7.99 respectively.

In the light of the above findings, it can be concluded that tapioca chips can replace cereal grains like maize up to a level of 40 per cent in swine rations, producing similar weight gains with equal feed efficiency and without causing any physiological dysfunction in animals. Further, at current market prices, inclusion

REFERENCES

REFERENCES

*Achaya, K.T. (1975). Cited by Raja, K.C.M., Abraham, E.H., Sreemulanathan, H. and Mathew, A.G. (1979). Chemistry and Technology of Cassava. Indian Food Packer. 33 (3) : 31-43.

Agarwala, O.P. (1963). Correlation among certain carcass traits in pigs. Indian Vet. J. 40 : 301-303.

Allee, G.L., Baker, D.H. and Leville, G.A. (1971). Fat utilisation and lipogenesis in the young pigs. J. Nutr. 101 : 1415.

Anni, M.A., Giorgetti, A. and Franci, O. (1980). Amino acid composition of two varieties of Sorghum grain. Anim. Feed. Sci. Technol. 5 (3) : 169-173.

A.O.A.C. (1970). Official methods of analysis. Association of Agricultural Chemists, Washington, D.C.

Arambawela, W.J., Nielsen, H.E., Danielsen, V. and Eggum, B.O. (1975). Effect of replacing barley with tapioca meal at two different levels of feeding on the growth and health of early weaned pigs. Livest. Prod. Sci. 2 (3) : 281-288.

*A.R.C. (1965). Cited by McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. (1975). Animal Nutrition . The English Language Book Society and Longman, London. 2nd ed. p.451.

Aunan, W.J., Hanson, L.E. and Meade, R.J. (1961). Influence of level of dietary protein on live weight gain and carcass characteristics of swine. J. Anim. Sci. 20 (10) : 148-153.

Babatunda, G.M., Pond, W.G., Van Vleck, L.D., Kroening, G.H. and Reid, J.T. (1967). Effect of plane of nutrition, sex and body weight on the chemical composition of Yorkshire pigs. J. Anim. Sci. 26 (4) : 718-724.

Baird, D.M., McCampbell, H.C. and Allison Jr. (1970). Levels of crude fibre with constant energy level for growing finishing swine using computarised ration. J. Anim. Sci. 31 (3) : 518-523.

Baird, D.M., Mc Campbell, H.C. and Allison Jr. (1975). Effects of crude fibre, protein and bulk in diets for finishing pigs. J. Anim. Sci. 41 (4): 1039.

Baker, D.H., Becker, D.E., Norton, H.W. and Jensen, A.H. (1969). Lysine imbalance of corn protein in the growing pig. J. Anim. Sci. 28 (1) : 23-26.

Baker, D.H., Becker, D.E., Jensen, A.H. and Harmon, B.G. (1970). Protein source and level for pregnant gilts. A comparison of corn, opaque-2 corn and corn soyabean meal. J. Anim. Sci. 30 (1) : 364-367.

Baker, D.H., Katey, R.S. and Easter, R.A. (1975). Lysine requirements of growing pigs at two levels of dietary protein. J. Anim. Sci. 40 : 851.

Barber, R.S., Braude, R. and Mitchell, K.G. (1957). Different levels of feeding for fattening pigs. J. agric. Sci. 48 (3) : 347.

Barber, R.S., Braude, R. and Mitchell, K.C. (1965). Studies on various growth stimulants for pigs with particular reference to their activity in supplementing that of copper sulphate. Br. J. Nutr. 19 : 575-579.

Barber, R.S., Braude, R., Mitchell, K.G. and Myres, A.W. (1971). The value of hydro carbon - grown yeast as a source of protein for growing pigs. Br. J. Nutr. 25 (3) : 285-294.

Barber, R.S., Braude, R., Mitchell, K.C. and Pittman, R.J. (1972). Effect of level of feed intake on the proformance and carcass composition of growing pigs. Anim. Prod. 14 (2) : 199-208.

Bardoloi, T., Raina, B.L. and Bhat, P.N. (1978). Prediction of body weight from linear body measurements in pigs. Indian J. Anim. Health 17 (2) : 149-154.

*Barrios, E.A. and Bressani, R. (1967). Chemical composition of root and leaf of some varieties of cassava Manihot. Nutr. Abstr. Rev. 38 (4) : 6738.

Bellis, D.B. (1965). Protein level for bacon pigs. Anim. Prod. 7 : 286.

Bellis, D.B. and Taylor, J. (1961). Nutritional factors affecting lean meat production in cutting pigs. Anim. Prod. 3 : 209-221.

Benjamin, M.M. (1974). Outline of Veterinary clinical Pathology. The Iowa state University press, U.S.A. 2nd ed. p. 56.

Bhagwat, S.V. and Sahasrabudhe, M.G. (1971). A study on the growth potential of exotic pigs in India. Indian Vet. J. 48 (10) : 1026-1034.

Biswas, D.K., Hurt, P.V., Chapman, A.B. and First, N.L. (1966). Feed efficiency and carcass desirability in swine. J. Anim. Sci. 25 : 344.

Blair, R. and English, P.R. (1965). The effect of sex on growth and carcass quality of the bacon pig. J. agric. Sci. 64 (2) : 169-176.

Blair, R., Dent, J.B., English, P.R. and Raeburn, J.R. (1969). Protein, lysine and feed intake levels on pig growth. J. agric. Sci. 72 (3) : 379-400

Boomgardt, J. and Baker, D.H. (1973). Tryptophan requirements for growing pigs at three levels of dietary protein. J. Anim. Sci. 36 (2) : 303-306.

Borgstrom, G. (1973). World Food Resources. Intext Educational Publishers, New York. p. 28, 183.

Braude, R., Townsend, M.J., Harrington, G. and Rowell, J.G. (1958). A large scale test of the effects of food restriction on the performance of fattening pigs. J. agric. Sci. 51 (2) : 208-217.

Braude, R. and Ryder, K. (1973). Copper level in diets for growing pigs. J. agric. Sci. 80 : 489-493.

Brooks, C.C. (1972). Molasses, sugar (sucrose), corn, tallow, soyabean oil and mixed fats as source of energy for growing swine. J. Anim. Sci. 34 (5): 217-224.

Brown, H.D., Harmon, B.G. and Jensen, A.H. (1973). Lysine requirement of the finishing pig for maximum rate of gain and efficiency. J. Anim. Sci. 37 (3) : 708-712.

Buck, S.F. (1963). A comparison of pigs slaughtered at three different weights. J. agric. Sci. 60 : 19-26.

*Buitrago, J. (1964). Cited by Gomez, G. (1979). Casava as a swine feed. World Animal Review. (29) : 13-20.

Burlacu, G., Ihiescu, M. and Stavri, J. (1978). Efficiency of utilisation of food energy by growing pigs. J. agric. sci. 90 (1) : 165-170.

Calder, A.F.C., Lodge, G.A. and Blair, R.(1959). The early weaning of pigs.- V The inclusion of digestive enzymes and antibiotics in diets for pigs weaned at 6-7 pounds live weight. J. agric. Sci. 53 (1) : 130-135.

Cameron, C.D.T. (1960). Effect of high fibre, and pelleted and nonpelleted high fibre-high fat rations on performance and carcass characteristics of bacon pigs. J. Anim. Sci. 40 : 126-133.

Campbell, R.G., Taverner, M.R. and Mullaney, P.D. (1975). The effect of dietary concentration of digestible energy on the performance and carcass characteristics of early weaned pigs. Indian J. Anim. Prod. 6 (12) : 46-54.

*Capstick, J.W. and Wood, T.B. (1922). Cited by Houghton, T.R., Butterworth, M.H., King, D. and Goodear, R. (1964). The effects of different levels of food intake on fattening pigs in the humid tropics. J. agric. Sci. 63 : 43.

Charette, L.A. (1961). The effect of sex and age of male at castration on growth and carcass quality of Yorkshire swine. Can. J. Anim. Sci. 41 : 30-39.

Clark, E.P. and Collip, J.R. (1925). A study of Tisdall method for the determination of blood calcium with a suggested modification. J. Biol. Chem. 63 : 461.

Clawson, A.J., Blumer, T.N., Smart, W.W.G. Jr. and Barrick, E.R. (1962). Influence of energy - protein ratio on performance and carcass characteristics of pigs. J. Anim. Sci. 21 (1) : 62-68.

Close, W.H. and Mount, L.E. (1978). The effects of plane of nutrition and environmental temperature on the energy metabolism of the growing pig. Growth rate, including protein and fat deposition. Br. J. Nutr. 40 (3) : 423.431.

Coffin, D.L. (1973). Manual of Veterinary Clinical Pathology. Comstock Publishing Associates, Ithaca, New York. 3rd Ed. pp. 149-150, 156-157.

Cole, D.J.A., Duckworth, J.E. and Holmes, W. (1968). Factors effecting voluntary feed intake in pigs.- III The effect of a period of feed restriction, nutrient density of the diet and sex on intake and carcass characteristics. Anim. Prod. 10 (4) : 345-356.

Cole, D.J.A., Clent, E.G. and Luscombe, J.R. (1969). Single cereal diets based on barley, wheat, maize meal, flaked maize or sorghum on performance and carcass characteristics. Anim. Prod. 11 (1) : 325-334.

Cole, D.J.A. and Luscombe, J.R. (1969). A note on the effect of variation in crude protein level in diets for bacon pigs. Anim. Prod. 11 (1) : 557-560.

Cole, P.J. Jr. and Wangsness, P.J. (1978). Rate, composition and efficiency of growth in lean and obese pigs. J. Anim. Sci. 47 (2) : 441-447.

Cornelius, C.E. and Kaneko, J.J. (1963). Clinical Biochemistry of Domestic Animals. Academic Press, New York. pp 168-169.

Costain, R.A. and Morgan, J.T. (1961). The effect of variations in the energy and protein status of the diets upon productive efficiency in the pigs. Anim. Prod. 3 (1) : 199-208.

*Coursey, D.G. (1973). Cited by Coursey, D.G. and Halliday, D. (1974). Cassava as animal feed. Outlook. Agric. 8 (1) : 10-14.

Coursey, D.G. and Halliday, D. (1974). Cassava as animal feed. Outlook. Agric. 8 (1) : 10-14.

Crampton and Harris (1969). Applied Animal Nutrition. W.H. Freeman and Company, San Francisco. p. 569.

Cunningham, P.J., Socha, T.E., Peo, E.R. Jr. and Mandigo, R.W. (1973). Gain, feed conversion and Carcass traits of swine fed under two nutritional regimes. J. Anim. Sci. 37 (1) : 75-80.

Cunha, T.J. (1977). Swine feeding and Nutrition. Academic Press, New York. pp. 249-250.

Davey, R.J. (1976). Growth and carcass characteristics of high and low fat swine fed diets varying in protein and lysine content. J. Anim. Sci. 43 (3) : 598-605.

Deo, S., Raina, B.L., Bhat, P.N. and Agarwala, D.K. (1980). Factors affecting carcass characteristics in Landrace, Large White and their half breds. Indian J. Anim. Sci. 50 (12) : 1088-1093.

Doxey, D.L. (1971). Veterinary Clinical Pathology. Baillier, Tindall, London. pp. 188-221.

Dukes, H.H. (1955). The Physiology of Domestic Animals. Bailliere Tindall and Cox, London. 7th ed. pp. 20-21 and 36.

*Dvor̆a'k, J.F. (1963). Influence of antibiotic supplements on vitamin C metabolism in growing pigs. Nutr. Abstr Rev. 33 (11) : 4051.

*Eusebio, J.A. and Sanes, D.P.(1970). Cited by Bardeloi, T., Raina, B.L. and Bhat, P.N. (1978). Prediction of body weight from linear body measurements in pigs. Indian J. Anim. Health. 17 (2) : 149-154.

Fetuga, B.L., Babatunda, G.M. and Oyenuga, V.A. (1975). Protein levels in diets for European pigs in the tropics - II The effect of lysine and methionine supplementation on the protein requirement of growing pigs. Anim. Prod. 20 (1) : 133-146.

Fiske, C.H. and Subba Row, Y.C. (1925). The calorimetric determination of phosphorus. J. Biol Chem. 66: 375.

*Forbes, T.J. and Holme, D.W. (1968). The effect of some dietery constituents on the performance of bacon pigs and quality of backfat. Nutr. Abstr. Rev. (39 (3): 5910.

Fuller, M.F. and Boyne, A.W. (1971). The effects of environmental temperature on the growth and metabolism of pigs given different amounts of food. Br. J. Nutr. 25 (1) : 259-272.

Fuller, M.F. and Livingstone, R.W. (1978). Effects of progressive feed restriction on the growth and carcass composition of pigs. Comparative responses of gilts and castrates. J. agric. Sci. 91 (2): 337-341.

Gill, D.R., Oldfield, J.E. and England, D.C. (1966). Comparative value of hullers barley, regular barley corn and wheat for growing pigs. J. Anim. Sci. 25 (4) : 34-36.

Gilster, K.E. and Wahlstrom, R.C. (1973). Protein levels for swine fed to heavy weights - I Effects on gain and feed efficiency. J. Anim. Sci. 36 (5) : 883-887.

Gilster, K.E. and Wahlstrom, R.C. (1973). Protein levels for swine fed to heavy weights - II Effects on quantitative and qualitative carcass characteristics of swine. J. Anim. Sci. 36 (6) : 1108-1113.

Gomes, G. (1979). Cassava as a swine feed. World Animal Review (29) : 13-20.

*Gonzales, C.A. Cited by Bardoloi, T., Raina, B.L. and Bhat, P.N. (1978). Prediction of body weight from linear body measurements in pigs. Indian J. Anim. Health. 17 (2) : 149-154.

Gornall, A.G., Bardawill, C.J. and David, M.M. (1949). Determination of serum protein by the biuret reaction. J. Biol. Chem. 177 : 751-766.

Hale, O.M., Jhonson, J.C. Jr. and Southwell, B.L. (1967). Influence of dietary protein level on performance and carcass characteristics because of dietary protein level, breed and sex. J. Anim. Sci. 26 : 341-344.

Hale, O.M., Jhonson, J.C.Jr. and Warren, E.P. (1968). Influence of season, sex and dietary energy concentration on performance and carcass traits of swine. J. Anim. Sci. 27 : 1577-1581.

Hale, O.M., Wilson, D.M. and Jay, E. (1978). Acceptability and digestibility of swine diets containing corn stored under different conditions. J. Anim. Sci. 47 (1) : 46-60.

* Henriques, V. and Hansen, C. (1901). Cited by Lister, D., Rhodes, D.N., Fowler, V.R. and Fuller, M.F. (1974). Meat Animals. Growth and productivity. Plenium Press, New York. pp 183-185.

Handlin, D.L., Ables, J.R., Kropf, D.H. and Wheeler, R.F. (1961). Effect of finishing ration on gain, and feed efficiency and carcass characteristics of pigs. J. Anim. Sci. 20 (3) : 585-588.

*Hansson, I. (1974). Effect of sex and weight on growth, feed efficiency and carcass characteristics of pigs - I Growth rate and feed efficiency of boars, barrows and gilts. Nutr. Abstr. Rev. 46 (2) : 1812.

*Hew, V.F. and Hutagalung, R.I. (1972). The utilization of cassava root meal in swine feeding. Anim. Feed Sci. Technol. 3 (4) : 345-380.

Holme, D.W. and Robinson, K.L. (1963). Some effects of dietary pencillin and zinc bacitracin on the performance of bacon pigs. Anim. Prod. 5 (1) : 251-257.

I.C.AR Report.(1977). Hand book of Animal Husbandry. Indian Council of Agricultural Research - New Delhi. pp. 153-155.

*Jones, W.O. (1959) . Cited by Krider, K.L. and Caroll, W.E. (1956). Swine Production. Tata Mc Graw Publishing Co. Ltd., Bombay. 4th ed. p. 327.

*Jucker, H., Pfirter, H.P. and Parabeutri, A.L.(1966). Effect of maize grain on fattening and carcass quality of pigs. Nutr. Abstr. Rev. 36 (3) : 7112.

Kats, R.S., Baker, D.H., Sasse, C.E.,Jensen, A.H. and Harmon, B.G. (1973). Effect of supplemental lysine, methionine and rolled oats for weanling pigs fed a low-protein corn-soyabean meal diet. J. Anim. Sci. 37 (5) : 1165-1168.

Kempster, A.J. (1978). Variation and trends in the weights and fat thickness of commercial British pigs. Livest. Prod. Sci. 5 (2) : 215-223.

*Ketika, A.O. and Oyenuga, V.A. (1972). Changes in the carbohydrate constituent of cassava root tuber (Manihot utilissima, Pohl) during growth. Nutr. Abstr. Rev. 43 (9) : 5850.

Kobayashi, T., Shin-ichiro otuska and Yugari, Y.(1980). Effect of dietary lysine on performance and carcass quality in finishing pigs. Jap. J. Zootech. Sci. 51 (2) : 120-126.

*Kramer, B. and Tisdall, F.E. (1921). Cited by Oser, B.L. (1965). Hawk's Physiological chemistry. Tata McGraw Hill Publishing Co. Ltd., Bombay. 14th ed.

Krider, J.L. and Caroll, W.E.(1956). Swine Production. Tata McGraw Publishing Co. Ltd. Bombay. 4th ed. pp. 337-338.

Kumar, A., Ranjhan, S.K. and Joshi, B.C. (1974). Feed efficiency and carcass composition of Large White Yorkshire pigs at different liveweights to determine economic slaughter weights. Indian J. Anim. Sci. 44 (7) : 485.

Kunjikutty, N., Ramachandran, P., Devassia, P.A., Thomas, C.T. and Nandakumar, N. (1977). Evaluation of the feeding value of tea waste (Camelia thea) as an ingredient in the ration for growing pigs. Kerala J. vet. Sci. 8 (2) : 127-132.

Laird, R. Jr (1964). A study on growth rate and carcass characteristics in a Large White Yorkshire herd. J. Anim. Prod. 6 : 257.

*Laverentjeva, A.M., Tokarev, V.S. and Cernyi, V.I. (1970). Qualitative and quantitative variations in slaughter products from Russian Large White Yorkshire pigs. Anim. Breed. Abstr. 39 (4) : 730.

Lawrence, T.L.J. (1967). High level cereal diets for the growing finishing pig.- I The effect of cereal preparation on the performance of pigs fed diets containing high level of maize, sorghum and barley. J. agric Sci. 69 (2) : 271-281.

Lawrence, T.L.J. (1968). High level cereal diets for the growing finishing pigs.- III A comparison with a control diet of diets containing high levels of maize, flaked sorghum, wheat and barley. J. agric. Sci. 70 (3) : 287-297.

Lawrence, T.L.J. (1973). An evaluation of the micronisation process for preparing cereals for the growing pigs.- I Effects on digestibility and nitrogen retention. Anim. Prod. 16 (1) : 99-107.

Lawrence, T.L.J. (1977). Some effects on the growth and composition of the carcass of the bacon pig by feeding micronised or ground maize or barley based diets to give three different digestible energy intake. Livest. Prod. Sci. 4 (4) : 343-353.

Livestock Census (1972). Volume I. Department of Animal Husbandry, Kerala State, Trivandrum. p. 10.

Lister, D., Rhodes, D.N., Fowlder, V.R. and Fuller, M.F. (1974). Meat Animals. Growth and Productivity. Plenium press, New York. pp. 183-185.

*Longe, O.G. (1978). Carbohydrate constituents of different cassava varieties grown in Nigeria. Food. Technol. Abstr. (154) : 2326.

Lucas, I.A.M. and Calder, A.F.C. (1956). The response of different types of pigs to varying levels of feeding from weaning to bacon weight, with particular reference to carcass quality. J. agric. Sci. 47 (3) : 287-318.

Luce, W.G., Jhonson, R.K. and Watters, L.E. (1975). Optimum levels of crude protein on performance of growing boars. J. Anim. Sci. 42 (5) : 1207.

Magruder, N.D., Sherman, W.C. and Reynolds, W.M. (1961). Evaluation of supplemental lysine for practical swine ration. J. Anim. Sci. 20 (3) : 573-577.

Mahajan, L., Chopra, A.K., Khera, A.S. and Makkar, G.S. (1974). A note on the quality of Rattan versus local maize. Indian J. Anim. Sci. 44 (5) : 337-338.

*Maner, J.H. (1972). Cited by Gomez, G. (1979). Cassava as a swine feed. World Animal Review. (29): 13-20.

Manickam, R., Gopalakrishnan, C.A. and Sivadasan Pillai, K.G. (1976). Studies on feeding of tapioca in pigs. Indian J. Anim. Res. 10 (1) : 11-16.

Maynard, L.A. (1946). The role and efficiency of animals in utilising feed to produce human food. J. Nutr. 32 : 345-360.

Maynard, L.A. and Loosli, J.K. (1969). Animal Nutrition. Tata McGraw - Hill Publishing Co. Ltd., Bombay. 6th ed. pp. 90-105.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. (1985). Animal Nutrition. The English Language Book Society and Longman, London. 2nd ed. p. 31.

Meade, R.J., Vermedhal, L.D., Rust, J.W. and Ware, D.F. (1969). Effect of protein content on the diet of the young pig on rate and efficiency of gain during early development and subsequent to 23.5 kg and carcass characteristics and composition of lean tissue. J. Anim. Sci. 28 (4) : 473-477.

Menge, H. and Frobish (1976). Protein and Energy in the diet of the weanling pigs. J. Anim. Sci. 43 (5) : 1014-1023.

*Merkel, R.A., Bray, R.W., Grummer, R.H. and Philips, P.H. (1958). Influence of limited feeding, using high fibre rations upon growth and carcass characteristics of swine - I Effect upon feed lot performance- II Effect upon carcass characteristics. Nutr. Abstr. Rev. 28 (3) : 6224.

Mervin, K.M., Swiger, L.A. and Mahan, D.C. (1975). Influence of dietary protein level on swine with different growth capabilities. J. Anim. Sci. 41 (4) : 1031.

Metz, S.H.M., Bergstorn, P.L., Lenis, N.P. and Dekker, R.A. (1980). The effect of daily energy intake on growth rate and carcass composition of weight gain in pigs. Livest. Prod. Sci. 7 (1) : 79-87.

Moody, V.M.G., Trible, L.F. and Naumann, H.D. (1961). Meatiness of swine as influenced by breed, sex and age. J. Anim. Sci. 20 (4) : 923.

Morgan, J.T., Green, F.R. Costain, R.A. and Williams, E.F. (1959). Growth, economy of feed utilization and carcass quality in pigs in relation to dietary protein level and antibiotic administration. J. agric. Sci. 52 (1) : 70-76.

Moroquin, C.R., Cornwell, G.L. and Hays, V.W. (1973). Nutritive value of several varieties of opaque - 2 corn and normal corn for growing swine. J. Anim. Sci. 36 (2) : 253-257.

Moulick, S.K., Battacharya, S. and Gupta, S. (1965). Effects of teramycin, aureomycin and high level of coppersulphate on growing pigs. Indian J. Vet. Sci. 35 : 275-281.

*Mount, L.E. (1959). Cited by Houghton, T.R., Butterworth, M.H., King, D. and Goodyear, R. (1964). The effects of different levels of food intake on fattening pigs in the humid tropics. J. agric. Sci. 63 : 43.

*Moustgaard, J., Neilson, P.B. and Sorenson, P.H. (1959). Cited by Houghton, T.R., Butterworth, M.H., King, D. and Goodyear, R. (1964). The effects of different levels of food intake on fattening pigs in the humid tropics. J. agric. Sci. 63 : 43.

*Muller, Z. and Nah, K.C. (1975). Cited by Oke, K.L. (1978). Problems in the use of cassava as an animal feed. Anim. Feed. Sci. Technol. 3 (4) : 345-350.

*Myers, P.(1963). The effect of maize on carcass quality of bacon pigs. Nutr. Abstr. Rev. 34 (1) : 1483.

National Commission Report (1976). Part VII. Animal Husbandry. Ministry of Agriculture and Irrigation, New Delhi. pp 282-310.

Narayana Rao, P.L., Srimumalu Reddy, K., Janardhanan Pillai, K. and Varadarajalu, P. (1968). Studies on the relationship of carcass yield, certain wholesale cuts and offals to the live weight of pigs. Indian J. Vet. Sci. 45 (10) 866-873.

*National Research Council. (1968). Cited by Maynard, L.A. and Loosli, J.K. (1969). Animal Nutrition. Tata McGraw - Hill Publishing Co. Ltd., Bombay. 6th ed. p. 582.

Neely, J.D., Johnson, R.K. and Watters, L.E. (1978). Efficiency of gain and carcass characteristics of swine of two degrees of fatness slaughtered at three weights. J. Anim. Sci. 48 (5) : 1049-1056.

*Nestle, B.J. (1976). Cited by Raja, K.C.M., Abraham, E.H., Sreemulanathan, H. and Mathew, A.G. (1979). Chemistry and technology of cassava. Indian Food Packer. 33 (3) : 31-43.

Newport, M.J. (1979). Artificial rearing of pigs. Effect of dietary protein level on performance, nitrogen retention and carcass composition. Br. J. Nutr. 41 (1) : 95-101.

Obligbesan, G.O. (1977). Investigation on Nigerian root and tuber crops : Effect of potassium on starch yield, hydrocyanic acid content and nutrient uptake of cassava cultivars(M. esculenta). J. agric. Sci. 89 (1) : 29-34.

Oke, K.L. (1978). Problems in the use of cassava as an animal feed. Anim. Feed. Sci. Technol. 3 (4) : 345-380.

Onaghese, G.T.V. and Bowland, J.P. (1977). Influence of dietary Faba beans and Cassava on performance, energy and nitrogen digestibility and thyroid activity of growing pigs. Can. J. Anim. Sci. 57 (1) : 159-167.

Oyefeso, J.A. (1976). Cassava indicated ailments - a lack of technological know - how of mere cassava consumption. Indian J. Nutr. Dietet. 13 (3) : 77-82.

*Oyenuga, V.A. and Amazigo, E.O. (1957). A note on the hydrocyanic acid content of cassava (Manihot utilissima. pohl). Nutr. Abstr. Rev. 29 (3) : 3719.

* Oyenuga, V.A. and Opeke, L.K. (1957). The value of cassava ration for pork and bacon production. Nutr. Abstr. Rev. 29 (3) : 4936.

Oyenuga, V.A. (1961). Nutritive value of cereal and cassava diets for growing and fattening pigs in Nigeria. Br. J. Nutr. 15 (1) : 327-338.

*Oyenuga, V.A. and Fetuga, B.L. (1975). Chemical composition, digestibility and energy value of some varieties of yarn, cassava, sweet potatoes and cocoyam for pigs. Nutr. Abstr. Rev. 47 (7) : 3558.

Pay, M.G. and Davies, T.E. (1973). Growth, food conversion and carcass characteristics in castrated and entire male pigs fed three different dietary protein levels. J. agric. Sci. 81 : 65-68.

Pearson, A.M., Reineke, E.P., Hoeffer, J.A. and Morrow, R.E. (1966). Effect of environmental temperature on heat production, energy retention and fat gain in early weaned piglets. Br. J. Nutr. 44 (3) : 313-323.

*Pfeiffer, H. and Ender, K. (1973). The effects of climate on carcass quality in pigs. Anim. Breed. Abstr. 41 : 548.

Phillips, T.P. (1979). Prospectus for processing and marketing cassava products as animal feed. World Animal Review. (31) : 36-40.

Plank, R.N. and Berg, R.J. (1963). Inheritance of plane of nutrition in swine-effects of season, plane of nutrition, sex and sire on feed lot performance and carcass characteristics. Can. J. Anim. Sci. 43 : 72-85.

*Pond, W.G. and Maner, J.H. (1974). Cited by Cunha, T.J. (1977). Swine feeding and nutrition. Academic Press, New York. pp. 249-250.

Pond, W.G., Yen, J.T. and Lindvall, R.N. (1980). Early protein deficiency: effects on later growth and carcass composition of lean or obese swine. J. Nutr. 110 (12) : 2506-2513.

Prescott, J.H.D. and Lamming, G.E. (1964). The effects of castration in meat production in cattle, sheep and pigs. J. agric. Sci. 63 : 341.

Prince, T.J., Hays, V.W. and Cromwell, G.L. (1979). Effect of copper sulphate and ferrows sulphide on performance and liver copper and iron stores of pigs. J. Anim. Sci. 49 (2) : 507-513.

Raja, K.C.M., Abraham E.H., Sreemulanathan, H. and Mathew, A.G. (1979). Chemistry and technology of cassava. Indian Food Packer. 33 (3): 31-43.

Ramachandran, P. (1977). Studies on growth rate, feed efficiency and carcass characteristics of pigs reared up to different market weights.on two dietary treatments. M.V.Sc. Thesis. Kerala Agricultural Univiversity, Mannuthy.

Rao, R.M., Khan, M.Y. and Ranjhan, S.K. (1978). Growth rate and feed efficiency of Large White Yorkshire pigs fed different levels of dietary energy. Indian J. Anim. Sci. 48 (2) : 123-125.

Ranjhan, S.K., Shukla, V.P., Kumar, I. Pathak, N. and Joshi, B.L. (1972). Effects of growth rate and carcass composition in Large White Pigs on various planes of nutrition during growth finishing period. Indian J. Anim. Sci. 42 (6) : 453.

Reddy, K.N. and Agarwala, O.P. (1975). Effects of rations with different protein energy ratios on the performance of growing graded Yorkshire pigs. Indian J. Anim. Prod. 6 (12) : 46-54.

*Reddy, S.R., Prasad, D.A., Rao, K.P., Thomas, L.P. and Sriramamurthy, A. (1980). Optimum energy and protein levels for growing swine and economic rations for growing and finishing Large White Yorkshire pigs. Scientific Seminar Abstracts College of Veterinary Sciences, Andhra Pradesh Agricultural University, Tirupati.

Ray, S.N. (1978). Livestock feeding. Indian Council of Agricultural Research, New Delhi. pp. 28-29, 137.

Robinson, D.W. and Lewis, D. (1964). Protein and energy nutrition of the Bacon pig. - II The Effect of varying the protein and energy level in diets of finishing pigs. J. agric. Sci. 63 (2) : 185-190.

Robinson, D.W., Morgan, J.T. and Lewis, D. (1964). Protein and energy levels of the bacon pig. J. agric. sci. 63 : 409.

Robinson D.W. (1965). The protein and energy nutrition of the pig. -V The effect of varying the protein and energy levels in the finishing diets of heavy pigs. J. agric. Sci. 65 (3) : 405-409.

Robinson, D.W., Prescott, J.H.D.and Lewis,D. (1965). The protein and energy nutrition of bacon pigs. - IV Digestible energy values of cereals in pig diets. J. agric. Sci. 64 (1) : 59-65.

Saseendran, P.C. (1979). The growth, carcass characteristics and economics of rearing of indigenous and exotic pigs. M.V.Sc. Thesis . Kerala Agricultural University, Mannuthy.

Schalm, O.W. (1961). Veterinary haematology. Lea and Febiger, Philadelphia, p. 188.

Sebastian, K.S. (1972). Utilisation of tapioca starch waste in swine ration. M.Sc. Thesis, Kerala Agricultural University, Mannuthy.

Seerley, R.W., McCampbell, H.C. and McDaaniel, M.C. (1979). Energy and protein studies with swine diets. J. Anim. Sci. 41: 328.

Seve, B. and Aumaitre, A. (1978). Recent advances in protein nutrition. World Review of Animal Production. 14 (2) : 25-32.

Sewell, R.F., Thomas, M.C. and Price, D. (1961). Protein energy relationships in the rations of early weaned pigs. J. Anim. Sci. 20 : 820.

Shanmuganatham, K. and Ranganathan, M. (1972). Studies on the carcass yield of middle white Yorkshire pigs. Indian Vet. J. 49 (2) : 180-185.

Sharda, D.P., Singh, P. and Pradhan, K. (1978). A study on replacing maize with barley in swine diets under tropical conditions. Indian J. Anim. Health. 17(2): 159-162.

Sihombing, D.T.H., Cormwell, G.L. and Hays, V.W. (1969). Nutritive value and digestibility of opaque-2 and normal corn for growing pigs. J. Anim. Sci. 29 (6) : 921-926.

Smith, H. and Lucas, I.A.M. (1957). The early weaning of pigs. The effect upon growth of variations in the protein, fat, sucrose, antibiotic, vitamin and mineral contents of diets for pigs of 8-25 pounds live weight and a comparison of wet and dry feeding. J. agric. Sci. 48 (2) : 220-234.

Smith, H.C., Adam, J.L. and Tonks, H.M. (1964). Effects of oxytetracycline and oleandomycin separately or together in pig diets. Anim. Prod. 6 (3) : 363.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. The Iowa state University Press, Ames, U.S.A. 6th ed.

*Solnev, K.M. and Vasilanko, S.S. (1963). Antibiotics for pigs. Nutr. Abstr. Rev. 39 (2).

*Speer, V.C. (1962). Possible effects of arsenilic acid on preweaning mortality and rate of gain in swine. Vet. Bull. 33 (6) : 2069.

Stahly, T.S. and Wahlstrom, R.C. (1973). Effects of dietary protein level and feed restriction on performance and carcass characteristics of swine. J. Anim. Sci. 36 (6) : 1108-1113.

Stahly, T.S. and Cromwell, G.L. (1979). Effect of environmental temperature and dietary fat supplementation on the performance and carcass characteristics of growing and finishing swine. J. Anim. Sci. 49 (6): 1478-1488.

Stahly, T.S., and Cromwell, G.L. and Aviotti, M.P. (1979). The effect of environmental temperature and dietary lysine source and level in the performance and carcass characteristics of growing swine. J. Anim. Sci. 49 (5) : 1242-1251.

*Stuckey, R.J., Stuckey, J.L. and Minnich, D.(1962). Possible effects of arsenilic acid on preweaning mortality and rate of gain in swine. Vet. Bull. 33 (6) : 2069.

Swan, H. and Lewis, D.(1976). Feed energy sources for livestock. Butterworths, London. pp. 21-22.

Thomas, C.T. and Chandran, K. (1974). Biological utilisation of protein as influenced by dietary carbohydrates. Kerala J. vet. Sci. 5 (2) : 99-112.

*Totsuka, K., Jwai, H., Ishii, M. and Shoji, K. (1978). Study of nutritive value of cassava in rations for growing and finishing pigs. Nutr. Abstr. Rev. 49 (1) : 360.

*Ullery, D.E., Miller, E.R., Brent, B.E., Bradly, B.L. and Hoeffer, J.A. (1967). Swine haematology from birth to maturity. - IV Serum calcium, magnesium, sodium, potassium, copper, zinc and inorganic phosphorus. Vet. Bull. 38 (2) : 1176.

Van Choubroeck, F., De Wilder, R. and Ph Lampe (1967). Quantitative effects of feed restriction in fattening pigs on weight gain, efficiency of feed utilisation and backfat thickness. Anim. Prod. 9 (1) : 67-74.

Veum, T.L., Pond, W.G., Van Vleck, L.D., Walkner, E.F. and Kreok, L. (1970). Effect of feeding-fasting interval on finishing pigs : weight gain, feed utilisation and physical and chemical carcass measurements. J. Anim. Sci. 30 (1) : 381-387.

Verstegen, M.W.A., Mateman, G., Brandsma, H.H. and Haartsen, P.I. (1979). Rate of gain and carcass quality in fattening pigs at low ambient temperature. Livest Prod. Sci. 6 (1) : 51-60.

Whitelaw, A.W.W., Elsley, F.W., Jones, R.S. and Boyne, A.W. (1966). The effect of protein level in creep feed on the growth rate and body composition of suckling pigs. J. agric. Sci. 66 (2) :203-209.

Wong, W.C., Boylan, W.J. and Stothers, S.C. (1968). Effects of dietary protein level and sex on swine performance and carcass traits. Can. J. Anim. Sci. 48 : 383-388.

*Zobrisky, S.E., Brady, D.E., Lasley, L.F. and Weaver, L.A. (1959). Cited by Narayana Rao, P.L., Sriramula Reddy, K., Janardana Pillai, K. and Varadarajulu, P. (1968). Studies on the relationship of carcass yield, certain wholesale cuts and offals to the live weight of pigs. Indian J. Vet. Sci. 45 (10) : 866-873.

* Original not consulted.

GROWTH AND CARCASS CHARACTERISTICS OF PIGS MAINTAINED ON RATIONS CONTAINING DIFFERENT LEVELS OF DRIED TAPIOCA CHIPS

BY

SASIKALA DEVI, K. A.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Animal Nutrition
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy - Trichur

1981

ABSTRACT

An investigation was carried out to assess the growth rate, feed efficiency, carcass quality and economics of production in swine with isoproteinic rations containing dried tapioca chips in partial or complete replacement of maize. Eighteen Large White Yorkshire weanling pigs were divided into three groups (Group I, II and III) of six animals each as uniformly as possible in regard to litter, sex, age and weight and maintained on three isoproteinic diets A, B and C containing 0, 20 and 40 per cent levels respectively of dried tapioca chips in partial and complete replacement of maize.

Records of feed intake, fortnightly body weights and body measurements were maintained throughout the course of the experiment. Digestibility coefficients of nutrients in the rations were determined. Two males and two females each from all the three groups were slaughtered when they attained the body weight of 70 kg for collecting data on carcass characteristics. Haematological studies were also carried out to assess the nutritional status of the animals.

The animals under all the three dietary treatments

recorded almost similar growth rates, the overall average daily gains being 385.9, 368.0 and 380.2 g respectively for the three groups I, II and III. The total food intake of the animals were similar indicating that the three rations, in addition to being isoproteimic, were also isocaloric and of almost equal palatability. The animals also showed similar feed conversion efficiency, the overall average values being 3.59, 3.62 and 3.57 respectively for the groups I, II and III. The digestibility coefficients of nutrients in the three rations were similar indicating that dried tapioca chips was as efficiently utilised as maize.

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

Results of studies on carcass characteristics revealed that the dressing percentage without head, carcass length, backfat thickness, loin-eye area and percentages of prime cuts against live weight were all found to be similar with both tapioca and maize based diets.

The diets used did not seem to markedly influence the melting point of body fat though there was significant difference between subcutaneous and leaf fat indicating a greater unsaturation of subcutaneous fat. Saponification values were found to be similar with all the three diets. With respect to both subcutaneous and leaf fat, iodine number was higher on maize based diets though there was significant difference only in regard to subcutaneous fat.

Cost of production per kg live weight of the animals in the three groups I, II and III were shown to be Rs.8.20, 8.19 and 7.99 respectively. An overall evaluation of results clearly indicated that dried tapioca chips can be safely and profitably incorporated in swine rations at a level of 40 per cent in place of conventional cereal grains like maize.