NUTRITIVE EVALUATION OF CARCASS MEAL FOR GROWTH AND CARCASS CHARACTERISTICS IN LARGE WHITE YORKSHIRE PIGS

By
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THESIS

Submitted in partial fulfilment of the requirement for the degree

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DECLARATION

I hereby declare that the thesis entitled "**NUTRITIVE EVALUATION OF CARCASS MEAL FOR GROWTH AND CARCASS CHARACTERISTICS IN LARGE WHITE YORKSHIRE PIGS**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled "**NUTRITIVE EVALUATION OF CARCASS MEAL FOR GROWTH AND CARCASS CHARACTERISTICS IN LARGE WHITE YORKSHIRE PIGS**" is a record of research work done independently by **Miss Marie Sinthiya, V.**, 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.

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To my beloved Parents
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Introduction

INTRODUCTION

Providing a balanced diet to the population of 930 million people in the country having different dietary habits is a difficult task. Mere increase in the production of cereals alone will not meet the demand of food for our people. There is an ever increasing demand for balanced food because of the tendency in improving the standard of living both in urban as well as in rural areas. The rapid growth of population is resulting in continued widening of gap between the demand and supply of the required quantity and quality of the food. The major deficiency in the diet of an average Indian man is that of protein. In India the per capita consumption of meat is only 1.97 kg/year, as against the requirement of 37 kg/year.

In order to bridge the gap between high requirements and low availability of animal protein, it is essential to improve and multiply all meat producing animals in the country. Improvement in the production of beef mutton and chevon may not be sufficient to meet such demand because the ruminants in general have a low rate of weight gain and also the generation interval is longer. The increased demand for meat can be met through pig and poultry as they do not have such biological restraints for high rates of production because of rapid rate

of growth, economic feed conversion efficiency, high prolificacy and short generation interval.

Pork, a valuable source of rich animal protein of low cost can play an important role in mitigating the protein shortage. Pigs excel other farm animals in respect of edible flesh. Pig industry gives high returns with a low investment, hence called "mortgage lifter".

The rearing of pigs requires comparatively very little investment when compared to dairy and poultry production. The returns from pig production are obtained much more quickly than from any other enterprise. With proper breeding, better feeding and management, pork production can be made more lucrative.

The ultimate success of pig raising largely depends on careful planning and availability of properly formulated feeds at reasonable price. In swine raising, feeding is the major expense, as 75 to 80 per cent of the total cost of raising them is for feed alone (Agarwala, 1970 and Narayana Rao, 1970). The feeding of swine for the production of pork, bacon or any other product has to be so designed that the requirement of the consumer is met. This is another side of the challenge which the pig nutritionist has to face besides the selection of feedstuffs. The ultimate success in this enterprise depends mainly on how best the rations are formulated from the

available feed stuffs. This field has to be further explored and experimented to identify alternative feed resources such as swill, farm by-products, slaughter house wastes etc.

The utilization of livestock by-products and animal waste is a vital aspect which has not yet received much attention in the developing countries. By-products of animal origin may be derived from (1) abattoirs/meat packing and rendering operations (2) poultry and poultry processing (3) milk and milk processing plants. At present, most of the by-products of animal origin are either wasted or utilised very little. The utilization of animal by-products as alternate feeds is one of the possible method by which meat, dairy and poultry processing plants can improve their operating margins and economy.

From the dead or slaughtered animals two types of wastes are obtained which can be made use of as an animal feed, viz., dead carcasses and wastes from abattoirs. Dead carcass could be a major source of raw materials in some countries. For eg. in India every year nearly 8-10 per cent of the livestock die due to various causes and these carcasses are not properly utilized. Besides causing economic loss, it is also a source of health hazard both for man and animals. The wastes from abattoirs include mostly, the byproducts such as blood, offals, ingesta and feathers. With appropriate processing

these could be commercially utilized as feed ingredients in rations for livestock and poultry.

Carcass meal is obtained from carcass utilization plant of the Livestock Products Technology Unit, College of Veterinary and Animal Sciences, Mannuthy. Carcass meal is prepared by processing of abattoir by-products such as soft tissues, bone, blood, skin and hide. So far no work has been carried out to assess the feeding value of carcass meal in pigs. As such an investigation was taken up to assess the nutritive value of carcass meal in the rations of growing and finishing pigs and to arrive at the economics of its inclusion as a substitute for conventional animal protein source like fish meal.

Review of Literature

REVIEW OF LITERATURE

Among the livestock species, pigs are considered to be one of the efficient converters of feedstuffs into edible meat. Both the quantity and quality of protein have to be given importance in feeding of pigs for better performance. Usually various animal protein concentrates are being made use of to achieve this. These concentrates are considered to be good sources of high quality protein. One such animal protein source is the by-products obtained from the abattoirs. At present most of these by-products which are going waste or utilised very little, can be used as a very good protein supplement in improving the nutritive value of rations fed to animals.

A. Abattoir by-products

1. Blood meal

Blood, a valuable raw material obtained from slaughter house, can be efficiently utilised as a livestock feed. When dried, blood represents a concentrate feed containing the highest possible protein content.

Dried blood contains over 80 per cent protein. However, the conventional methods used for drying blood have resulted in a product of poor palatability and low protein

digestibility for swine. The average per cent composition of blood meal was dry matter - 91.8, protein-84.5, fat 1.1, fibre-1.0, nitrogen free extract-0.7, total ash-4.5, digestible protein-60 and TDN-61.3 (Morrison, 1964). Other methods of processing which utilise a lower temperature gives a product in which some of the amino acids particularly lysine is more readily available to animal (Doty, 1973). Miller *et al.* (1976) reported that ring process dried blood meal had a lysine availability of 70 per cent. Kulundzic *et al.* (1994) estimated the nutrient composition of dried blood from slaughtered pigs and stated that crude protein content was 85 per cent of which 80 per cent was true protein and further an important natural source of lysine. Partenan and Nasi (1995) reported that formic acid preserved blood mucosa product, which is a mixture of slaughter house blood, gastrointestinal mucosa, proteins and fats separated from slaughter house process water contained 17 per cent DM, 68 per cent CP and 19 per cent EE and was a feasible protein and energy source for pigs.

Wahlstrom and Libal (1977) in their study reported that rotary steam dried blood meal could replace approximately 60 per cent of the protein supplied by soybean meal and could also constitute 60 per cent of the supplemental protein when combined with meat meal in growing finishing swine diets with no significant differences in average daily gain, feed

consumption or feed efficiency. Addition of less than 12 per cent blood meal in the diet of grower and finisher pigs, did not affect the performance or carcass quality (King and Campbell, 1978). Incorporation of flash dried blood meal in ration of starter, grower and finisher pigs at 6 per cent, 4 per cent and 3 per cent level respectively, resulted in no significant difference in average daily gain and feed conversion efficiency compared with those on maize-soybean meal diet (Miller and Parsons, 1981). Barbosa *et al.* (1983) observed that blood meal effectively replaced soyabean meal in the diet of growing and finishing pigs, but daily intake of feed tended to increase and feed conversion decreased with increasing blood meal level in the ration. Orda *et al.* (1986) found that when meat cum bone meal was replaced with blood meal or Livex (preparation of blood and whey), the daily weight gain and carcass quality were not significantly different between groups. Oshida *et al.* (1989) recorded that pelleted slaughter house waste containing blood meal and ground fresh pig bone was found to be a good source of feed for pigs and had no adverse effect on the pork quality. Tuitoek and Ayangbile (1992) reported that fermented cattle blood could be incorporated upto 10 per cent in the diet of pigs without affecting performance. Crawshaw (1993) showed that growth rate and feed conversion efficiency were optimal with addition of 5 per cent blood meal in the diets of pigs and broilers. Damonte *et al.* (1996) reported that when

soyabean meal was replaced with chicken blood there was no significant difference in average daily gain and carcass traits and that inclusion of chicken blood decreased cost of production of pork.

Palm kernel meal which had been reported to be unacceptable to pigs, could in fact be efficiently utilised in combination with blood meal in diets for growing and fattening pigs to obtain reasonably good growth rate and desirable carcass traits (Fetuga *et al.*, 1977). Ilori *et al.* (1984) suggested that a combination of peanut meal and flash dried blood meal could replace soyabean meal completely in isolysinic growing-finishing pig diets without reduction in rate and efficiency of gain, nutrient utilization or carcass quality.

Kats *et al.* (1992) reported that addition of blood meal in starter diets of pigs increased average daily gain, average daily feed intake and gain:feed ratio. Dritz *et al.* (1993) observed that avian and bovine spray dried blood meal were of similar nutritive value and inclusion of these in the starter ration of pigs improved the average daily gain and gain:feed ratio. As an animal protein supplement, porcine blood had a positive influence on the growth performance of early weaned pigs (Hansen *et al.*, 1993). Kats *et al.* (1993) reported that though there was no significant difference in average daily

gain, there was an increase in average daily feed intake and lower gain:feed ratio in starter pigs fed spray dried blood meal as compared to fish by-products. Kats *et al.* (1994) concluded from their experiment that incorporation of spray dried blood in the diets of early weaned and starter pigs improved the average daily gain and gain:feed ratio, but higher level of inclusion in the grower diets decreased average daily gain and gain:feed ratio. Wolf and Hitchcock (1995) found that the practical level of inclusion of spray dried blood meal in starter pig diet was 3 per cent, as it improved the average daily gain and gain:feed ratio, than those obtained at other levels of inclusion.

2. Meat cum bone meal

Meat meal is defined as the product obtained by drying and grinding whole or parts of warm-blooded land animals from which the fat may have been partially extracted or physically removed. When carcass along with the bone is used as the raw material and the phosphorus content is >4 per cent, it is meat and bone meal.

Just *et al.* (1983) estimated the nutritive value of meat cum bone meal and reported that the ash and CP contents ranged from 22.0 to 38.5 and 47.2 to 65.9 per cent respectively. They also stated that the amino acid composition, digestibility of protein and energy value of meal

decreased with increasing ash content. The chemical composition of meat cum bone meal prepared from forced air-dried and traditionally dried had crude protein, 57.1 and 49.7 per cent, fat 9.1 and 13 per cent, fibre 4.0 and 4.7 per cent, calcium 10 and 10 per cent and phosphorus 4.8 and 5.4 per cent respectively (Prokepenko and Kolyada, 1989). Lawniezak and Gavecki (1991) estimated the chemical composition of meat cum bone meal containing blood and post-flotation deposit and found 91.6 per cent dry matter, 56.6 per cent crude protein, 16.8 per cent ether extract, 6.1 per cent nitrogen free extract and 16.6 per cent ash (3.62% Ca and 2.83% P). Meat meal generally contained protein 660 to 700 g/kg compared with 450 to 550 g/kg for meat and bone meal. The fat content was variable, ranging from 30 to 130 g/kg. It was an excellent source of calcium, phosphorus, manganese, good source of B-complex especially riboflavin, choline, nicotinamide and B_{12} (McDonald *et al.*, 1995). Mozzocco and Profiti (1994) reported that a liquid fraction which resulted from processing of meat by-products contained 90 per cent water, 80 per cent of DM consisting of protein and 9 per cent of fat. They also found that it could be incorporated into animal feeds.

Beames and Daniel (1970) reported that increase in the level of inclusion of meat cum bone meal from 15 to 20 per cent and the use of meat cum bone meal with low bone content improved the growth and carcass quality of pigs. Ismailov

and Kalashyan (1981) showed that meat cum bone meal when included in the ration of sows gave greater litter size and body weight of piglets and inclusion in the ration of young pigs resulted in improved average daily gain, feed:gain ratio, and the pigs reaching the weight earlier without affecting the carcass quality. Snitsar *et al.* (1982) found that incorporation of meat cum bone meal in the diet of fattening pigs improved average daily gain and feed efficiency. Brookes *et al.* (1992) showed that inclusion of meat cum bone meal at 3, 6 and 9 per cent level in diet of growing and finishing pigs had no significant effect on daily gain, feed conversion efficiency or back fat thickness and levels upto 9 per cent were well tolerated. Rajic *et al.* (1995) reported that crude bone meal when fed to weaned piglets resulted in better daily body weight gain and feed:gain ratio. Russo *et al.* (1995) found that meat meal slurry had no adverse effect on meat quality characteristics in Italian heavy pigs. Yatsenko (1995) indicated that bone broth can be included in the fattening pig diets satisfactorily.

When meat cum bone meal was replaced by feather meal in the diets of fattening pig, the daily weight gain and gain:feed ratio decreased (Kalous *et al.*, 1982). A comparative study between keratin meal and meat cum bone meal in fattening pigs showed that pigs on meat cum bone meal had better average daily gain and feed conversion efficiency, the digestibility

of keratin meals being lower than that of meat cum bone meal (Rozhanchuk *et al.*, 1982). A study on the replacement of fish meal by meat cum bone meal in the diet of fattening pigs showed that there was no significant difference in mean daily gain, feed efficiency and carcass traits (Mishev *et al.*, 1983). In another study, replacement of fish meal and dried skim milk with meat cum bone meal in balanced mixed feeds of pigs did not affect the mean daily gain and digestibility of nutrients was best with 4.2 per cent meat cum bone meal (Galuskha *et al.*, 1990). The meat and bone meal effectively replaced dried skim milk and fish meal partially in the pig diet without any adverse effects on weight gain or feed utilization (Snitsar *et al.*, 1992). Aar *et al.* (1994) concluded that meat cum bone meal produced by Dutch renderers had some favourable properties over soyabean meal when used in weaning pigs.

B. Nutrient requirements

1. Protein requirement

One of the most important prerequisite for obtaining optimum performance in swine is by providing an adequate supply of good quality protein in their diet.

High protein levels in the ration of growing swine did not have any significant effect on the average daily gain and

feed efficiency (Aunan *et al.*, 1961; Dimussion *et al.*, 1961; Washington and Cripp, 1980 and Feng *et al.*, 1983). Klay (1964) stated that as the level of dietary protein increased total intake of both protein and lysine increased, while rate of gain, feed conversion efficiency and feed consumption showed linear decrease. Maede *et al.* (1969) showed that starter pigs fed low protein diets had significantly low weight gain and poor gain:feed ratios. Davey (1976) reported a reduced growth rate in growing Duroc Yorkshire pigs when fed low protein diets. It was suggested that pigs weaned at three weeks of age could be fed a diet which contained 20 to 24 per cent protein with a calorie:protein ratio of 15 to 18 (Menge and Forbish, 1976). Lunchick *et al.* (1978) found that maximum performance was attained when young growing pigs diet contained 16 per cent protein and 0.93 per cent of lysine. Shields and Mahan (1980) suggested that temporary moderate restrictions of protein in pig diets had no adverse effects on overall gain or carcass quality. Christian *et al.* (1980) suggested that leaner strains of pigs fed high protein diet had improved feed conversion efficiency.

The approximate crude protein requirements of growing swine fed *ad libitum* as cited by Ranjhan (1981) were 22, 18 and 14 per cent for body weights 5 to 12, 12 to 50 and 50 to 100 kg respectively. Skoryatina and Korop (1981) reported that in a concentrate based diet the optimum level of protein

for Large White Yorkshire pigs was 18 per cent for weaners, 16 per cent for pigs upto 6 months of age and 14 per cent from 6 to 8 months age on dry matter basis. Tyler *et al.* (1983) showed that grower and finisher pigs fed diets with protein levels of 20 per cent and 18 per cent respectively had improved average daily gain, feed conversion efficiency and back fat thickness. National Research Council (NRC, 1988) recommendation of protein per cent for 1-5 kg, 5-10, 10-20, 20-50 and 50-110 kg body weight was 24, 20, 18, 15 and 13 per cent respectively.

The Landrace male pigs during their growing phase required about 20.18 per cent crude protein for maximum performance (Donzele *et al.*, 1994a) and growing gilts required 19.74 per cent crude protein for maximum performance (Donzele *et al.*, 1994b). Lattimier and Dourmad (1994) in their study on the effect of three protein feeding strategies for grower and finisher pigs reported that the growth rate and feed conversion efficiency were similar for all groups and that the dressing percentage decreased with increased dietary protein. Sixteen per cent crude protein in grower diets of pigs resulted in unprofitable performance (Martin, 1994; Jost *et al.*, 1995). They reported that satisfactory growth was obtained with 17 per cent crude protein and 13.9 MJ DE when the feed was supplemented with the first two limiting aminoacids lysine and tryptophan. The diets of fattening pigs

which contained 17 and 15 per cent CP during the growing and finishing period respectively, showed increased average daily gain and improved feed:gain ratio (Barac *et al.*, 1996). The DE intake and daily gain of castrated male pigs offered low protein diets were lower than that of pigs fed high protein diets (Hata *et al.*, 1996). According to Moita *et al.* (1996) 12 to 28 days old piglets required 23.43 to 23.13 per cent crude protein in their diets. Oldenberg and Heinrich (1996) showed that finisher pig diets which contained 17 per cent and 13.5 per cent CP had no significant effect on finishing and slaughter performance. Wu *et al.* (1996) reported that the average daily gain and feed:gain ratio during the starter, grower and finisher phase increased when ideal protein intake was 129 to 130 g/day, 310 to 319 g/day and 350 to 370 g/day respectively.

The dietary lysine requirements of pigs over the weight interval of 50 to 100 lb and 100 to 200 lb were 1.0 per cent and 0.5 to 0.6 per cent respectively (Costain and Morgan, 1961). Klay (1964) stated that decreased absorption of lysine appeared to be a major cause of the increase in lysine requirement which accompanied the increases in dietary protein levels. Maede *et al.* (1966) reported that addition of lysine alone or in combination with methionine to 14 per cent and 16 per cent protein, did not significantly affect rate of gain, efficiency of feed utilization or backfat thickness. Boomgart

and Baker (1967) stated that the expression of amino acid requirement as percentage of dietary protein is preferable to that as a percentage of total diet. These authors had also recorded the tryptophan requirements of growing swine to be 0.71, 0.67 and 0.66 per cent at dietary protein levels of 10, 14 and 18 per cent respectively. Brown *et al.* (1973) estimated that a dietary lysine level of 0.48 per cent of diet was required for maximum daily gain and 0.62 per cent of diet for maximum gain:feed ratio. Easter *et al.* (1980) found that lysine requirement could be reduced when CP levels were reduced by replacing soyabean meal with synthetic lysine. Dollmann *et al.* (1984) reported that 17 per cent CP ration which supplied 8 to 9 g lysine/day was needed for maximum performance of starter pigs.

Taylor *et al.* (1984) demonstrated the interaction between leucine, isoleucine and valine. Lysine levels lower than that of the basal levels resulted in the reduction in body weight gain, feed intake and feed efficiency (Edmonds and Baker, 1987). Fuller *et al.* (1989) indicated that for 1 g body protein accreation in growing pigs the dietary amino acid requirements should be threonine-47 mg, valine-53 mg, methionine + cystine-36 mg, methionine-19 mg, isoleucine-43 mg, leucine-78 mg, phenylalanine + tyrosine-84 mg, phenylalanine-41 mg, lysine-68 mg and tryptophan-12 mg. Wu

and Zhow (1992) showed that in growing and finishing pigs the average daily gain and feed intake were lower on low protein diet but higher with low protein diet + amino acid supplements. The dietary protein could be decreased in heavy pig production provided lysine supplements are used (Parsini *et al.*, 1994). The crude protein content of the diet of growing pigs can be reduced by 20 per cent provided the concentration of lysine, methionine, tryptophan and threonine are maintained (Schutte *et al.*, 1994 and Valaja *et al.*, 1995). Kuhn and Burgstallar (1995) showed that low protein diets for heavy finishing pigs when provided with lysine level of 5 g/100 g CP showed no significant difference in average daily gain, feed conversion ratio, carcass yield and quality. Nam *et al.* (1995) suggested that pigs are unable to control their protein and lysine intake for growth when given a choice of two isocaloric diets which differed in protein and lysine content. Trinidad *et al.* (1995) reported that 16 per cent crude protein was sufficient to meet the requirements in diets of pigs weaned at 28 days old if supplemented with lysine, methionine and cystine. Zollitsch *et al.* (1995) concluded that dietary crude protein can be decreased without affecting finishing and slaughter performance provided the amino acids were supplemented.

2. Energy requirements

Energy is reported to be the predominant factor which affected production performance followed by protein and trace elements (Xie *et al.*, 1995).

The digestible energy requirement for weaner (5-12 kg), grower (12-50 kg) and finisher (50-100 kg) pigs were 3500 Kcal/kg, 3500 Kcal/kg and 3300 Kcal/kg respectively (Ranjhan, 1981). The net efficiency of utilisation of metabolisable energy in young pigs between 10 and 50 kg body weight was 73.8 per cent and that for maintenance they required 103.4 kcal ME/$kg^{0.75}$ or 76.3 kcal NE/$kg^{0.75}$/day (Illescu *et al.*, 1982). Balogun *et al.* (1988) reported that best results were achieved when Large White pigs which weighed 22 and 36 kg were fed diets which contained digestible energy of 3.23 and 3.39 MCal/kg respectively. The National Research Council (NRC, 1988) specification for energy was shown to be 3,220 kcal ME/kg, 3,240 kcal ME/kg, 3,250 kcal ME/kg, 3,260 kcal ME/kg and 3,275 kcal ME/kg for pigs of 1-5 kg, 5-10 kg, 10-20 kg, 20-50 kg and 50 to 110 kg body weight respectively. The metabolisable energy required for maintenance was 0.982 MJ/$kg^{0.63}$ daily for Landrace entire male pedigree pigs (Rao and McCracken, 1991). Schieman *et al.* (1991) from their experiment with barrows concluded that maintenance energy requirement was ME-955 KJ/$kg^{0.62}$, and that increase in protein

in diets did not increase energy required for maintenance. Optimum requirement for DE, CP and trace elements was 13.81 MJ/kg, 16 per cent and 0.5 per cent at 20-35 kg, 13.81 MJ/kg, 14 per cent and 0.5 per cent at 35-60 kg and 13.81 MJ/kg, 12.27 per cent and 0.4 per cent at 60-90 kg respectively. Back fat thickness and daily gain were affected by energy level and the lean per cent by CP level (Xie *et al.*, 1995).

Ranjhan *et al.* (1972) reported that restriction of energy after 50 kg of body weight reduced the growth rate and feed efficiency. He also suggested that the slaughter weight should be 70 kg rather than 90 kg. Pigs fed high energy diets had faster gain and required less feed/kg gain and the dressing percentage reduced with low energy diets (Talley *et al.*, 1976, Makhaw, 1981 and Campbell *et al.*, 1985). Utilisation of calories for growth was estimated to be equal for low and high energy diets during cool season but high energy diets was more efficient in warm season (Seerly *et al.*, 1978). Difference in daily energy intake by 20 per cent caused a 15 per cent lower live weight gain and a 12 per cent lower nitrogen retention (Mertz *et al.* (1980). Thomas and Singh (1984) observed that reduction in the DE content of grower pig ration by 25 per cent from NRC standards reduced average daily gain and digestibilities of nutrients. Daily growth rate increased linearly with increasing ME intake (Hata *et al.*, 1990). When Landrace x Large White growing pigs were fed

diets which contained energy levels of 15 per cent or 30 per cent below recommended levels Baran (1991) observed reduced average daily gain and increased feed:gain ratio.

Akita *et al.* (1992) reported that the mean daily gain was decreased when TDN was lowered and increased when TDN level was increased. Increasing the intake of energy significantly increased rates of live weight, empty body weight, and protein and lipid gains of pigs (Kyriazakis and Emmans, 1992). Hata *et al.* (1994) reported that energy retention was not affected by growth stage and was changed with feeding level and decreased by 0.2 units with an increase in ME intake of one $MJ/kg^{0.75}$ daily. Quiniou *et al.* (1995) showed that the average daily gain of pigs increased linearly with ME intake whereas feed conversion efficiency was not affected by energy intake. Heugtan and Stumpf (1996) indicated that a level of 3275 KCal of ME/kg gain was sufficient to maximize average daily gain and that further increase in ME level had no effect on average daily gain but reduced feed intake and improved feed:gain ratio. High energy density diets resulted in higher average daily gain and nitrogen retention at lower lysine/DE ratios than lower energy density diets (Lunen and Cole, 1996).

3. Calorie protein ratio

Energy protein inter relationship in the diets of pigs is well established. Pigs could tolerate a wider energy protein

ratio at the finishing period than during early growth period (Costain and Morgan, 1961). Clawson *et al.* (1962) emphasized the need for a higher dietary protein level with increased energy content and observed that narrow energy-protein ratio had a significant effect on the daily feed consumption and growth rate during the first 28 days. The efficiency of protein conversion was greater on low protein high energy diets and that high energy diets had protein saving effect by improving feed efficiency (Baird *et al.*, 1975). According to Feng *et al.* (1983) there were no significant differences in daily gain and feed conversion efficiency among pigs given diets with high or with intermediate energy and protein.

Campbell *et al.* (1985) reported that the rate of protein deposited increased linearly with increase in energy intake upto 33 MJ DE daily but it was not significantly affected by further increase in energy intake. There were no significant difference in average daily gain, feed efficiency and carcass characteristics of pigs fed rations containing different energy protein ratios (Sivaraman and Mercy, 1986). Oslage *et al.* (1987) showed that different levels of energy had a greater effect on growth than the gradation in protein supply. Chiba *et al.* (1989) reported that pigs responded linearly to an increase in lysine:DE ratio upto 3.00 or 3.4 g/MCal and showed little or no improvement with further increases. It was concluded that the efficiency of protein utilisation

increased with an increase in starch uptake (Kyriazakis and Emmans, 1992). Reducing energy intake without reducing protein intake significantly reduced the live weight gain (Rao and McCracken, 1992). Kulisiewicz *et al.* (1995) reported that raising dietary levels of protein and energy increased feed conversion efficiency, regardless of genotype.

C. Carcass quality

1. Influence of protein levels

Higher levels of protein in the diet of pigs was reported to enhance lean growth (Cunningham *et al.*, 1973; Baird *et al.*, 1975 and Irwin *et al.*, 1975); decrease back fat (Cunningham *et al.*, 1973; Irwin *et al.*, 1975; Cromwell *et al.*, 1978 and Tyler, 1983) and increase loin eye area (Cunningham *et al.*, 1973 and Tyler, 1983). Ramachandran (1977) could not notice any significant difference in carcass characteristics of pigs maintained on different dietary protein levels. Shields and Mahan (1980) suggested that temporary moderate protein restrictions in diets did not affect carcass quality and that gilts had leaner carcass than barrows. Feng *et al.* (1985) observed no significant difference in carcass dressing percentage among pigs given diets with high or with intermediate energy and protein. An increase in dietary crude protein or lysine:energy led to a significant improvement in

lean content (Castell *et al.*, 1994). Latimier and Dourmad (1994) reported that dressing percentage decreased with increased dietary protein. When low protein diets were supplemented with lysine for heavy finishing pigs there was no significant difference in carcass yield and quality (Kuhn and Burgstaller, 1995).

2. Influence of energy levels

Higher energy level increased carcass backfat thickness (Baird *et al.*, 1970) and lower energy level decreased carcass backfat (Mertz *et al.*, 1980; Kairis, 1983 and Sinacek and Prokop, 1983). Talley (1976) reported that pigs fed low energy diets had lower dressing percentage. Ramachandran (1977) reported that variation in dietary energy and protein levels in the rations of pigs did not have any effect on carcass characteristics. Increase in the intake of energy significantly increased empty body weight and protein and lipid gains of pigs slaughtered (Kyriazakis and Emmans, 1992). The back fat thickness was affected by energy level and the lean percentage by crude protein level (Xie *et al.*, 1995). Huegtan and Stumpf (1996) indicated that a ME of 3275 kcal/kg gain was sufficient to maximize average daily gain and average daily lean gain, and a further increase in the level of energy resulted in increased backfat thickness in finishing pigs.

3. Influence of fibre levels

Ranjhan *et al.* (1972) observed that there was a significant reduction in backfat thickness when the fibre level was increased and when the energy level was decreased in diet of pigs after they reached 50 kg body weight. Baird *et al.* (1975) reported that low fibre diets produced leaner carcasses when compared to high fibre diets.

4. Influence of season

Seerly *et al.* (1978) showed that in summer season when pig diets were supplemented with 9 per cent fat the carcass yielded had higher dressing percentage, more backfat and lesser loin eye area.

5. Influence of sex

Agarwala (1963) reported that dressing percentage was higher in females than in male pigs, while the percentage of carcass weight was estimated to be higher in males than in females. Robinson (1965) Seerly *et al.* (1965) Christian *et al.* (1980) and Shields and Mahan (1980) reported that gilts yielded better carcasses with lesser backfat. Shanmugasundaram and Ranganathan (1973) could not find any influence of sex on carcass characteristics. Sukh Deo *et al.* (1980) and Singh *et al.* (1986) observed no significant effect

of sex on ham per cent. Jogi *et al.* (1991) from their study of ham, shoulder and Loin yields from carcasses of common Indian pigs concluded that these traits were significantly affected by generation but the effect of sex on them was non-significant. Singh and Mishra (1992) showed that males had better carcass traits than females. Kloosterman and Huiskes (1993) reported that gilts had better back fat thickness and lean meat per cent than barrows under restricted feeding regime. Sex significantly influenced carcass length, eye muscle area, dressing percentage and Backfat thickness (Bardolai and Raina, 1995).

6. Influence of live weight

A significant difference was noted by Kumar *et al.* (1974) in the carcass length, backfat thickness and loin eye area but no significant difference in dressing percentage and ham per cent between different weight groups and it was concluded that slaughter of pigs at 70 kg would be more economical than at 50 and 90 kg weights under Indian condition. Anjaneyulu *et al.* (1984) concluded that yield of head, hot and chilled carcass, dressing per cent, backfat thickness and loin eye area were significantly more in higher age groups and per cent Ham, lean cut of carcass was significantly higher in young animals. Ramaswami *et al.* (1985) reported that the dressing per cent at 60 kg body weight of pure bred Yorkshire as 77 per cent while

the dressing percentage in crossbred pigs was found to be 64.5 per cent by Battacharyya and Sundaram (1991). Mishra and Sharma (1991) collected data on various traits under four weight groups <70, 71-80, 81-90 kg and above and found that, there was an increased trend in dressing per cent, carcass length, and backfat thickness with increase in carcass weight. The loin and ham weight were higher in those animals which were heavier. Cisneros *et al.* (1996) reported that as the slaughter weight increased, feed intake, backfat thickness and loin-eye area increased and that slaughter weight had little effect on growth rate or gain:feed ratio.

Materials and Methods

MATERIALS AND METHODS

Twenty four Large White Yorkshire female piglets with an average body weight of 20 kg belonging to the University Pig Breeding Farm were used as the experimental animals. The piglets were allotted randomly into four groups of six piglings each, as uniformly as possible with regard to age and body weight. Each group was housed in different pens and was maintained under identical managemental conditions. Before the commencement of the experiment all the animals were dewormed and sprayed with ectoparasiticide.

Experimental diets

The pigs were divided into four groups I, II, III and IV and were allotted to the following isonitrogenous and isocaloric dietary treatments.

T_1 - Control diet - Fish meal incorporated at a level of 12 per cent in grower and 8 per cent in finisher diet.

T_2 - 50 per cent of the fish meal was replaced with carcass meal ie., 6 per cent in grower and 4 per cent in finisher diets.

T_3 - 100 per cent of the fish meal was replaced with carcass meal ie., 12 per cent in grower and 8 per cent in finisher diets.

T_4 - Carcass meal was incorporated at a higher level i.e., 18 per cent in grower and 12 per cent in finisher ration.

The pigs were fed rations formulated to contain 18 per cent and 14 per cent crude protein, during the grower and finisher phase respectively. The pigs were fed the experimental rations ie., the grower ration until they attained an average body weight of 50 kg and thereafter changed to the finisher ration until the animals were slaughtered.

The pigs were allowed to consume as much feed as they could within a period of one hour both in morning and evening. Clean drinking water was provided adlibitum throughout the experimental period.

The percentage ingredient composition of the grower and finisher diets (Dietary treatments T_1, T_2, T_3 and T_4) are given in Table 1 and 2 respectively and the percentage chemical composition in Table 3.

The method described in Association of Official Analytical Chemists (AOAC, 1990) was followed to estimate the chemical composition of the ration and carcass meal.

Records of daily feed intake, fortnightly body weights and body measurements were maintained. Body measurements like

Table 1. Percentage ingredient composition of grower diets

Ingredients	T_1	T_2	T_3	T_4
Yellow maize	40.0	40.0	44.0	42.0
Groundnut cake (expellar)	11.0	13.5	15.5	9.5
Rice polish	15.0	14.0	12.0	15.0
Wheat bran	20.5	19.0	15.0	14.0
Unsalted dried fish	12.0	6.0	-	-
Carcass meal	-	6.0	12.0	18.0
Mineral mixture	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5

Vitamin supplement added @ 10 gram per 100 kg feed mixed

Indomix(R) vitamin supplement (Prinamal Health Care, Mumbai)

Composition per gram

Vitamin A - 40,000 IU, Vitamin D_3 5000 IU and Vit B_2 20 mg

Table 2. Percentage ingredient composition of finisher diets

Ingredients	T_1	T_2	T_3	T_4
Yellow maize	60.5	60.5	61.5	61.0
Groundnut cake (expellar)	5.0	5.5	5.5	2.0
Rice polish	19.0	18.5	19.0	19.5
Wheat bran	6.0	6.0	4.5	4.0
Unsalted dried fish	8.0	4.0	-	-
Carcass meal	-	4.0	8.0	12.0
Mineral mixture	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5

Vitamin supplement added @ 10 gram per 100 kg feed mixed

Indomix(R) vitamin supplement (Prinamal Health Care, Mumbai)

Composition per gram

Vitamin A - 40,000 IU, Vitamin D_3 5000 IU and Vit B_2 20 mg

Table 3. Percentage chemical composition of grower and finisher diets[a]

Ingredients	Grower diets				Finisher diets			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Dry matter	92.6	91.7	92.3	92.7	91.3	91.4	91.9	92.1
Crude protein (Nx6.25)	18.1	18.0	18.1	18.2	14.1	14.1	14.2	14.0
Ether extract	4.8	5.1	5.9	6.7	5.6	5.6	6.0	6.3
Crude fibre	5.9	5.7	5.5	4.6	5.3	5.5	5.8	5.6
Nitrogen free extract	61.1	61.0	60.2	58.6	64.9	65.7	64.5	64.1
Total ash	10.1	10.2	10.3	11.9	10.1	9.1	9.5	10.0
Acid insoluble ash	4.0	3.4	1.5	1.9	5.1	3.2	2.5	2.4
Calcium	1.05	1.91	2.6	2.7	1.4	1.1	1.2	1.6
Phosphorus	0.70	0.95	1.2	1.0	0.7	0.9	0.9	1.0

a On dry matter basis

body length, chest girth and shoulder height were recorded fortnightly.

The carcass meal which was incorporated in the feed was a product prepared by the process of dry rendering in the carcass utilization plant, Livestock Products Technology, Mannuthy.

The animals were maintained on their respective diets until they were slaughtered.

Three animals from each dietary treatment were selected randomly and were slaughtered at the end of the experiment for evaluation of their carcass characteristics as given below.

The head was removed at the atlanto-occipital joint and the dressed weight of the carcass without head was recorded to determine the dressing percentage of the hot carcass. Weight of head was also recorded. Length of the 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 the last lumbar vertebrae, and the average of these three readings was taken as the average backfat thickness. The cross-sectional area of the eye-muscle was calculated from its impression obtained at the region of the tenth rib. The ham

was removed by cutting at the point approximately, two and a half inches from the most anterior part of the aitch bone by sawing through the sacral vertebrae and shaft of ilium.

Economics of gain, when carcass meal replaced fish meal in the ration of pig was calculated.

Statistical analysis of the data was carried out by the completely randomized design method as described by Snedecor and Cochran (1981).

Results

RESULTS

Proximate and amino acid composition of carcass meal

Proximate composition of carcass meal utilized for the experimental purpose was estimated and is given in Table 4.

The amino acid composition of the pooled sample of carcass meal was estimated at the Central Institute of Fisheries Technology, Cochin and is given in Table 5.

Live weight gain, Body measurements and Feed conversion efficiency

The results on the mean values of body weight, body length, body girth and body height, recorded at fortnightly interval, summarised data on average gain in body weight and body measurements, cumulative average daily gain and total feed intake, total body weight gain and feed conversion efficiency of animals in the four groups I, II, III and IV under the respective dietary treatments T_1, T_2, T_3 and T_4 are presented in Tables 6 to 12 and represented by Fig.1 and 2.

Age and weight at slaughter

The age and the average weight at slaughter of pigs belonging to the groups I, II, III and IV are given in Table 13.

Table 4. Percentage chemical composition of carcass meal[a]

Component	Average with S.E.[b]
Dry matter	96.4 ± 0.08
Crude protein	47.7 ± 0.16
Ether extract	11.2 ± 0.18
Crude fibre	0.8 ± 0.16
Nitrogen free extract	5.7 ± 0.81
Total ash	34.6 ± 0.32
Acid insoluble ash	0.8 ± 0.19
Calcium	11.7 ± 0.25
Phosphorus	6.1 ± 0.35

a On dry matter basis
b Average of six values

Table 5. Amino acid composition of carcass meal

Amino acid	g/16 g N
Aspartic acid	8.01
Threonine	3.08
Serine	3.68
Glutamic acid	12.57
Proline	7.52
Glycine	15.60
Alanine	8.50
Valine	3.89
Methionine	0.93
Isoleucine	2.32
Leucine	6.18
Tyrosine	2.02
Phenyl alanine	3.45
Histidine	2.78
Lysine	7.53
Arginine	9.54
Tryptophan	0.35

Table 6. Body weight (kg) of pigs on different dietary treatments at fortnightly intervals (Mean ± SE)

Treatments	Fortnights									
	0	1	2	3	4	5	6	7	8	9
T_1	20.1± 1.87	25.7± 2.79	31.2± 2.83	36.4± 2.78	43.2± 3.01	51.3± 4.12	57.6± 4.00	63.5± 4.95	69.2± 5.84	73.8± 5.91
T_2	20.0± 2.32	25.9± 2.65	30.4± 3.36	37.1± 4.26	43.2± 4.76	48.6± 4.59	52.9± 4.74	60.4± 5.10	66.0± 5.39	71.4± 5.62
T_3	20.1± 2.04	26.1± 2.43	31.0± 3.28	38.3± 4.29	43.8± 4.99	50.2± 6.21	56.5± 6.15	62.3± 6.24	68.5± 7.41	74.0± 7.47
T_4	20.4± 1.46	26.4± 1.57	32.3± 2.18	37.8± 2.02	43.5± 1.99	51.5± 2.59	57.6± 2.13	63.4± 2.16	68.8± 2.49	73.7± 2.47

Table 7. Body length (cm) of pigs maintained on different dietary treatments at fortnightly intervals (Mean ± SE)

Treatments	Fortnigts									
	0	1	2	3	4	5	6	7	8	9
T_1	58.8± 2.77	64.2± 1.51	65.8± 1.17	68.5± 0.76	71.8± 1.30	77.7± 2.63	79.5± 2.43	80.7± 2.03	82.5± 2.35	88.3± 2.65
T_2	60.7± 2.27	62.5± 2.11	63.3± 2.17	65.7± 2.08	68.5± 2.25	75.0± 2.96	76.8± 3.44	79.5± 3.93	81.5± 3.88	86.2± 3.42
T_3	60.7± 2.92	63.5± 2.36	66.0± 1.69	69.2± 1.87	73.8± 1.74	78.8± 3.02	80.2± 2.85	82.2± 2.41	84.7± 3.05	89.7± 2.69
T_4	61.3± 1.58	63.7± 1.43	66.0± 1.63	69.3± 0.88	74.3± 1.18	80.2± 1.20	82.0± 1.21	83.5± 1.54	85.3± 1.31	89.0± 2.40

Table 8. Body girth (cm) of pigs maintained on different dietary treatments at fortnightly intervals (Mean ± SE)

Treatments	Fortnights									
	0	1	2	3	4	5	6	7	8	9
T_1	61.0± 2.60	70.2± 2.59	72.0± 2.02	77.0± 2.83	81.0± 2.11	84.5± 2.05	87.9± 1.46	91.0± 1.79	95.7± 2.62	98.3± 2.22
T_2	60.0± 2.84	67.0± 3.15	71.0± 4.22	73.7± 4.53	80.3± 3.27	82.7± 3.14	86.0± 3.47	87.8± 3.59	91.5± 3.82	96.5± 3.80
T_3	61.8± 1.87	66.8± 3.61	69.5± 2.79	75.4± 3.90	80.7± 3.42	83.0± 3.63	88.5± 3.40	90.5± 3.45	93.3± 3.14	98.0± 4.04
T_4	62.5± 1.02	68.5± 1.33	70.8± 1.96	75.8± 1.82	79.2± 2.18	83.5± 1.33	87.8± 2.27	91.3± 2.27	93.7± 1.87	97.33± 2.26

Table 9. Body height (cm) of pigs maintained on different dietary treatments at fortnightly intervals (Mean ± SE)

Treatments	Fortnights									
	0	1	2	3	4	5	6	7	8	9
T_1	37.2± 1.56	44.0± 0.86	45.7± 1.40	48.2± 1.35	51.5± 1.87	55.2± 1.89	57.3± 1.67	59.7± 2.03	60.0± 1.91	62.5± 1.67
T_2	34.5± 3.56	42.0± 2.65	45.3± 2.40	47.8± 1.45	51.2± 1.68	52.3± 1.73	54.3± 1.86	56.5± 1.99	59.0± 2.11	60.3± 2.22
T_3	36.3± 1.89	41.3± 1.86	44.7± 1.89	48.2± 2.02	51.7± 1.87	53.0± 1.91	54.8± 2.37	56.3± 2.11	57.8± 1.92	60.7± 2.06
T_4	37.5± 1.09	43.2± 1.01	45.8± 0.98	48.5± 0.67	50.7± 0.92	53.2± 1.22	56.2± 0.87	58.0± 0.51	59.5± 1.33	61.0± 1.13

Table 10. Summarised data on average gain in body weight (kg) and body measurements (cm) of the pigs on different treatments[a,b]

Gain	T_1	T_2	T_3	T_4
Body weight	53.7± 2.00	51.4± 1.16	53.9± 2.45	53.3± 0.58
Body length	29.5± 0.64	25.5± 0.58	29.0± 0.45	27.7± 0.51
Chest girth	37.3± 0.71	36.5± 0.60	36.2± 0.51	33.8± 0.53
Shoulder height	25.3± 0.60	25.8± 0.63	24.3± 0.42	23.5± 0.42

[a] Mean of six values with SE
[b] Values do not differ (P>0.05)

Table 11. Average daily gain (g) of pigs maintained on different dietary treatments

Dietary treatment	Initial body weight (kg)	Final body weight (kg)	Total weight gain (kg)	Number of days under experiment	Average daily gain
T_1	20.1± 1.87	73.8± 5.91	53.7± 2.00	141	381.0± 14.19 [a]
T_2	20.0± 2.32	71.4± 5.62	51.4± 1.16	141	389.0± 8.22 [a]
T_3	20.1± 2.04	74.0± 7.47	53.9± 2.45	141	382.0± 17.38 [a]
T_4	20.4± 1.46	73.7± 2.47	53.3± 0.58	141	376.0± 4.10 [a]

a Values do not differ ($P>0.05$)

Table 12. Summarised data on feed intake, live weight gain and feed conversion efficiency of pigs on different treatments[a]

Dietary treatment	Total feed intake (kg)	Total live weight gain (kg)	Feed conversion efficiency (kg feed/kg gain)
T_1	234.6	53.7 ± 2.00	4.36 ± 0.26[b]
T_2	234.6	51.4 ± 1.16	4.56 ± 0.38[b]
T_3	234.6	53.9 ± 2.45	4.35 ± 0.20[b]
T_4	234.6	53.3 ± 0.58	4.48 ± 0.25[b]

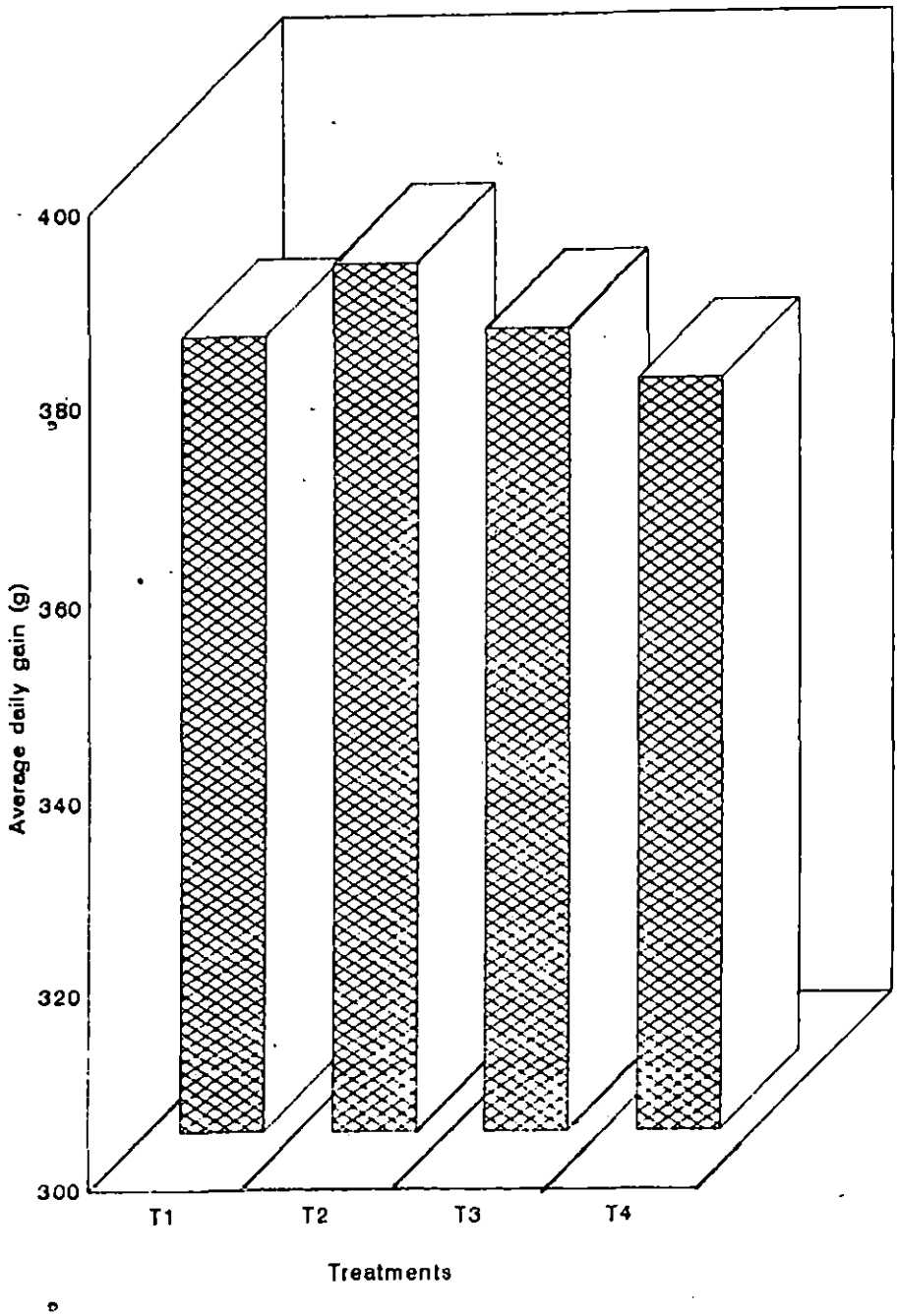
[a] Mean of six values with SE
[b] Values do not differ (P>0.05)

Table 13. Age at slaughter and carcass characteristics of pigs on different treatments[a]

Dietary Treatments	Age at slaughter (days)	Live weight (kg)	Weight of head (kg)	Dressed weight without head (kg)	Dressed weight with head (kg)	Carcass length (cm)	Average backfat thickness (cm)	Weight of ham (kg)	LOIN-EYE area (cm^2)	Dressing percentage without head
T_1	216	77.3± 4.34	5.2± 0.32	55.8± 3.32	61.0± 3.54	80.7± 1.45	2.33± 0.29	5.76± 0.32	30.7± 3.73	72.4± 3.64
T_2	216	77.8± 3.45	5.1± 0.28	57.7± 4.91	62.7± 5.17	77.7± 1.33	2.79± 0.18	6.05± 0.35	29.4± 2.63	73.9± 4.07
T_3	216	85.8± 1.36	5.3± 0.21	58.7± 0.88	64.0± 1.06	77.0± 0.58	3.02± 0.38	6.09± 0.24	34.9± 3.05	68.4± 2.08
T_4	216	75.7± 3.71	5.6± 0.09	55.7± 3.29	61.2 3.21	77.7± 0.62	2.82± 0.06	6.43± 0.38	36.9± 0.81	73.5± 0.86

a Values do not differ ($P>0.05$)

Fig.1 AVERAGE CUMULATIVE DAILY WEIGHT GAIN (g) OF PIGS MAINTAINED ON FOUR DIETARY TREATMENTS



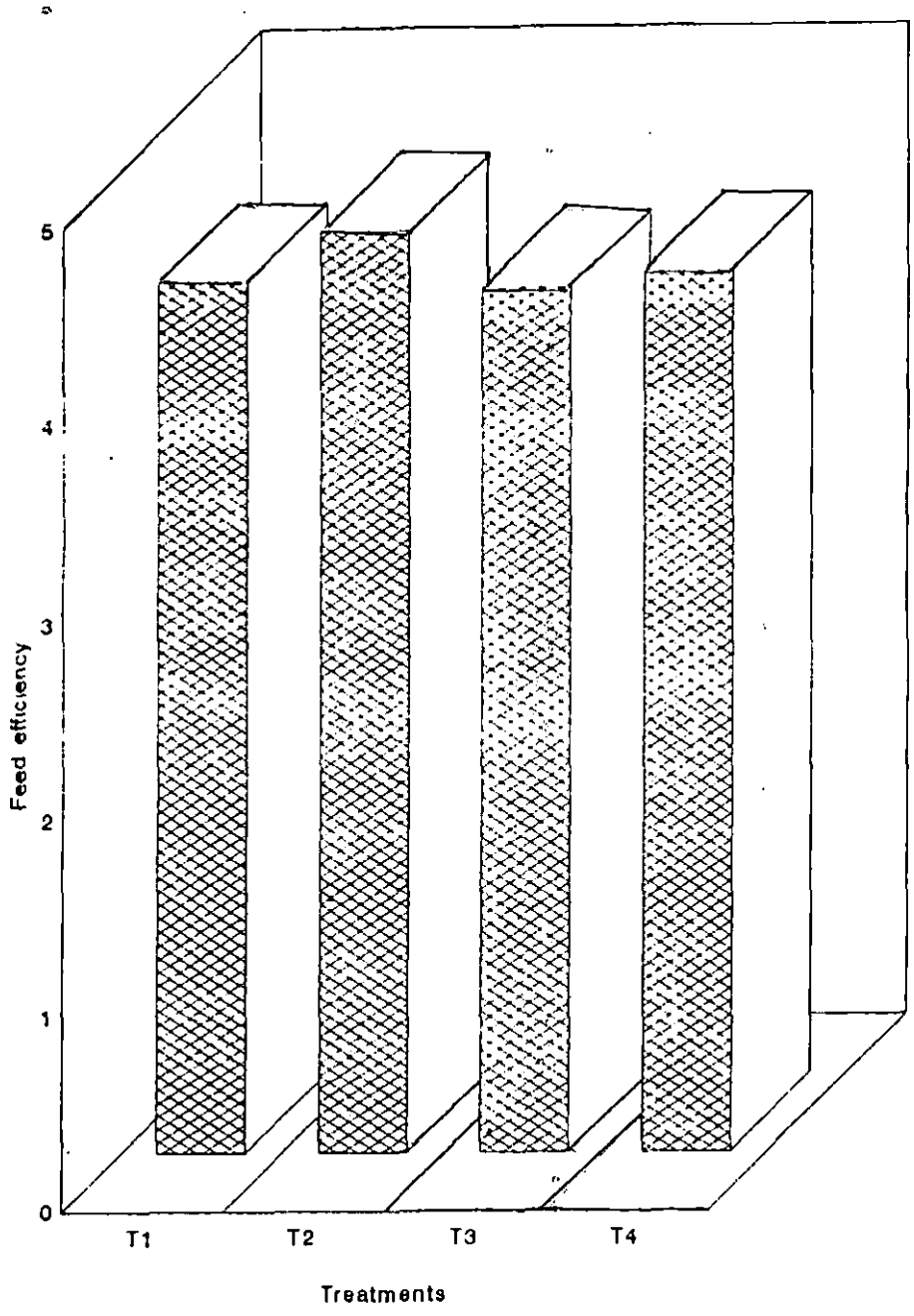
T_1 - **Control**

T_2 - **Carcass meal replacing fish meal at 50% level**

T_3 - **Carcass meal replacing fish meal at 100% level**

T_4 - **Carcass meal at a higher level**

Fig.2 AVERAGE CUMULATIVE FEED EFFICIENCY OF PIGS MAINTAINED ON FOUR DIETARY TREATMENTS



T_1 - Control
T_2 - Carcass meal replacing fish meal at 50% level
T_3 - Carcass meal replacing fish meal at 100% level
T_4 - Carcass meal at a higher level

Carcass characteristics

Data on carcass characteristics of animals slaughtered are presented in Table 13.

Economics on gain

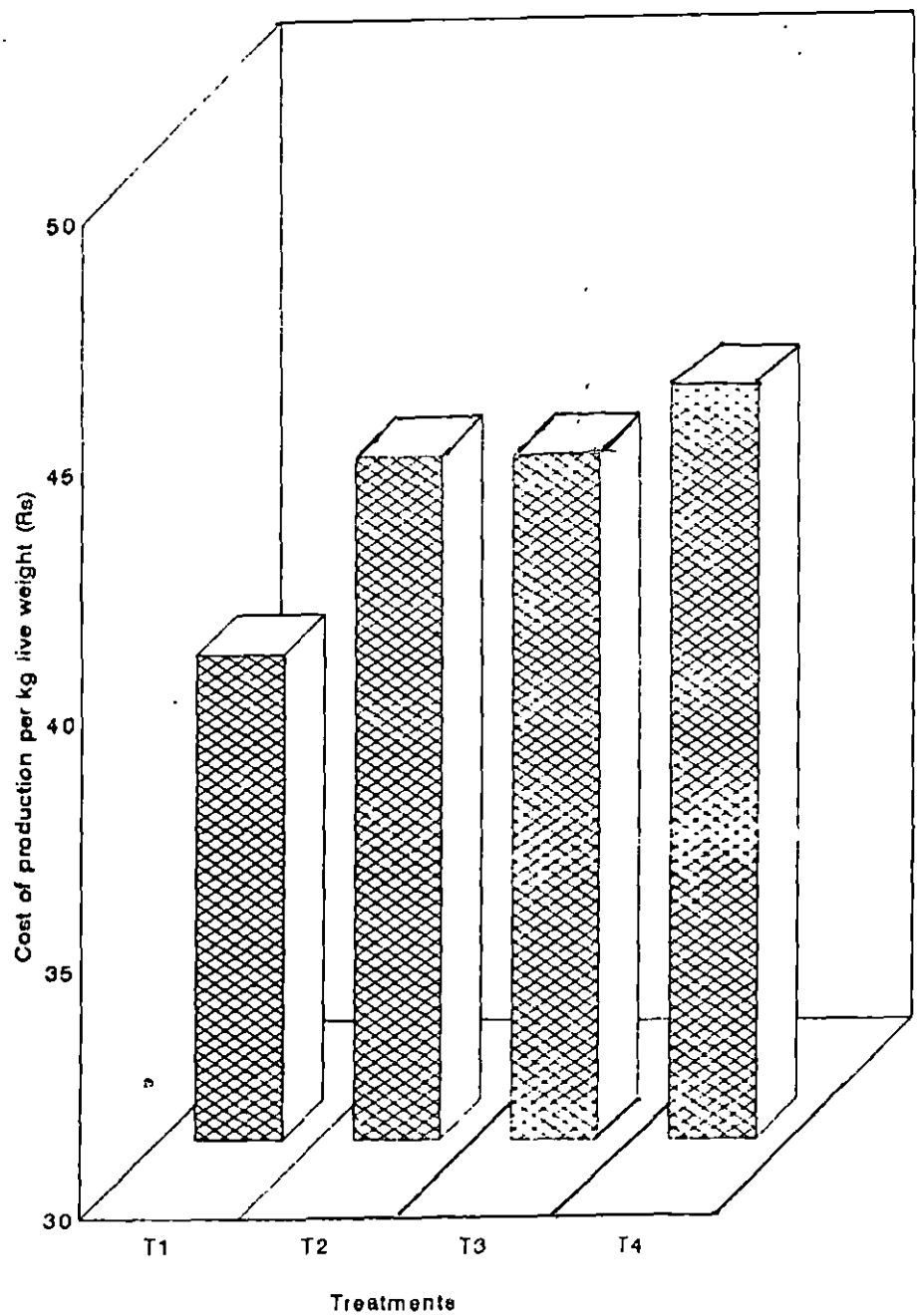
Data on cost of production (Rs.) per kg live body weight of pigs maintained on the four dietary treatments are presented in Table 14 and represented by Fig.3.

Table 14. Economics of gain: cost of production (Rs.) per kg live body weight of pigs maintained on different dietary treatments

	T_1	T_2	T_3	T_4
Cost/kg of grower ration (Rs.)	7.02	7.49	7.98	8.12
Cost/kg of finisher ration (Rs.)	6.64	6.86	7.07	7.12
Cost of production per kg live weight (Rs.)[a]	39.78	43.70	43.73	45.11

a Calculated under the assumption that cost of feed accounts for about 75% of the total cost of production in pigs (Krider and Carrol, 1971)

Fig 3 ECONOMICS ON GAIN · COST OF PRODUCTION PER Kg LIVE BODY WEIGHT OF PIGS MAINTAINED ON FOUR DIETARY TREATMENTS



T_1 - **Control**

T_2 - **Carcass meal replacing fish meal at 50% level**

T_3 - **Carcass meal replacing fish meal at 100% level**

T_4 - **Carcass meal at a higher level**

Discussion

DISCUSSION

Chemical composition of carcass meal

From the results presented in Table 4, it is seen that in carcass meal the crude protein, ether extract, nitrogen free extract, total ash, calcium and phosphorus in per cent on dry matter basis were 47.7, 11.2, 5.7, 34.6, 11.7 and 6.1 respectively. These values are in the range of the values, reported by Just *et al.* (1983), who got a crude protein and ash content of 47.2 to 65.9 per cent and 22 to 32.5 per cent respectively for meat cum bone meal. Prokopenko and Kolyada (1989) had reported the crude protein, fat, calcium and phosphorus content of meat cum bone meal as 49.7 per cent, 13 per cent 10 per cent and 5.4 per cent respectively while McDonald *et al.* (1995) recorded the crude protein and fat content of meat cum bone meal as 450 to 550 g and 30 to 130 g/kg of feed respectively.

Live weight gain

The results given in Table 6, represent the average fortnightly body weights, which show that the animals maintained on the four dietary treatments gained weights satisfactorily and at comparable rates during the entire experimental period. The average cumulative daily gain were 381, 389, 382 and 376 g for the four dietary treatments T_1, T_2, T_3 and T_4 respectively.

Statistical analysis of the above parameters showed that there were no significant differences among the four treatment groups.

The result obtained in the present study is in agreement with those reported by Brookes *et al.* (1992) who showed that inclusion of meat cum bone meal in the diet of growing and finishing pigs at 3, 6 and 9 per cent levels had no significant effect on daily gain and feed conversion efficiency. Mishev *et al.* (1983), Galuskha (1990) and Snitsar *et al.* (1992) also observed no significant effect on either the mean daily gain or feed conversion efficiency when fish meal was completely replaced by meat cum bone meal in the diet of pigs.

Average daily gain of 396 and 359 g obtained by Propenko and Kolyada (1991) for force dried and traditionally dried meat cum bone meal respectively when added at 5.7 per cent level to pig diet, is in agreement with the results of the present experiment. Ismailov and Kalashyan (1982) noted an higher average daily gain of over 600 g when meat cum bone meal was supplemented at 10 per cent level. Similar observation was also observed by Snitsar *et al.* (1982) and Mishev *et al.* (1983) when meat cum bone meal replaced fish meal completely, which may be attributed to other factors like genetic and environmental, besides nutrition.

Feed conversion efficiency

Table 12 shows the cumulative feed conversion efficiency for the four dietary treatments T_1, T_2, T_3 and T_4 to be 4.36, 4.56, 4.35 and 4.48 respectively.

The feed conversion efficiency obtained by Snitsar *et al.* (1982) were 4.62 and 4.64 when meat cum bone meal was supplemented at two levels 0 and 6 per cent respectively. Supplementation of meat cum bone meal at 10 per cent level resulted in a feed conversion efficiency of 4.62 in studies carried out by Ismailov and Kalashyan (1982). Bhagawat and Sahasrabuddhe (1971) reported a FCE of 1:4.2 in Large White Yorkshire growing pigs and Kumar *et al.* (1972) showed feed efficiency values of Large White Yorkshire pigs to be 3.4, 4.0 and 4.5 at the body weights of 50 kg, 50 to 70 kg and 70 to 90 kg respectively. The results obtained in the present investigation is comparable to those obtained by the above authors.

Body measurements

The data in Table 7 to 9 indicate that the gain in body measurements takes place parallel to gain in body weight. This shows that the body weight and body measurements are correlated with each other as reported by Gruev and Machev (1970). The linear relationship between live weight gain and body

measurement was also recorded by several other authors (Mickwitz and Bobeth, 1972; Deo and Raina, 1983 and Sahayaruban *et al.*, 1984). Statistical analysis of data on body measurements revealed no significant difference among the treatment groups.

Carcass characteristics

Dressing percentage

The average values of dressing percentage recorded were 72.4, 73.9, 68.4 and 73.5 per cent for the pigs maintained on the four dietary treatments T_1, T_2, T_3 and T_4 respectively (Table 13).

Baird *et al.* (1970); Sebastian (1972); Ramachandran (1977); Devi (1981); Thomas and Singh (1984) and Sivaraman and Mercy (1986) obtained dressing percentage values ranging from 63.0 to 73.0 per cent in pigs slaughtered at 70 to 90 kg body weight. Their observation is in agreement with those obtained in the present study. Goldobin *et al.* (1995), on supplementation of meat cum bone meal obtained a dressing percentage of 75 to 76 per cent. Ismailov and Kalashyan (1981) reported that inclusion of meat cum bone meal in the diet of pigs at 0 and 10 per cent level resulted in no significant difference among groups in the dressing percentage.

Carcass length

The average carcass length of animals recorded under the four dietary treatments T_1, T_2, T_3 and T_4 were 80.7, 77.7, 77.0 and 77.7 cm respectively. Statistical analysis showed that they did not differ significantly.

Baird *et al.* (1970), Sebastian (1972), Ramachandran (1977), Devi (1981), Thomas and Singh (1984) and Sivaraman and Mercy (1986) observed values ranging from 70.0 to 80 cm for carcass length in pigs slaughtered at 70 to 90 kg. These values are similar to those obtained for pigs in the present investigation.

Backfat thickness

The average backfat thickness for the pigs maintained on four dietary treatments T_1, T_2, T_3 and T_4 were 2.33, 2.80, 3.02 and 2.82 cm respectively and they did not differ. Mishra *et al.* (1990) reported an average backfat thickness of 1.73 cm to 2.79 cm in pigs belonging to different live weight groups of 51 to 100 kg. Mishra and Sharma (1991) in their study on the effect of live weight on carcass weight showed the average backfat thickness of 71 to 80 kg weight group to be 2.82 cm and for 81 to 90 kg to be 3.04 cm which is comparable with the result obtained in the present study.

Loin-Eye area

The average values for loin eye area of pigs in the four treatments T_1, T_2 and T_3 and T_4 were 30.7, 29.4, 34.8 and 36.9 sq cm respectively. This is in agreement with the results obtained by Mishra *et al.* (1990) who obtained loin eye area which ranged from 28.9 to 37.1 sq cm for the different weight groups from 61 to 70 kg to 81 to 90 kg respectively. Goldobin *et al.* (1995) obtained a loin eye area of 35.0, 28.7 and 34.3 sq cm when meat and bone meal was supplemented in the diets of castrated, uncastrated Large White pigs and uncastrated Large White x Landrace pigs respectively.

Weight of ham

The average values for the weight of ham of pigs belonging to the four dietary treatments T_1, T_2, T_3 and T_4 were 5.76, 6.05, 6.29 and 6.43 kg respectively and did not vary significantly among groups. The observations in the present study are in agreement with the values reported for yield of ham by Sebastian (1972), Baird *et al.* (1975), Ramachandran (1977), Devi (1981) and Sivaraman and Mercy (1986).

Economics of gain

The cost of carcass meal was Rs.15/kg and that of fish meal was Rs.10.25/kg. The performance obtained due to the

inclusion of carcass meal was similar to that of fish meal but due to the high cost of carcass meal the cost of production/kg live body weight was slightly more when compared to fish meal.

The cost of production per kg live body weight of pigs maintained on the four dietary treatments T_1, T_2, T_3 and T_4 were Rs.39.78, 43.70, 43.73 and 45.11 respectively.

An overall critical evaluation of the results obtained in the present study indicates that carcass meal can be substituted for fish meal in growing and fattening swine rations as no significant difference in live weight gain feed conversion efficiency or carcass characteristics were obtained.

Summary

SUMMARY

A study was undertaken to assess the effect of carcass meal, a product processed from slaughter house byproducts, on growth performance and carcass characteristics in Large White Yorkshire pigs. Carcass meal was incorporated in the pig diets replacing the commonly used animal protein supplement, fish meal at four levels. Twenty-four Large White Yorkshire female piglets with an average live weight of about 20 kg were randomly selected and allotted into four groups of six animals each as uniformly as possible. These four groups (I, II, III and VI) were given the dietary treatments T_1, T_2, T_3 and T_4 which were isoproteimic and isocaloric and contained carcass meal replacing fish meal at 0, 6, 12 and 18 per cent level in grower rations and at 0, 4, 8 and 12 per cent level in finisher rations respectively. The animals were maintained on their respective diets with 18 per cent protein until they reached an average body weight of 50 kg and on 14 per cent protein, till slaughter.

Records of daily feed intake and fortnightly body weight and body measurements were maintained throughout the period of the experiment. Three animals from each group were randomly selected and slaughtered at the end of the experiment to obtain the data on carcass characteristics.

Animals under all the four dietary treatments gained weight satisfactorily and there was no significant difference in weight gain throughout the course of the experiment. The overall average daily gains for the four groups I, II, III and IV were 381, 389, 382 and 376 g, respectively.

The data on body measurements indicated that gain in body measurements were directly proportional to gain in body weight.

With regard to the feed conversion efficiency there was no significant difference among the four groups. The average overall values were 4.36, 4.56, 4.35 and 4.48 for the four groups I, II, III and IV respectively.

Carcass characteristics did not vary significantly among the four treatments. The average values for dressing percentage for the animals in the four groups (I, II, III and IV) were similar and found to be 72.4, 73.9, 68.4 and 73.5 per cent respectively. The average carcass length were 80.7, 77.7, 77.0 and 77.7 cm for the four groups I, II, III and IV respectively. The average values for backfat thickness were 2.33, 2.79, 3.02 and 2.82 cm, loin eye area were 30.7, 29.4, 34.9 and 36.9 cm^2 and that of weight of ham were 5.76, 6.05, 6.09 and 6.43 kg for the four groups I, II, III and IV respectively.

Inclusion of carcass meal resulted in a slight increase in the cost of production when compared to fish meal. The cost of production per kg live weight of animals in group I, II, III and IV were found to be Rs.39.78, 43.70, 43.73 and 45.11 respectively.

It can be concluded that carcass meal can be used to replace fish meal partially or completely in swine diets without adverse effects on the growth rate, feed efficiency and carcass traits.

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NUTRITIVE EVALUATION OF CARCASS MEAL FOR GROWTH AND CARCASS CHARACTERISTICS IN LARGE WHITE YORKSHIRE PIGS

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ABSTRACT OF A THESIS

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ABSTRACT

An investigation was carried out to assess the effect of carcass meal, a product processed from slaughter house by-products, on the growth rate, feed conversion efficiency, carcass quality and economics of production in growing and finishing pigs. The conventional animal protein supplement fish meal was replaced with carcass meal.

Twenty four Large White Yorkshire female piglets with an average live weight of 20 kg were divided into four groups (Groups I, II, III and IV) of six animals each as uniformly as possible. They were maintained on four isoproteimic and isocaloric diets T_1, T_2, T_3 and T_4 containing 0, 6, 12 and 18 per cent in grower rations and at 0, 4, 8 and 12 per cent in finisher rations respectively of carcass meal replacing fish meal.

The animals under all the four dietary treatments had similar growth rates with an overall average daily gain of 381, 389, 382 and 376 g for the groups I, II, III and IV respectively. The total feed intake of the animals in different groups were similar. There was no significant difference in the feed conversion efficiency among groups, the overall average values being 4.36, 4.56, 4.35 and 4.48 for the groups I, II, III and IV respectively.

Results of the studies on carcass characteristics revealed that there was no significant difference in the dressing percentage, carcass length, backfat thickness, loin eye area and weight of ham among the groups.

Cost of production per kg live weight of animals in the four groups I, II, III and IV were Rs.39.78, 43.70, 43.73 and 45.11 respectively which is attributed to the high cost of carcass meal as compared to fish meal.

The above results indicate that carcass meal can be effectively included in the diets of growing and finishing pigs without affecting either the growth performance or the carcass characteristics.