INFLUENCE OF DIFFERENT LEVELS OF ENERGY ON GROWTH PERFORMANCE OF CROSSBRED 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 **"INFLUENCE OF DIFFERENT LEVELS OF ENERGY ON GROWTH PERFORMANCE OF CROSSBRED 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.

Mannuthy,
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CERTIFICATE

Certified that the thesis, entitled **"INFLUENCE OF DIFFERENT LEVELS OF ENERGY ON GROWTH PERFORMANCE OF CROSSBRED PIGS"** submitted for the degree of M.V.Sc. in the subject of Animal Nutrition of the Kerala Agricultural University, is a bonafide research work carried out by Miss. Rekha, P., under my supervision and that no part of this thesis has been submitted for any other degree.

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REKHA

To

My Parents

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Introduction

1. INTRODUCTION

Swine production assumes great importance in India due to the fact that pigs are the most efficient among domestic animals in the conversion of feed stuffs and wastes of domestic and agro-industrial origin into edible meat. Animal proteins are considered to be the best source of essential amino acids to supplement vegetable proteins in the diet of man and the contribution of pork in this regard is commentable.

Pig farming provides reasonable returns to the farmer considering the low investment needed and the shorter span for each generation. Desi pigs continue to be popular among village farmers due to the lesser care, feed and managerial requirements compared to their imported counterparts like Yorkshire and Landrace. Improvement of Desi pig by crossbreeding with imported breeds with a view to improve their feed efficiency is an approved programme of the Indian Council of Agricultural Research and is being carried out under the All India Co-ordinated Research Project (AICRP).

The ultimate success of pig raising largely depends on the supply of nutritionally balanced economical rations. Seventy to eighty per cent of the cost of rearing a pig to market weight is for feed. 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.

Little work has so far been done in India to ascertain the requirements of protein and energy for crossbred pigs. Knowledge of the effect of energy intake on growth performance and body composition of pigs is essential for the development of biologically and economically efficient feeding strategies. Little has been reported on the optimum level of digestible energy for crossbred swine fed on practical diets. In view of these shortcomings, the present investigation was designed and conducted to assess the performance of crossbred (Large White Yorkshire x Desi) pigs fed on three different rations varying in their energy levels.

Review of Literature

2. REVIEW OF LITERATURE

2.1 Nutrient requirement of pigs

2.1.1 Protein requirements

Aunan *et al.* (1961) reported that dietary protein levels of 14, 16 or 18 per cent did not have a significant effect on daily gain and feed efficiency.

Cunningham *et al.* (1973) observed that pigs fed a 10 per cent protein diet gained slower and were fatter than pigs fed a 14 per cent protein diet.

Irvin *et al.* (1975) found that feed conversion was lowest in pigs fed on 14 per cent crude protein diet compared to those fed on 12, 16 and 18 per cent crude protein diets. They also found that daily feed intake was higher with 12 per cent protein diet.

Davey (1976) observed that growth rate of Duroc and Yorkshire pigs was less when the protein level in their diet was reduced to 11 per cent compared to a 12 per cent protein diet, whereas a 16 per cent diet decreased marbling scores and improved feed efficiency.

Campbell *et al.* (1984) showed that protein intake required for the maximal rate of protein deposition was related to energy intake and was not a function of daily protein intake *per se*.

Campbell *et al.* (1985a) showed that in pigs of 45 to 70 kg body weight protein deposition was found to increase upto an energy intake of 33 MJ DE/day. Above that energy level further increase of protein to maintain the constant energy protein ratio was found to have little effect. This suggests a decline in the concentration of protein in the ration to support maximum gain when the energy concentration is raised from 33 to 39.2 MJ DE/day.

Indian Council of Agricultural Research (ICAR, 1985) recommends crude protein levels of 18, 16 and 14 per cent for pigs weighing from 5 to 10, 10 to 40 and 40 to 60 kg, respectively.

Henry *et al.* (1992) reported that increasing the protein level from 13 to 15.6 per cent did not affect feed intake, but growth rate was lower and feed/gain ratio was increased. They also reported that addition of glutamic acid as a source of non-essential amino acid, decreased the daily feed intake, but feed conversion ratio was unchanged.

Trinidade *et al.* (1994) opined that 16 per cent crude protein supplemented with lysine, methionine and cystine was sufficient to meet the requirements in diets of pigs weaned at 28 days of age.

National Research Council (NRC, 1998) recommendation of protein for pigs of 3 to 5, 5 to 10, 10 to 20, 20 to 50, 50 to 80 and 80 to 120 kg body weights are 26.0, 23.7, 20.9, 18.0, 15.5 and 13.2 per cent respectively.

2.1.2 Amino acid requirements

Baker *et al.* (1969) found that tryptophan is the first limiting and lysine the second limiting amino acid in corn protein and that isoleucine, threonine and glutamic acid-glycine mixture can be considered as a possible third limiting factor.

Boomgaardt and Baker (1973) suggested that the minimal levels of tryptophan required for maximal weight gain in pigs were 0.71, 0.67 and 0.66 per cent of the protein, respectively at 10, 14 and 18 per cent dietary protein.

Lewis *et al.* (1981) found that weight gains decreased as the lysine content exceeded 1.25 per cent of the diet.

Davydenko (1982) suggested that the methionine + cystine requirement for young pigs was 3.3 to 3.5 per cent of dietary crude protein.

Batterham *et al.* (1985) observed that when Large White pigs were fed *ad libitum*, maximum daily gain was produced by feeding at least 10 g lysine per kg feed at 20 kg in males, declining to about 8 g/kg at 80 kg and 9.9 g lysine per kg at 20 kg in females, declining to less than 5-6 g/kg at 75 kg. Carcass characteristics were largely unaffected by lysine concentration.

For pigs between 20 and 45 kg live weight, the dietary lysine requirement for maximal growth and rate of protein deposition were 0.78 and 0.81 g/MJ digestible energy, respectively (Campbell *et al.*, 1985b).

Henry *et al.* (1992) reported that increasing dietary level of lysine from 0.55 to 0.65 per cent in finishing pigs with *ad libitum* access to feed improved average daily gain as well as muscle and fat. Feed/gain was decreased in relation to increased daily feed intake and there was a decrease in carcass length and an increase in muscle depth.

Bikker *et al.* (1994) found that approximately 0.60 g of ileal digestible lysine/MJ of digestible energy was required to optimise performance in gilts with high genetic potential for lean growth irrespective of the feed intake. Lawrence *et al.* (1994) found that a lysine:DE ratio of 3.0 to 3.5 g of lysine/Mcal of digestible energy was required to maximize lean and protein deposition. According to Chang *et al.* (2000) the optimum lysine:DE ratios were 3.2 and 3.8 of lysine/Mcal DE per kg diet for barrows and gilts of 16 to 57 kg body weight, respectively.

Friesen *et al.* (1994) observed that high-lean-growth gilts require at least 22 g/day total lysine intake from 34 to 72 kg to maximize crude protein accretion. Friesen *et al.* (1995) observed a greater dietary lysine requirement for high-lean growth gilts than current National Research Council estimate (19 g/day from 50 to 110 kg) for average daily gain (72 to 104 kg) and gain: feed (72 to 136 kg).

Nam *et al.* (1995) suggested that pigs were unable to control their protein and lysine intakes to meet their requirements for growth when given a choice of two isoenergetic diets which differed in protein and lysine contents.

Owen *et al.* (1995) suggested that segregated early-weaned pigs require approximately 0.48 to 0.52 per cent dietary methionine to maximize growth performance from day 0 to 14 post weaning.

National Research Council (NRC, 1998) recommendation of lysine for pigs of 3 to 5, 5 to 10, 10 to 20, 20 to 50, 50 to 80 and 80 to 120 kg body weights are 1.5, 1.35, 1.15, 0.95, 0.75 and 0.60 per cent, respectively, while the methionine requirements are 0.40, 0.35, 0.30, 0.25, 0.20 and 0.16 per cent, respectively.

2.1.3 Energy requirements

A study conducted by Ranjhan *et al.* (1972) showed reduction in growth rate and feed efficiency when energy was restricted in the diet of pigs weighing more than 50 kg body weight.

Seerley *et al.* (1978) reported that the utilization of calories for growth was estimated to be equal for low and high energy diets during cool season, but high energy diets were more efficient in warm season.

Thomas and Singh (1984a) found that the overall performance of pigs fed on 90 per cent NRC levels of digestible energy was found to be better and more economic than 100 per cent and 85 per cent NRC levels.

Campbell *et al.* (1985a) found that protein deposition was linearly related to energy intake, the protein deposition reaching the maximum at 33 MJ digestible energy per day.

Indian Council of Agricultural Research (ICAR, 1985) recommends digestible energy levels of 3100 and 3000 Kcal/kg feed for pigs weighing 5 to 10 and 10 to 60 kg, respectively.

Verhagen *et al.* (1987) found that when pigs were exposed to 15°C, maintenance requirement was increased to 58 KJ/kg $M^{0.75}$ and energy retained as protein was decreased to 49 KJ/kg $M^{0.75}$ for the first six days of exposure compared to pigs exposed to 25°C.

Akita *et al.* (1991) reported that the average daily gain increased with increase in TDN intake. Nam and Aherne (1993) reported that when pigs were given increasing levels of energy (13.3, 14.0 and 14.7 MJ digestible energy/kg), the average daily gain, gain to feed ratio and back fat thickness increased linearly with increase in digestible energy level. The maximum average daily gain was with 14.13 MJ digestible energy/kg. Williams *et al.* (1994) reported that increasing energy intake resulted in a linear increase in average daily gain.

Kyriazakis and Emmans (1992) reported that increasing the intake of energy resulted in significant increases in the rates of live weight, empty body weight and protein and lipid gains of pigs. According to Bikker *et al.* (1996)

the lean tissue percentage and efficiency of lean tissue gain decreased with increasing energy intake.

In an experiment conducted by Bikker *et al.* (1994), they found that compared with animals with *ad libitum* access to feed, protein and lipid deposition and lipid deposition :protein deposition were much lower for the gilts on the 2.5 and 3.0 times energy for maintenance treatments.

Lawrence *et al.* (1994) found that when pigs were fed rations containing 3.5 and 3.78 Mcal of DE/kg, there was a reduction in feed intake and an improvement in feed efficiency as the digestible energy level was increased.

Heugten and Stumpf (1996) suggested that the level of 3275 Kcal of metabolizable energy/kg was sufficient to maximize average daily gain and average daily lean gain in pigs.

Smith *et al.* (1996) were of the opinion that energy density of the growing phase diet can be increased to improve gain:feed, however, during the finishing phase increasing energy density decreased average daily gain.

The National Research Council (NRC, 1998) recommended 3400 Kcal of digestible energy or 3265 Kcal of metabolizable energy per kg diet for pigs of all age groups.

2.1.4 Energy-protein inter-relationship

Baird *et al.* (1975) reported that high energy diets improved the efficiency of the dietary protein for animal gains. Kyriazakis and Emmans (1992) were also of the view that the efficiency of protein utilization increased with increasing starch (energy) intake.

Reddy *et al.* (1982) found that a diet with 18 per cent protein and 3.1 or 3.3 Mcals of DE/kg was superior in promoting better average daily gain and feed efficiency in growing Large White Yorkshire pigs. Reddy *et al.* (1986) concluded that for growing desi pigs (14 to 45 kg body weight) a diet with 16 per cent crude protein and 3.0 Mcal DE/kg was superior in terms of average daily gain, efficiency of feed utilization, digestibilities of dry matter, nitrogen free extract and crude protein. However, Sivaraman and Mercy (1986) observed no significant difference in the average daily gain and feed efficiency of pigs fed rations containing three levels of protein, viz., 14, 17 and 20 per cent and three levels of energy, viz., 2900, 3100 and 3300 kcals of digestible energy per kg eventhough, the cost per kg live weight was the least for the animals maintained on 20 per cent crude protein and 3300 kcals of digestible energy per kg feed.

Rao and McCracken (1992) reported that reducing the energy intake without reducing the protein intake significantly reduced live weight gain. They opined that energy is more limiting than protein when the intake of a

diet providing for optimal growth of high potential boars is restricted between 33 and 90 kg live weight.

Xie *et al.* (1994) found that the optimum requirement for digestible energy and crude protein was 13.81 MJ/kg and 16 per cent at 20-35 kg; 13.81 MJ/kg and 14 per cent at 35 to 60 kg and 13.81 MJ/kg and 12.27 per cent at 60-90 kg.

2.2 Feed conversion efficiency and average daily gain

Aunan *et al.* (1961) reported that there were highly significant differences in daily gain between breeds. Duroc pigs gained weight faster and more efficiently than Hampshire.

Dhudapker *et al.* (1971) found that there is no significant difference in average daily gain when pigs were fed rations with three different levels of digestible energy (3500, 3200 and 3000 kcal of DE/kg of ration), the average daily gain being 460 g. Also no significant difference in efficiency of feed utilization was noticed. But Cromwell *et al.* (1978) opined that increasing the dietary energy level from 2900 to 3670 kcal of metabolizable energy/kg resulted in a linear improvement in gain. Also Quiniou *et al.* (1995) reported that average daily gain increased linearly with increase in metabolizable energy intake whereas feed conversion ratio was not affected by energy intake. Stein *et al.* (1996) found that gain:feed decreased with decreasing energy concentrations in the diets.

Cunningham *et al.* (1973) reported that the effect of level of dietary protein on feed efficiency was highly significant ($P<0.001$). They found that pigs fed 14 per cent protein diet had a feed efficiency of 3.2 compared to 3.87 for pigs fed 10 per cent protein diet. Davey (1976) reported that when pigs were fed diets with 11 and 16 per cent crude protein, the average daily gain and feed/gain were significantly better in pigs given 16 per cent crude protein.

Sikka *et al.* (1987) reported that the efficiency of feed utilization of pigs maintained on 14 and 16 per cent protein diets were lower than those maintained on 18, 20 and 22 per cent protein diets.

Kumar *et al.* (1974) reported that feed efficiency in pigs decreased gradually with increase in body weight. Dash and Mishra (1986) reported that the feed efficiency for Large White Yorkshire and its crossbreds with indigenous pigs was 4.4 and 4.5 at 20 weeks, while the same at 24 weeks was 5.39 and 5.94. They concluded that the feed efficiency decreased with increase in the slaughter age and that it was better in the Large White Yorkshire piglets than their crossbreds.

Pond *et al.* (1981) found that alfalfa meal at 20 per cent level in corn-soybean meal type diets decreased daily body weight gain and increased feed to gain ratio in pigs.

Agrawal *et al.* (1982) obtained no significant difference in the mean daily weight gain, time taken to attain slaughter weight and feed/gain ratio

could be observed when 30 and 60 per cent maize in the rations of pigs were replaced by wheat bran.

Campbell *et al.* (1984) found that there was a significant interaction between the effects of dietary protein content and feeding level for growth rate and feed conversion ratio. Pigs fed at the higher level (1.93 kg per pig per day at 45 kg to a maximum of 2.97 per pig per day at 80 kg live weight) grew faster than those fed more restrictedly (1.51 kg per pig per day at 45 kg to a maximum of 2.32 kg per pig per day at 80 kg live weight).

Thomas and Singh (1984a) found that when pigs were fed rations with 100 per cent, 90 per cent and 85 per cent of NRC levels of digestible energy, there was significant reduction in average daily gain as the plane of feeding was reduced.

Crister *et al.* (1995) reported that gilts showed higher average daily gain and average daily gain/average daily feed intake than barrows with increasing dietary crude protein levels.

2.3 Apparent digestibility of nutrients

2.3.1 Influence of energy levels in the diet

Dhudapker *et al.* (1971) found that the digestibility of organic matter and nitrogen-free extract was significantly higher with ration containing 3500 kcal of DE per kg than for rations with 3200 and 3000 kcal of DE per kg.

Thomas and Singh (1984a) found that when pigs were fed rations with 100 per cent, 90 per cent and 85 per cent of NRC levels of digestible energy, there was significant reduction in the digestibilities of dry matter, organic matter, ether extract, crude carbohydrate and crude protein.

Chang *et al.* (2000) reported that for barrows, digestibilities of gross energy, dry matter, crude protein, crude fat, crude ash and phosphorus (P) increased as lysine:DE ratio decreased, but with gilts, in contrast, digestibilities of the nutrients increased with increasing lysine:DE ratio.

2.3.2 Influence of protein levels in the diet

Sikka *et al.* (1987) conducted metabolism trials to assess the effect of protein level on nitrogen digestibility and observed that in summer, the apparent nitrogen digestibilities of 14 and 16 per cent protein diets were lower (71.24 and 72.05) than those of 20 and 22 per cent protein diets (76.75 and 77.15). In winter, the digestibility of nitrogen of the 14 per cent protein diet (71.3) was lower than that of 20 and 22 per cent (76.75 and 77.8) but higher than that of 16 per cent (69.61).

2.3.3 Influence of crude fibre levels

Ranjhan *et al.* (1972) found that the dry matter and crude protein digestibility were significantly depressed when high fibre diets were fed to pigs (during the finishing period).

Everts *et al.* (1986) reported that digestibilities of dry matter, organic matter and crude protein were decreased with increased crude fibre in the diet.

2.3.4 Influence of genotype

Yen *et al.* (1983) stated that contemporary, lean and obese genotypes in pigs had no effect on digestibility coefficients of nitrogen and energy.

Flipot *et al.* (1992) also observed that the apparent digestibility coefficients of dry matter and energy were not affected by breed.

2.3.5 Influence of body weight

Everts *et al.* (1986) reported that the digestibilities of dry matter, organic matter and crude protein were increased with increased body weights.

Jentsch *et al.* (1991) reported that during growth, digestibility of energy increased upto 30 kg live weight. They also found that there was no consistent effect of plane of nutrition on the digestibility of nutrients during maintenance and growth.

2.4 Estimation of digestibility by indicator method

Yen *et al.* (1983) suggested that 4 N HCl insoluble ash may be used as a natural indicator for estimating apparent nutrient digestibility in pigs, especially in younger ages.

Moughan *et al.* (1991) used chromic oxide and acid insoluble ash as faecal markers in young growing pigs. They found that total faeces collection gave significantly higher apparent digestibility coefficients compared to chromic oxide indicator method for dry matter, organic matter and gross energy. There were no significant differences ($P>0.05$) however, for apparent nutrient digestibility based either on total collection of faeces or determined by reference to the marker acid-insoluble ash.

Jagger *et al.* (1992) suggested that for the determination of ileal and faecal apparent digestibility values in the pig, the most appropriate marker to use was titanium dioxide at a rate of 1g/kg feed.

Kemme *et al.* (1996) calculated apparent total tract digestibility of phosphorus and calcium by using chromic oxide as the marker. They concluded that there were only small differences in the apparent total tract digestibility of phosphorus and calcium between the marker method and quantitative collection method. The average chromium recovery was 101.7 per cent.

2.5 Body weight

The body weights of pigs at sixth month of age ranged from 55.0 to 57.6 kg when varying levels of tapioca starch waste was added in swine ration (Sebastian, 1972). Almost similar body weights were reported by Subramanian (1998) while studying the effect of modified environment during summer on the performance of pigs.

Pandey *et al.* (1997) reported that genetic group, season of birth and weaning weight had highly significant effect on body weight at all ages whereas sex and interaction between genetic group and sex had non-significant influence at all ages. Birth weight had highly significant influence during pre-weaning period but its effect was non -significant during post weaning period.

2.6 Carcass quality

2.6.1 Influence of energy levels

Talley *et al.* (1976) found that higher energy level increased carcass back fat thickness while lower energy level decreased back fat thickness and dressing percentage. They opined that the energy density level for optimum performance and carcass quality might be somewhat higher than the values suggested by NRC in 1973.

Thomas and Singh (1984b) reported that the dressing percentage, carcass length, eye muscle area and back fat thickness were significantly low as the level of DE in the rations were decreased from 100 per cent or 90 per cent to 85 per cent of NRC standards.

Sivaraman and Mercy (1986) could not obtain significant difference in any of the carcass characteristics when pigs were fed rations varying in dietary energy and protein levels except that the leaf fat weight showed a positive correlation with the energy content of the ration.

Williams *et al.* (1994) reported that energy intake had no effect on dressing percentage whereas Sikka *et al.* (1987) found that dressing percentage and back fat thickness decreased with decreasing energy concentrations in the diet.

Bikker *et al.* (1995) reported that the lean tissue percentage, the efficiency of lean tissue gain, and the proportion of body protein in the lean tissue of growing gilts (20 to 45 kg) decreased with increasing energy intake.

2.6.2 Influence of dietary protein levels

Aunan *et al.* (1961) reported that dietary protein levels of 14, 16 or 18 per cent did not have a significant effect on daily gains and carcass measurements in pigs. But several workers reported that the carcass desirability was improved with increasing levels of dietary protein (Baird *et al.*, 1975 and Davey *et al.*, 1976).

Cunningham *et al.* (1973) found that carcasses from pigs fed 10 per cent protein diet had more back fat, less per cent ham and loin and smaller loin eye area compared to pigs fed 14 per cent protein. Irvin *et al.* (1975) reported that increasing the protein level from 12 to 18 per cent resulted in decreasing back fat and increasing lean for straight breds while not affecting back fat thickness in crossbreds.

Cromwell *et al.* (1978) found that pigs fed high protein diet gained faster and more efficiently and had carcasses with less back fat and more loin eye area than those fed low protein diets.

Campbell *et al.* (1984) reported that, for pigs given diets deficient in crude protein, rate of protein deposition was linearly related to protein intake but independent of energy intake. For pigs given a diet adequate in crude protein, rate of protein deposition was related to energy intake independent of crude protein intake.

Latimier and Dourmad (1994) studied the effect of three protein feeding strategies for grower and finisher pigs and found that growth rate and feed conversion efficiency were similar in all groups, while the dressing percentage decreased with increased dietary protein.

Xie *et al.* (1994) reported that back fat thickness was influenced by energy level and the lean percentage by crude protein level.

2.6.3 Influence of calorie: protein ratio

Sharda and Vidyasàgar (1986) reported that pigs fed diets containing 16.2, 14.4, 12.6 and 11.7 per cent CP and 3500, 3300, 3300 and 3300 kcal digestible energy per kg diet during 10-20, 20-35, 35-60 and 60-75 kg body weight periods, respectively, produced leanest carcasses. The dressing per cent and carcass length were not influenced to great extent by altering the calorie: protein ratio in the diet.

2.6.4 Influence of levels of crude fibre in the diet

Ranjhan *et al.* (1972) found that there was significant reduction in back fat thickness when the fibre level was increased and energy level was decreased in the diet of pigs after they reached 50 kg body weight.

Baird *et al.* (1975) showed that feeding a diet which had 4 per cent crude fibre, resulted in lower dressing per cent and back fat thickness, but higher percentages of ham and loin and significantly more lean cuts than did a diet which had 8 per cent crude fibre.

2.6.5 Influence of live weight and age at slaughter

Ranjhan *et al.* (1972) suggested a slaughter weight of 70 kg than 90 kg, as the efficiency of feed utilization was significantly decreased as body weight increased from 70 to 90 kg. Kumar *et al.* (1974) opined that slaughter of pigs at 70 kg would be more economical than at 50 or 90 kg weights. Sivaraman and Mercy (1986) suggested that for obtaining better carcasses in terms of dressing percentage and leanness, optimum slaughter weight for pigs should be 75 kg.

Deo *et al.* (1980) reported that age and weight of the animals at slaughter had no effect on carcass characteristics.

Gupta *et al.* (1982) reported that high correlation existed between live weight and dressed weight, carcass length and dressing percentage in both

sexes. They opined that males may preferably be slaughtered around 90 kg of body weight.

Anjaneyulu *et al.* (1984) found that with increase in slaughter weight, there was an increase in carcass length, dressing percentage, loin eye area and a decrease in the per cent of primal and lean cuts. Carcass length, loin eye area and back fat thickness increased with increase in slaughter weight (Mishra *et al.*, 1992 and Kumar and Barsaul, 1987). Arora *et al.* (1994) also concluded that all the carcass characters improved with an increase in weight at slaughter.

Cisneros *et al.* (1996) reported that increases in slaughter weight were associated with increases in feed intake, back fat depth and loin eye area and that slaughter weight produced minimal changes in growth rate or gain: feed.

Singh *et al.* (1998) stated that the body weight, carcass weight, carcass length and ham weight increased with age at slaughter for Landrace and Large White Yorkshire pigs. They concluded that the optimum slaughter age for these two breeds were 131 to 190 and 371 to 430 days respectively.

2.6.6 Effect of sex

Cunningham *et al.* (1973) reported that gilt carcasses had a longer loin eye area than that of barrows.

Seerley *et al.* (1978) also reported that gilt carcasses were superior to that of barrows. Gilt carcasses were significantly longer than barrows and had larger loin eye areas and greater percentages of ham, loin and lean cuts. This report is in accordance with that obtained by Christian *et al.* (1980) and Kumar and Barsaul (1987).

Deo *et al.* (1980) were of the opinion that sex of the animals had significant effect on dressing percentage, back fat thickness, loin eye area and carcass length.

Arora *et al.* (1994) reported that male pigs had significantly higher head weight and shoulder percentage, whereas females had significantly longer carcasses.

Singh *et al.* (1997) found that sex and its interaction with genetic group had non-significant effect on slaughter weight, back fat thickness, carcass weight and loin eye area, but sex had significant effect on dressing percentage.

Reddy and Rao (1999) reported that feed intake was more for castrated males compared to entire males and females, and that entire males produced leaner carcasses and were more economical to rear than castrated males.

2.6.7 Effect of breed

Aunan *et al.* (1961) reported that there was a highly significant effect of breed on all measures of carcass leanness and daily gain in pigs. Hampshire

pigs produced longer carcasses with less fat, larger loin eye area and higher yield of lean cut.

Deo *et al.* (1980) reported that genetic group had significant effect on back fat thickness, carcass length, loin eye area and shoulder weight. Arora *et al.* (1994) opined that genetic group had non-significant effect on the carcass traits except loin eye area.

Dash and Mishra (1986) found that at the slaughter age of 24 weeks, the crossbreds of Large White Yorkshire with indigenous pigs were as good as Large White Yorkshire in pork production. They noticed that Large White Yorkshire possessed back fat thickness greater than that of crossbreds.

Deo *et al.* (1992) opined that genetic group differences had significant effect on all stages of growth.

Studies conducted by Lakhani and Jogi (1999) on the dressing percentage in indigenous pigs and their Large White Yorkshire grades showed that the overall least squares mean was 61.24 and that it was lower for purebreds than crossbreds.

In an experiment conducted with Large White Yorkshire, Hampshire and Naga local pig breeds, Rohilla *et al.* (2000) found that the slaughter weight, hot carcass weight, dressing percentage, and back fat thickness were significantly higher for Hampshire pigs followed by Large White Yorkshire and Naga local pigs.

2.6.8 Influence of season

Deo *et al.* (1980) reported that the season of birth had significant effect on carcass length, dressing percentage, back fat thickness, carcass length and ham weight.

Materials and Methods

3. MATERIALS AND METHODS

3.1 Animals

Fifteen male and fifteen female weaned crossbred piglets (Large White Yorkshire x Desi) of three months of age with an average body weight of 12.9 kg belonging to the Centre for Pig Production and Research, Mannuthy formed the experimental animals. All the male piglets were castrated two weeks prior to the commencement of the experiment.

The piglets were divided into three equal groups as uniformly as possible with regard to age, sex and body weight. The three groups of piglets were randomly allotted to three dietary treatments (T1, T2 and T3). The ten piglets in each treatment were randomly distributed into five replicates of two piglets each. Each replicate consisted of piglets of opposite sex and was housed in separate and identical pens. All the animals were dewormed before the commencement of the experiment and were maintained under identical managemental conditions during the experimental period of 182 days or till they attained 70 kg body weight.

3.2 Experimental diets

The piglets in the three groups were fed on rations with 16 per cent crude protein but with three different levels of energy, viz.,

T1 - 2800 kcal of DE/kg

T2 - 3000 kcal of DE/kg (control)

T3 – 3200 kcal of DE/kg

The standard methods (AOAC, 1990) were followed to estimate the chemical composition of the diets. The ingredient composition and the chemical composition of the experimental diets are given in Table 1 and 2 respectively.

Table 1. Per cent ingredient composition of experimental diets

Ingredients	T1	T2	T3
Yellow maize	25.0	40.0	59.0
Soyabean meal	5.0	7.0	9.0
Wheat bran	46.0	34.0	15.0
Unsalted dried fish	10.0	10.0	10.0
Lucerne meal	12.5	7.5	5.5
Mineral mixture*	1.0	1.0	1.0
Salt	0.5	0.5	0.5

Indomix A+B2+D3** added @ 25 g per 100 kg feed mixed
Indomix-BE*** added @ 25 g per 100 kg feed mixed

* Keyes mineral mixture without salt (KSE Ltd., Irinjalakuda)
Ingredients: Calcium – 24.0%, Phosphorus – 12.0%, Magnesium – 6.5%, Sulphur – 0.5%, Iron – 0.5%, Zinc – 0.38%, Manganese – 0.15%, Copper – 0.5%, Iodine – 0.03%, Cobalt – 0.02%, Fluorine (max) – 0.04%, Acid insoluble ash (max) – 2% and moisture – 4%.

Vitamin supplement

**INDOMIX $A+B_2+D_3$ (Nicholas Piramal India Ltd., Mumbai).

Composition per gram: Vitamin A – 40,000 IU, Vitamin B_2 - 20 mg, Vitamin D_3 – 5,000 IU

***INDOMIX-BE (Nicholas Piramal India Ltd., Mumbai).

Composition per gram: Vitamin B_1 – 4 mg, Vitamin B_6 – 8 mg, Vitamin B_{12} – 40 mcg, Niacin – 60 mg, Calcium pantothenate – 40 mg, Vitamin E – 40 mg.

Table 2. Per cent chemical composition of experimental diets[a]

Item	T1	T2	T3
Dry matter	88.9	88.5	87.9
Crude protein (Nx6.25)	15.9	16.0	16.4
Ether extract	3.1	3.6	4.4
Crude fibre	11.3	10.3	5.5
Nitrogen free extract	56.8	58.9	63.4
Total ash	12.9	11.2	10.3
Acid insoluble ash	6.8	6.2	5.6
Calcium	1.78	1.58	1.10
Phosphorus	0.82	0.78	0.61
Calculated DE (kcal/kg)	2870	3040	3199

[a] – on dry matter basis

3.3 Feeding trial

The piglets housed in the same pen were offered feed twice a day (8.00 AM and 3.30 PM). The quantity of feed offered was sufficient enough so that

every time there was some leftover feed. Clean drinking water was provided in all the pens throughout the experimental period.

Records of daily feed intake and fortnightly body weights were maintained throughout the experimental period.

3.4 Digestibility trial

Digestibility trial was conducted after the middle of the experiment to determine the digestibility coefficients of nutrients of the experimental diets. Acid insoluble ash was taken as the internal indicator for determining the digestibility coefficients of nutrients.

Faecal grab samples, uncontaminated with urine and dirt in the stall, were collected from different places of each pen at 12:00, 15:00 and 18:00 hours, during the period of three days. The samples of faeces from each pen were pooled every day and placed in double lined polythene bags, labelled and preserved in a deep freezer for analysis. From the pooled feed and faecal samples, sub-samples were taken and analysed for proximate composition as per the standard methods (AOAC, 1990).

The digestibility coefficients were calculated using appropriate formulae (Maynard *et al.*, 1979; Mc Donald *et al.*, 1995).

3.5 Slaughter studies

The experimental pigs that attained slaughter weight of 70 kg were slaughtered while those that did not attain slaughter weight were slaughtered at the termination of the experiment (6 months). The carcass characteristics of six animals from each group were studied.

The head was removed at the atlanto-occipital joint and the dressed weight of the carcass without head was recorded to determine dressing percentage of the hot carcass (carcass weight divided by live weight x 100).

The length of the carcass was measured from the anterior edge of the aitch bone (Os-sacrum) to the anterior aspect of the first rib. The back fat thickness was estimated as an average of the measurements taken at the first rib, the last rib and the last lumbar vertebra. The loin eye area or the area of the *Longissimus dorsi* muscle between 10^{th} and 11^{th} rib was cut and recorded on a transparent paper and the area was calculated by plotting the traced surface on graph paper.

3.6 Statistical analysis

The data obtained were analysed as per the methods described by Snedecor and Cochran (1987).

Results

4. RESULTS

4.1 Live weight gain and feed conversion efficiency

The results on the mean values of body weights of pigs under the three dietary treatments T1, T2 and T3, recorded at fortnightly intervals are presented in Table 3 and graphically represented in Fig.1. The data on fortnightly average daily gain and monthly feed conversion efficiency are presented in Tables 4 and 5, respectively and graphically represented in Fig.2 and 3, respectively. Table 6 contains data on cumulative average daily gain and feed conversion efficiency of animals of the three dietary treatments (Fig.4 and 5). The average values for body weight gain of animals belonging to the groups T1, T2 and T3 were 46.6, 51.3 and 54.3 kg, respectively.

4.2 Digestibility coefficients of nutrients

The chemical composition of faeces of pigs fed different experimental diets are presented in Table 7. Data on digestibility coefficients of nutrients of the three experimental diets T1, T2 and T3 are presented in Table 8 and graphically represented in Fig.6. The digestibility coefficients of dry matter of T1, T2 and T3 were 61.3, 65.2 and 72.4; of crude protein were 71.2, 72.2 and 74.8; of ether extract were 34.9, 47.2 and 56.5; of crude fibre were 32.2, 27.4 and 21.6 and of nitrogen free extract were 75.3, 79.9 and 86.1.

4.3 Carcass characteristics

Data on carcass characteristics of pigs maintained on the three experimental diets T1, T2 and T3 are set out in Table 9.

The values for body weights at slaughter were 60.0, 67.3 and 70.2 kg, respectively for T1, T2 and T3; 43.3, 49.7 and 52.7 kg for dressed weight without head; 71.6, 74.5 and 75.9 per cent for dressing percentage; 59.2, 60.0 and 62.4 cm for carcass length; 3.0, 3.3 and 3.0 cm for back fat thickness and 17.4, 16.8 and 21.4 cm^2 for loin eye area.

4.4 Economics of gain

Data on cost of feed per kg body weight gain of pigs maintained on the three dietary treatments are presented in Table 10 and Fig.7. The values were Rs.49.9, 43.3 and 34.1 for T1, T2 and T3, respectively.

Table 3. Fortnightly body weights (kg) of pigs maintained on different dietary treatments[a]

Fortnights	Treatments		
	T1	T2	T3
0	12.9 ± 1.03	12.9 ± 0.64	12.9 ± 0.86
1	14.8 ± 1.08	15.1 ± 0.78	15.8 ± 1.13
2	17.9 ± 1.18	19.6 ± 1.09	20.5 ± 1.19
3	22.0 ± 1.27	23.3 ± 1.24	25.6 ± 1.32
4*	26.2^{b} ± 1.37	28.2^{bc} ± 1.16	31.8^{c} ± 1.34
5*	30.5^{b} ± 1.37	32.8^{bc} ± 1.56	36.7^{c} ± 1.41
6**	35.0^{b} ± 1.61	38.3^{b} ± 1.56	44.1^{c} ± 1.22
7**	39.9^{b} ± 1.66	44.6^{b} ± 1.69	50.5^{c} ± 1.36
8**	44.8^{b} ± 1.92	48.6^{b} ± 1.92	55.5^{c} ± 1.61
9**	49.5^{b} ± 1.85	53.3^{b} ± 2.18	61.7^{c} ± 1.51
10**	53.1^{b} ± 2.06	57.1^{b} ± 2.49	67.1^{c} ± 1.53
11**	55.8^{b} ± 2.13	59.7^{b} ± 1.92	67.8^{c} ± 1.49
12	57.6 ± 1.44	61.8 ± 1.66	d

[a]Mean of ten values with SE

b,c-Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)

** Significant ($P<0.01$)

d – Animals in the group T3 attained slaughter weight earlier and were slaughtered between the tenth and twelfth fortnights.

Fig.1. Fortnightly average body weights of pigs fed different experimental diets

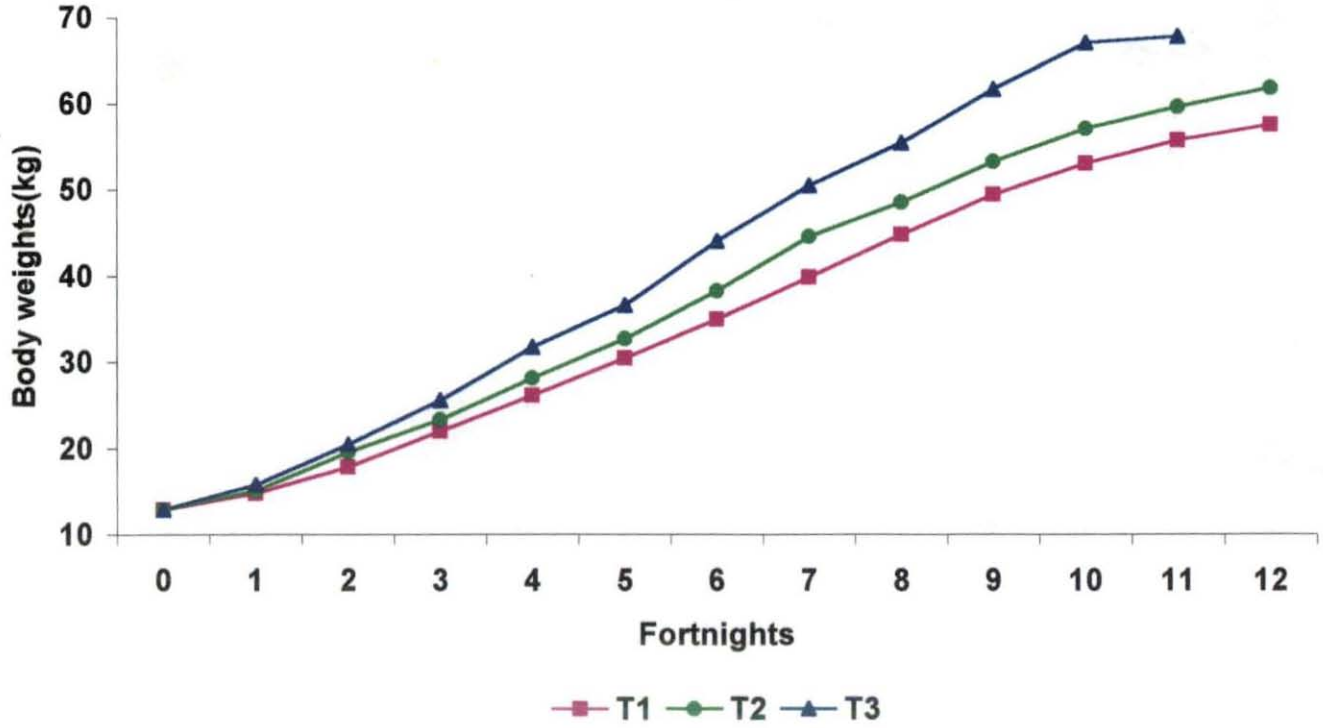


Table 4. Fortnightly average daily gain (g) of pigs maintained on different dietary treatments[a]

Fortnights	Treatments		
	T1	T2	T3
1	121.9 ± 20.03	138.1± 21.64	175.6 ± 28.53
2**	221.4^{b} ± 30.21	324.3^{c} ± 25.74	340.0^{cd} ± 11.38
3*	294.3^{bc}± 33.97	264.3^{b}± 25.27	360.7^{c} ± 15.98
4**	297.1^{b} ± 24.84	347.9^{b} ± 15.79	441.4^{c} ± 9.15
5	285.3 ± 11.32	306.0 ± 32.97	326.7 ± 29.49
6**	303.3^{b} ± 37.7	367.3^{b} ± 22.23	498.7^{c} ± 34.74
7**	340.0^{b} ± 25.54	446.4^{c} ± 28.24	473.0^{cd} ± 30.06
8	330.7 ± 31.93	226.7 ± 25.65	334.8 ± 40.41
9*	291.3^{b} ± 23.63	293.8^{bc} ± 33.39	387.5^{c} ± 33.10
10	280.0 ± 44.56	293.1 ± 54.62	417.9 ± 31.66
11**	176.7^{b} ± 37.11	371.7^{c} ± 32.44	315.0^{cd} ± 26.58
12	254.2 ± 33.32	243.5 ± 22.47	

[a]Mean of ten values
b,c,d-Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)
** Significant ($P<0.01$)

Fig.2. Fortnightly average daily gain of pigs maintained on the three dietary treatments

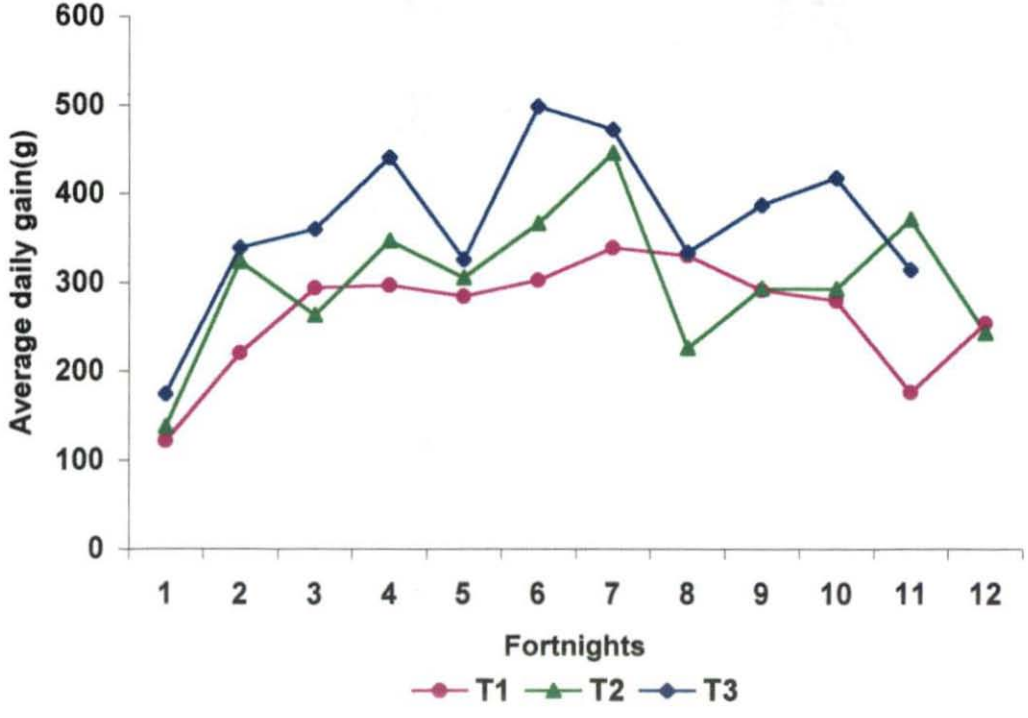


Table 5. Feed conversion efficiency of pigs maintained on different dietary treatments at monthly intervals (Mean ± SE)

Months	Treatments		
	T1	T2	T3
1*	$5.6^{a} \pm 0.64$	$4.9^{ab} \pm 0.61$	$3.5^{b} \pm 0.26$
2**	$4.5^{a} \pm 0.36$	$3.9^{a} \pm 0.27$	$3.2^{b} \pm 0.13$
3**	$4.8^{a} \pm 0.33$	$4.2^{a} \pm 0.23$	$3.4^{b} \pm 0.08$
4**	$5.0^{a} \pm 0.25$	$4.5^{a} \pm 0.22$	$3.7^{b} \pm 0.09$
5**	$5.4^{a} \pm 0.27$	$4.9^{a} \pm 0.25$	$4.0^{b} \pm 0.07$
6**	$6.0^{a} \pm 0.34$	$5.2^{a} \pm 0.29$	$4.1^{b} \pm 0.11$

a,b-Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)
** Significant ($P<0.01$)

Fig.3. Monthly feed conversion efficiency of pigs maintained on the three dietary treatments

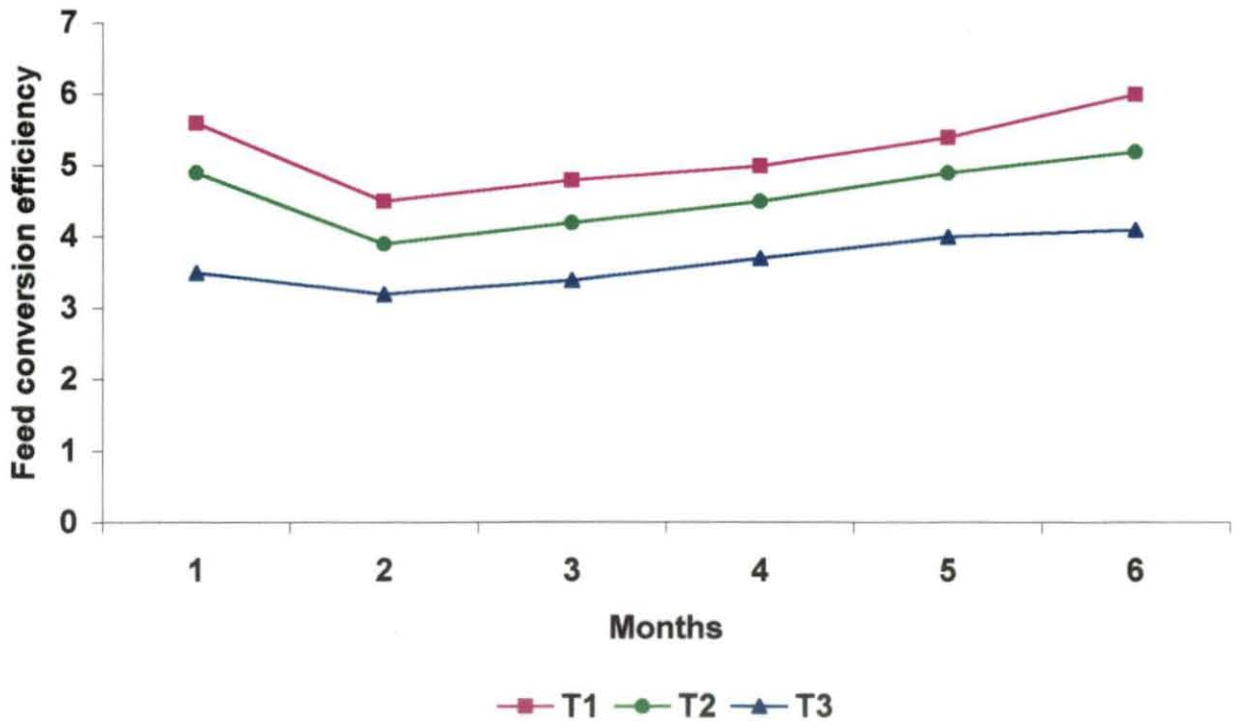


Table 6. Cumulative average daily gain and feed conversion efficiency of pigs maintained on different dietary treatments (Mean ± SE)

Item	Treatments		
	T1	T2	T3
Initial body weight (kg)	12.9 ± 1.03	12.9 ± 0.64	12.9 ± 0.86
Final body weight (kg)*	59.5^{a} ± 1.66	64.2^{b} ± 1.39	67.3^{bc} ± 2.16
Body weight gain (kg)*	46.6^{a} ± 1.68	51.3^{b} ± 1.25	54.3^{bc} ± 2.13
Total feed intake (kg)**	281.6^{a} ± 4.31	265.7^{a} ± 9.87	222.1^{b} ± 11.32
Average daily gain (g)**	262.9^{a} ± 11.67	302.0^{b} ± 13.74	362.8^{c} ± 6.74
Feed conversion efficiency (kg feed/kg gain)**	6.0^{a} ± 0.34	5.2^{a} ± 0.29	4.1^{b} ± 0.11

a,b,c-Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)
** Significant ($P<0.01$)

Fig.4. Cumulative average daily gain of pigs maintained on the three dietary treatments

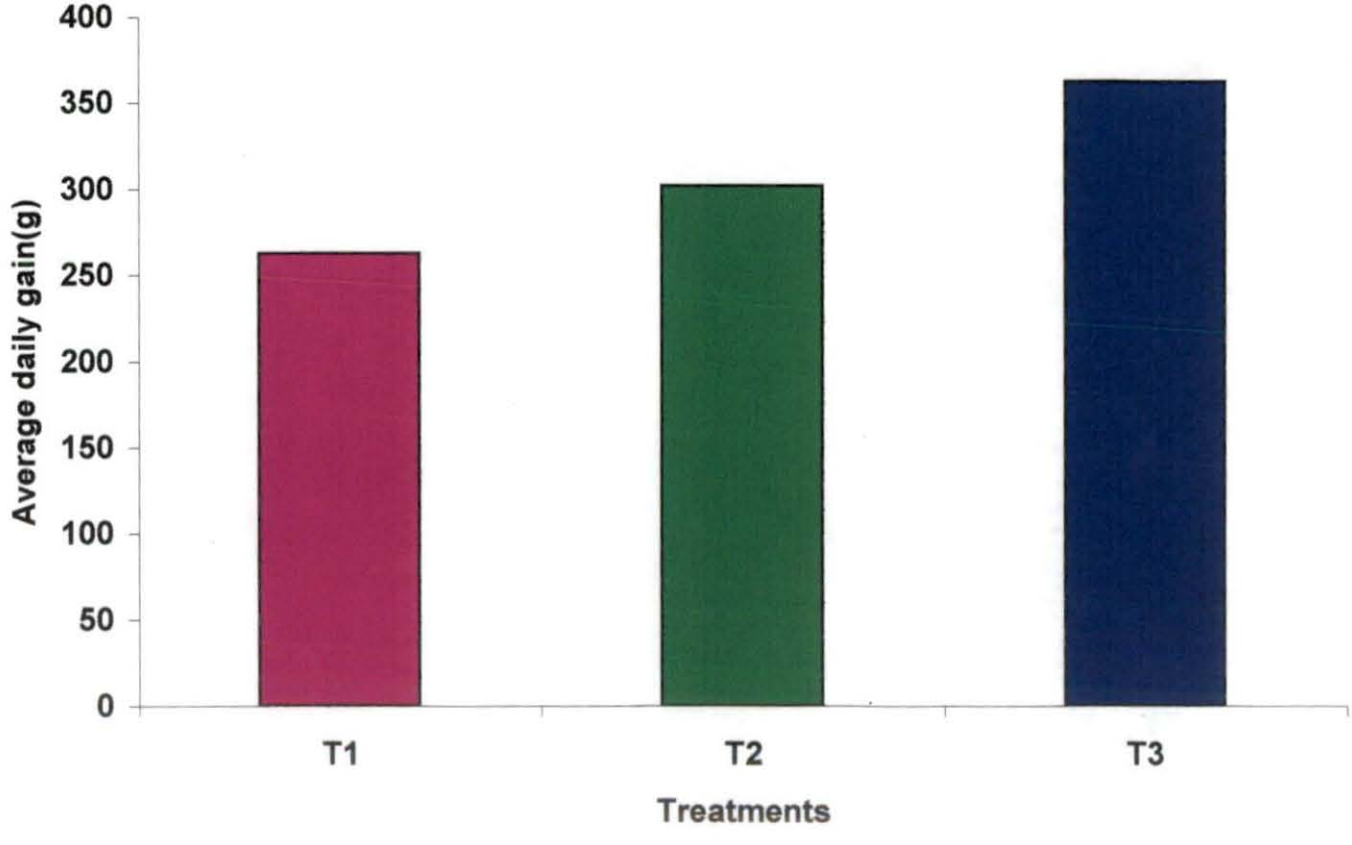


Fig.5. Cumulative feed conversion efficiency of pigs maintained on the three dietary treatments

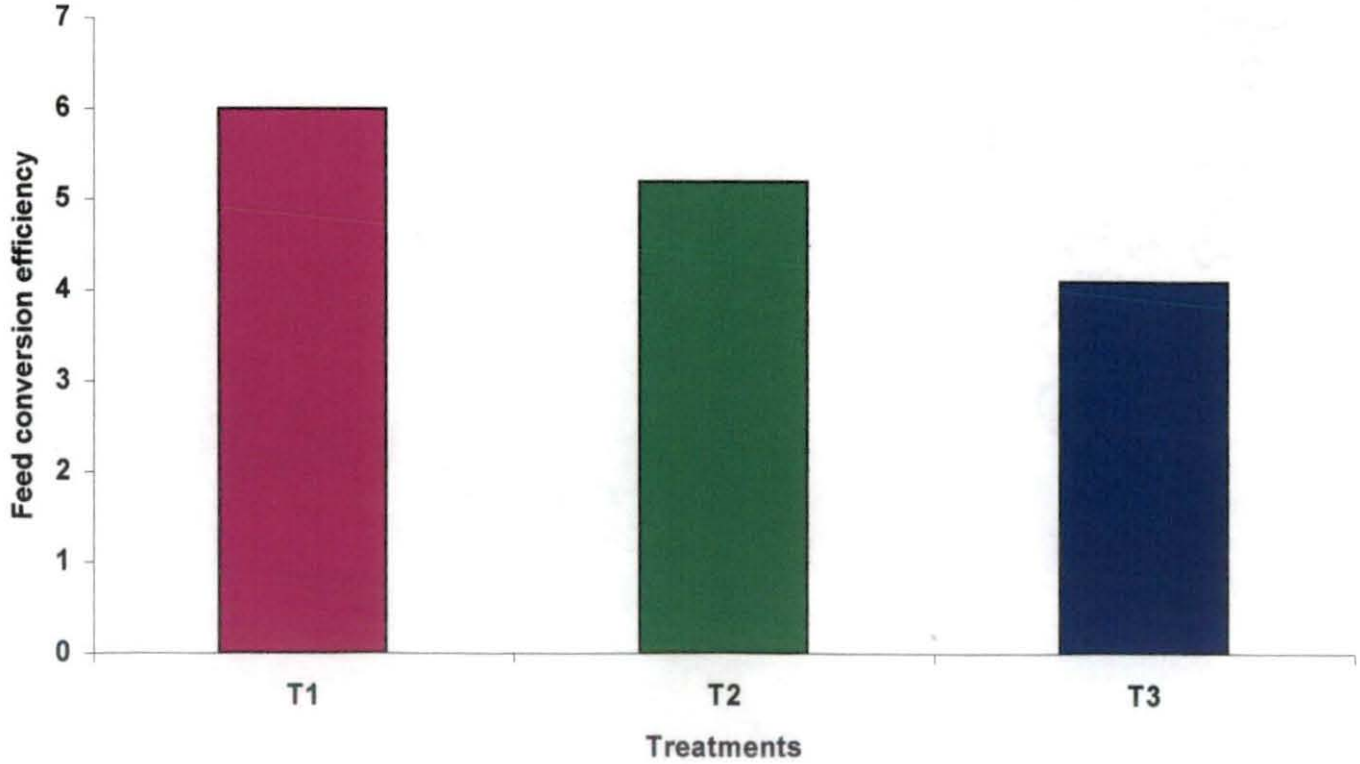


Table 7. Per cent chemical composition of faeces of pigs fed different experimental diets[a]

Item	Treatments		
	T1	T2	T3
Moisture	70.98	69.44	68.52
Crude protein (N x 6.25)	11.16	11.79	13.73
Ether extract	5.20	5.44	6.93
Crude fibre	19.72	21.60	15.68
Nitrogen free extract	36.06	33.56	32.01
Total ash	27.86	27.61	31.65
Acid insoluble ash	17.99	17.92	20.48

a - Average of ten values on dry matter basis

Table 8. Average digestibility coefficients of nutrients of the three experimental diets (Mean ± SE)[a]

Nutrients	Treatments		
	T1	T2	T3
Dry matter**	61.3[b] ± 1.72	65.2[b] ± 1.45	72.4[c] ± 0.83
Crude protein	71.2 ± 2.56	72.2 ± 1.15	74.8 ± 1.10
Ether extract*	34.9[b] ± 3.38	47.2[c] ± 3.63	56.5[d] ± 1.75
Crude fibre	32.2 ± 4.65	27.4 ± 2.17	21.6 ± 2.73
Nitrogen free extract**	75.3[b] ± 1.25	79.9[c] ± 1.64	86.1[d] ± 0.75

[a]Mean of ten values
b,c,d-Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)
** Significant ($P<0.01$)

Fig.6. Average digestibility coefficients of nutrients of the three experimental diets

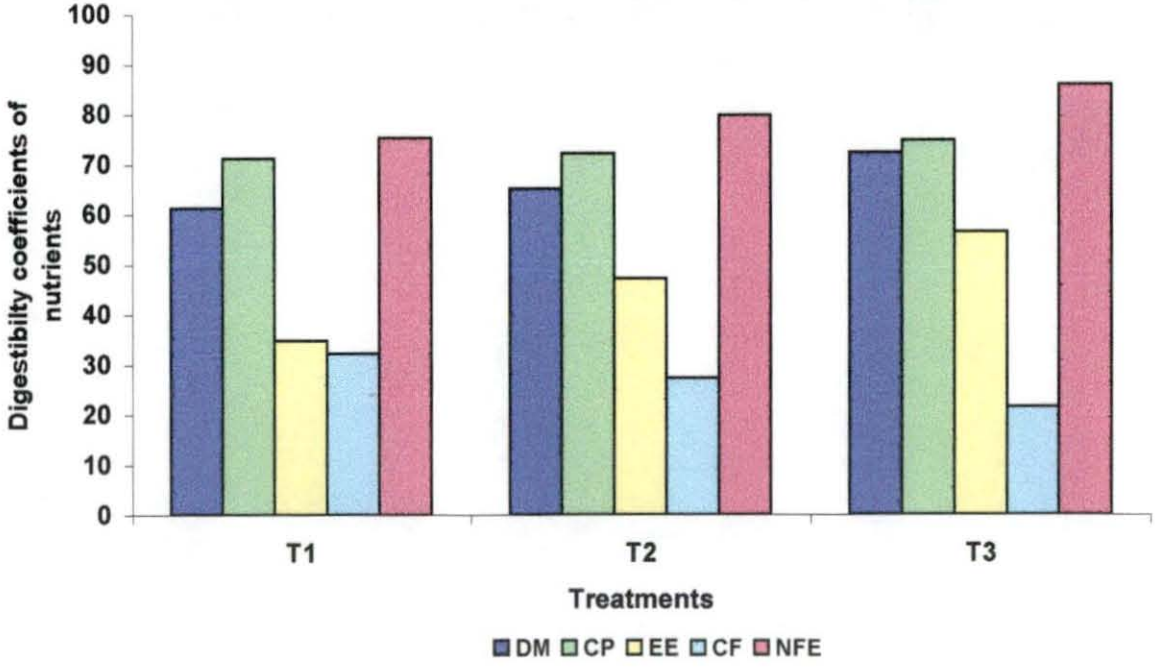


Table 9. Carcass characteristics of pigs fed different experimental diets[a]

Item	Treatments		
	T1	T2	T3
Live body weight (kg)**	60.0 [b] ± 2.05	67.3 [c] ± 0.79	70.2 [cd] ± 1.26
Dressed weight without head (kg)**	43.3 [b] ± 0.76	49.7 [c] ± 1.15	52.7 [cd] ± 1.36
Dressing percentage	71.6 ± 2.59	74.5 ± 1.26	75.9 ± 1.04
Carcass length (cm)	59.2 ± 1.22	60.0 ± 1.19	62.4 ± 0.78
Back fat thickness (cm)	3.0 ± 0.10	3.3 ± 0.17	3.0 ± 0.06
Loin eye area (cm^2)*	17.4 [b] ± 1.35	16.8 [b] ± 0.91	21.4 [c] ± 0.72

[a] Mean of six values with SE
b,c,d-Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)
** Significant ($P<0.01$)

Table 10. Cost of feed (Rs.) per kg body weight gain of pigs maintained on different dietary treatments

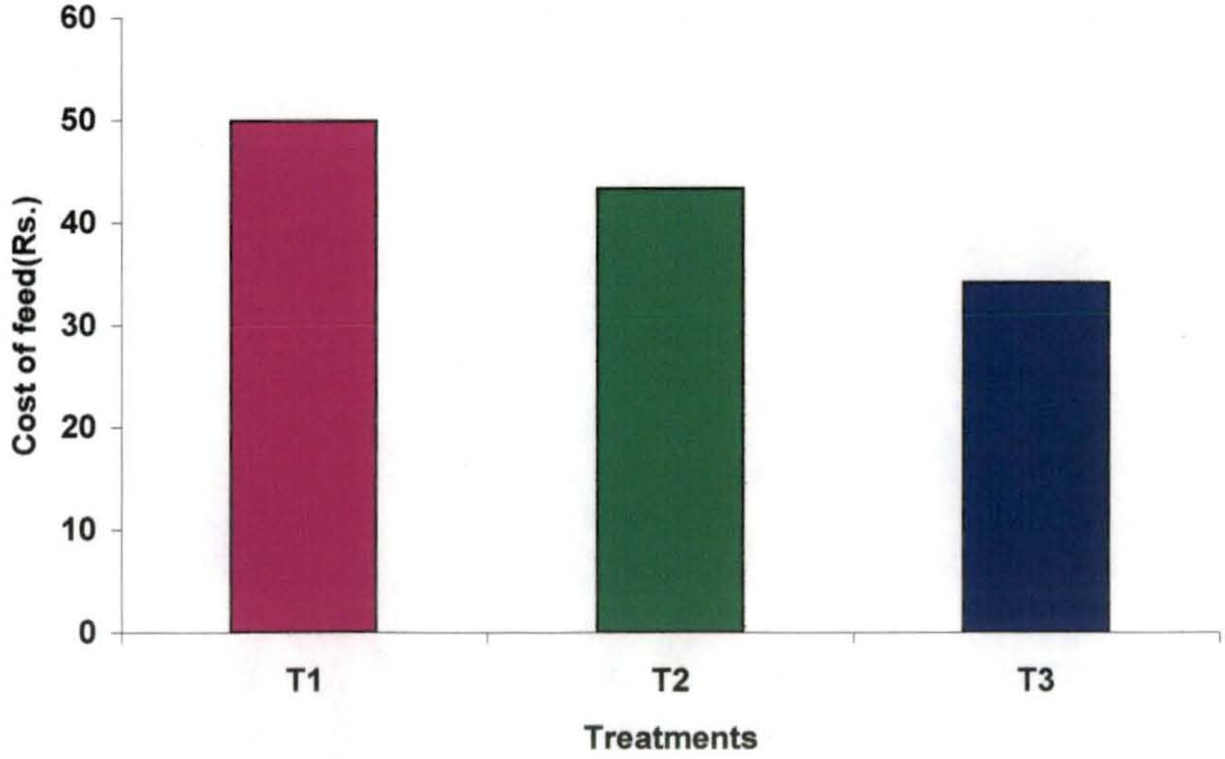
Item	Treatments		
	T1	T2	T3
Cost/kg of ration[a]	7.38	7.32	7.35
Cost of feed per kg ** body weight gain (Mean ± SE)	$49.9^{b} \pm 2.75$	$43.3^{b} \pm 2.4$	$34.1^{c} \pm 0.94$

[a] Cost of feed ingredients is based on the rate contract fixed for the supply of various feed ingredients to the farm for the year 2000-2001

b,c-Means with different superscripts within the same row differ significantly

** Significant ($P<0.01$)

Fig.7. Cost of feed per kg weight gain of pigs fed different experimental diets



Discussion

5. DISCUSSION

5.1 Body weights

From the results given in Table 3, it could be seen that though there was no significant difference in the average fortnightly body weights of pigs maintained on the three dietary treatments till the end of third fortnight, pigs fed on the high energy ration (3200 kcal/kg, T3) recorded higher ($P<0.05$) body weights than those fed on the control (3000 kcal/kg, T2) and low energy ration (2800 kcal/kg, T1) from the fourth fortnight onwards. Significant difference could be noticed in the average fortnightly body weights between T3 and T1 as well as between T3 and T2, whereas T2 and T1 did not differ significantly. The body weights recorded for groups T1, T2 and T3 were 55.8, 59.7 and 67.8 kg respectively at the eleventh fortnight (Table 3 and Fig.1).

Dhudapker *et al.* (1971) reported that the body weights of pigs at sixth month of age were 70.2, 69.6 and 68.6, respectively when Middle White Yorkshire pigs were fed rations containing 18 per cent crude protein and 3500, 3200 and 3000 kcal of DE/kg, respectively. These values are considerably higher than those obtained in the present study probably due to the difference in the breed.

Sebastian (1972) reported that the body weights of pigs at sixth month of age ranged from 55.0 to 57.6 kg when varying levels of tapioca starch

waste was added in swine ration. Slightly lower values (45.3 to 51.5 kg) were reported by Subramanian (1998) when the effect of modified environment during summer on the performance of growing pigs were studied.

5.2 Average daily gain

The data given in Table 6 revealed that pigs fed diets with 3200 (T3) and 3000 (T2) kcal of DE/kg recorded higher ($P<0.05$) body weight gain than those fed diet with 2800 (T1) kcal of DE/kg. The values for body weight gain during the experimental period were 46.6, 51.3 and 54.3 kg for T1, T2 and T3, respectively. The average daily body weight gains (Table 6 and Fig.4) were 262.9, 302.0 and 362.8 g for groups T1, T2 and T3 respectively. The data indicate that as the energy in the diet is increased body weights also increased. Animals in T3 showed significantly higher gains than T1 and T2. Reddy *et al.* (1986) found that the average daily gain of indigenous pigs given diets with 16 per cent crude protein and 3.0 and 2.7 Mcal of DE/kg diet were 319 and 276 g respectively. These values are comparable with those observed in the present study. Sivaraman and Mercy (1986) obtained values ranging from 336.0 to 472.0 when Large White Yorkshire pigs were fed diets containing 2900, 3100 and 3300 kcal of DE/kg and 14, 17 and 20 per cent crude protein in nine different combinations and they could not observe any significant difference between the groups maintained on different energy and protein levels. The values obtained for diets with 3100 and 3300 kcal of DE/kg are comparable with the present values obtained for T3.

Dhudapker *et al.* (1971) obtained an average daily gain of 460 g per day for Middle White Yorkshire pigs from weaning to 70 kg body weight. In the present study, all the animals in T3, most of the animals in T2 and a few animals in T1, attained the targeted weight of 70.0 kg much ahead of the termination of the experiment. However, the average daily gain obtained was much lower than that obtained by the above authors. Seerley *et al.* (1978) recorded an average daily gain of 730 and 780 g for pigs fed diets containing 3350 and 3700 kcal of DE/kg respectively. Thomas and Singh (1984a) reported average daily gains of 529.0, 460.0 and 327.0 g, respectively when Large White Yorkshire pigs were fed diets containing 100, 90 and 85 per cent of NRC levels of digestible energy. These values are considerably higher than those observed in the present study.

5.3 Feed conversion efficiency

The data given in Table 6 and represented in Fig.5 indicate that pigs given diet with 3200 kcal of DE/kg (T3) recorded higher ($P<0.01$) feed conversion efficiency than those fed diets with 3000 (T2) and 2800 (T1) kcal of DE/kg, the values being 6.0, 5.2 and 4.1 respectively for the groups T1, T2 and T3. Reddy *et al.* (1986) reported feed conversion efficiencies of 4.48 and 5.29 for indigenous pigs given diets containing 3.0 and 2.7 Mcal of DE/kg, these being in agreement with the values observed in the present study.

Dhudapker *et al.* (1971) recorded values of 4.4, 4.4 and 4.6 for pigs given diets containing 3500, 3200 and 3000 kcal of DE/kg of diet

respectively, while Sivaraman and Mercy (1986) obtained values ranging from 3.03 to 4.6, the above values being higher than those obtained in the present study.

5.4 Digestibility coefficients of nutrients

5.4.1 Dry matter

The digestibility coefficients of dry matter of the three experimental diets T1, T2 and T3 were 61.3, 65.2 and 72.4 respectively (Table 8 and Fig.6). The value was significantly higher ($P<0.01$) for treatment T3 compared to T1 and T2. No significant difference in dry matter digestibility was observed between T1 and T2. Enhanced digestibility of dry matter in T3 is explained due to the lesser content of crude fibre. The dry matter digestibility was found to improve linearly with increase in energy content in the feed. Ranjhan *et al.* (1972) reported low values for dry matter digestibility for diets with high crude fibre.

Dhudapker *et al.* (1971) obtained dry matter digestibilities of 72.2, 70.9 and 83.3 per cent respectively, when Middle White Yorkshire pigs were fed diets with rations containing 3000, 3[illegible]0 and 3500 kcal of digestible energy per kg and 18.0 per cent crude protein. Devi (1981) reported digestibility coefficients of dry matter that ranged from 79.6 to 82.4 for diets containing 16 per cent protein with varying levels of dried tapioca chips. Reddy *et al.* (1986) observed dry matter digestibilities of 79.4 and 71.37 per cent in diets containing 16 per cent crude protein and 3.0 and 2.7 Mcal of DE/

respectively. The values obtained by the above workers are higher than the values observed in the present study.

Thomas and Singh (1984a) reported that lowering of digestible energy content of grower pig rations by 10 per cent and 15 per cent from NRC level lowered the dry matter digestibility from 81.08 to 60.39 and 42.92 per cent respectively. Ramamoorthy (1999) obtained dry matter digestibilities of 53.1, 48.8 and 46.3 per cent respectively when pigs were given diets with 16 per cent crude protein and 3000 kcal/kg of digestible energy. Vasudevan (2000) recorded a digestibility coefficient of 55.49, 57.24 and 60.40 respectively in pigs fed on rations containing maize of different particle size of 3 mm, 1 mm and <0.1 mm respectively. Compared to these, the present experiment gave higher values for digestibility coefficient of dry matter.

5.4.2 Crude protein

The digestibility coefficients of crude protein of the three experimental diets T1, T2 and T3 were 71.2, 72.2 and 74.8 respectively (Table 8 and Fig. 6). The values did not differ significantly between the treatments. Dhudapker *et al.* (1971) reported average digestibility coefficients of crude protein which ranged from 73.3 to 77.1 for diets containing different levels of energy. Devi (1981); Yen *et al.* (1983) and Reddy *et al.* (1986) obtained average digestibility coefficients of crude protein that ranged from 73.0 to 80.3, 70.4 to 75.9 and 71.68 to 80.53 respectively. Similar values were also reported by Thomas and Singh (1984a). The values obtained in the present investigation

are in agreement with those obtained by the above workers. However, Ranjhan *et al.* (1972) obtained average digestibility coefficients of crude protein ranging from 66.5 to 42.2 for diets containing varying levels of crude fibre. Ramamoorthy (1999) reported values ranging from 65.2 to 60.7 for diets containing different levels of silk worm pupae meal. The values recorded by the above authors are lower than those obtained in the present investigation.

5.4.3 Ether extract

The digestibility coefficients of ether extract obtained in the present experiment were 34.9, 47.2 and 56.5 respectively for diets T1, T2 and T3 respectively. The value for T3 was significantly higher ($P<0.05$) than that of T2 and T1 and the value for T2 was significantly higher ($P<0.05$) than that of T1. The digestibility coefficients of ether extract was found improved with increase in energy content of the rations. The values obtained in the present study are comparable to those reported by Ramamoorthy (1999) in his studies incorporating different levels of silk worm pupae meal in pig ration.

Thomas and Singh (1984a) reported that lowering of digestible energy content of grower pig rations by 10 per cent from NRC level resulted in lowering of ether extract digestibility from 91.76 to 76.84 per cent and a further lowering of digestible energy values by five per cent brought down the ether extract digestibility to 55.1 per cent. The reducing trend in ether extract digestibility with decrease in energy content in feed is observed in the present

study also. In contrary to this, Dhudapker *et al.* (1971) obtained ether extract digestibilities of 62.8, 77.7 and 76.2 per cent in Middle White Yorkshire pigs for diets containing 3500, 3200 and 3000 kcal of digestible energy per kg feed.

The values reported by Ranjhan *et al.* (1972), Devi (1981) and Reddy *et al.* (1986) ranged from 68.7 to 79, 66.9 to 69.9 and 56.81 to 63.10 respectively, these being higher than those obtained in the present experiment.

5.4.4 Crude fibre

The data presented in Table 8 reveal that the digestibility coefficients of crude fibre for the three experimental diets T1, T2 and T3 were 32.2, 27.4 and 21.6 respectively. The values did not differ significantly between the treatments. Reddy *et al.* (1986) obtained values of 33.00 and 29.07 respectively for indigenous pigs given diets with 16 per cent crude protein and 3.0 and 2.7 Mcal of DE/kg of the diet, these being in agreement with the values recorded in the present trial.

Dhudapker *et al.* (1971) obtained crude fibre digestibilities of 36.2, 33.7 and 47.0 respectively when pigs were given diets containing 3500, 3200 and 3000 kcal of digestible energy per kg. Ranjhan *et al.* (1972) obtained values ranging from 30.7 to 46.2 for diets with varying crude fibre levels. Devi (1981) reported digestibility coefficients of crude fibre from 37.1 to 40.0 for diets containing 16 per cent crude protein and varying levels of dried

tapioca chips. The values obtained by the above workers are higher than those observed in the present experiment.

5.4.5 Nitrogen free extract

From the results given in Table 8, it could be seen that the digestibility coefficients of nitrogen free extract for the three experimental diets T1, T2 and T3 were 75.3, 79.9 and 86.1 respectively. The value was higher ($P<0.01$) for pigs fed diet T3 than for those fed diets T1 and T2 and T2 in turn recorded higher ($P<0.01$) values than T1. Almost similar values have been reported by Dhudapker *et al.* (1971) and Reddy *et al.* (1986) in their studies with diets containing varying levels of energy. Devi (1981) recorded digestibility coefficients of nitrogen free extract that ranged from 86.3 to 90.1 for diets containing 16 per cent crude protein and varying levels of dried tapioca chips, the above figures being almost similar to those obtained in the present study. However, Ranjhan *et al.* (1972) obtained values ranging from 58.9 to 64.5 for diets with varying levels of crude fibre. Ramamoorthy (1999) stated values of 67.7, 60.3 and 54.9, when pigs were fed diets containing different levels of silk worm pupae meal. The values reported by Vasudevan (2000) ranged from 57.8 to 62.2 when pigs were given rations containing maize ground to different particle sizes. The values obtained by the above workers are considerably lower than those obtained in present study.

A perusal of the digestibility coefficients of nutrients indicate that except for crude fibre and crude protein, the digestibility of all proximate principles was found to increase with increase in dietary energy level.

5.5 Carcass characteristics

5.5.1 Live weight at slaughter

The live weight at slaughter for the pigs fed different experimental diets T1, T2 and T3 were 60.0, 67.3 and 70.2 respectively (Table 9). Pigs fed diets containing 3200 and 3000 kcal of DE/kg feed had higher ($P<0.01$) live weight at slaughter than those fed diets having 2800 kcal of DE/kg diet. There was no significant difference between T2 and T3.

5.5.2 Dressing percentage

The dressing percentage for the pigs in the three dietary treatments T1, T2 and T3 presented in Table 9 were 71.6, 74.5 and 75.9 per cent respectively and they did not differ significantly. Talley *et al.* (1976) reported values ranging from 73.0 to 77.0 for dressing percentage of pigs fed diets with different levels of metabolizable energy, while Anjaneyulu *et al.* (1984) obtained dressing percentages varying from 70.9 to 71.4 for pigs slaughtered at the age of 191 to 290 days. These are in agreement with the results obtained in the present study.

However, the values reported by Baird *et al.* (1975); Sebastian (1972), Ramachandran (1977); Devi (1981); Thomas and Singh (1984b); Sivaraman

and Mercy (1986) and Sharda and Vidyasagar (1986) are slightly higher than the values obtained in the present investigation.

5.5.3 Carcass length

The carcass length of pigs in the three dietary treatments T1, T2 and T3 presented in Table 9 were 59.2, 60.0 and 62.4 cm, respectively and they did not differ significantly.

Sebastian (1972); Baird *et al.* (1975), Ramachandran (1977), Devi (1981), Anjaneyulu *et al.* (1984), Thomas and Singh (1984b), Sharda and Vidyasagar (1986), Sivaraman and Mercy (1986) and Arora *et al.* (1994) obtained values ranging from 68.5 to 80.0 cm for carcass length of pigs slaughtered from 70 to 90 kg. These values are far higher than those recorded in the present study.

5.5.4 Back fat thickness

The back fat thickness of pigs maintained on the three dietary treatments T1, T2 and T3 were 3.0 cm, 3.3 cm and 3.0 cm respectively (Table 9), no significant difference being observed between the treatments in this regard. Baird *et al.* (1975), Talley *et al.* (1976), and Seerley *et al.* (1978) also reported similar values in pigs fed rations containing varying levels of crude fibre, crude protein and dietary energy.

However, Devi (1981) and Vasudevan (2000) obtained values ranging from 2.2 to 2.8 cm which were lower than those obtained in the present study.

While Sharda and Vidyasagar (1986) stated values that ranged from 3.2 to 4.2, these being higher than that observed in the present study.

Thomas and Singh (1984b) observed a reduction in back fat thickness from 4.5 to 2.7 cm in growing pigs when the digestible energy content of the ration was lowered by 10 and 15 per cent of NRC standards. In contrary to this, in the present study no significant difference in back fat thickness was observed when energy content of the rations was reduced from 3200 to 3000 and 3000 to 2800 kcal of DE/kg.

5.5.5 Eye muscle area

The average values for eye muscle area of pigs in the three treatments T1, T2 and T3 presented in Table 9 were 17.4, 16.8 and 21.4 cm^2 respectively. There were significant differences ($P<0.05$) between T1 and T3 and T2 and T3, the value observed being the highest for T3.

Sebastian (1972), Baird *et al.* (1975), Talley *et al.* (1976), Seerley *et al.* (1978), Devi (1981), Anjaneyulu *et al.* (1984), Thomas and Singh (1984b) and Arora *et al.* (1994) obtained values that ranged from 23.6 to 34.5 cm^2, which were all higher than that obtained for pigs in the present study.

5.6 Economics of gain

A perusal of the data presented in Table *10 in*dicates that the cost of feed per kg body weight gain of pigs maintained on the three dietary treatments T1, T2 and T3 were Rs.49.90, 43.30 and 34.10 respectively. *The*

cost of feed per kg body weight gain was significantly lower ($P<0.01$) for T3 than those for T2 and T1. The cost per kg weight gain was found to decrease as the energy level in the feed increased although significant difference was observed only between T1 and T3 and between T2 and T3.

An overall critical evaluation of the results obtained in the present study indicates that crossbred pigs (Large White Yorkshire x Desi) require an energy content of 3200 kcal of DE/kg feed for better growth performance provided the crude protein content in the ration is maintained at 16 per cent as the performance of pigs fed high energy ration was superior in every aspect of production such as average daily gain, meat yield, eye muscle area, carcass yield and feed efficiency. It would be worthwhile to investigate whether higher levels of energy than those used in the present study would be beneficial to further enhance the production performances before recommending optimum energy level for growth in crossbred pigs.

Summary

6. SUMMARY

A study was carried out to assess the influence of difference levels of energy on the growth performance of crossbred (Large White Yorkshire x Desi) pigs. Fifteen male (castrated) and fifteen female weaned crossbred piglets with an average body weight of 12.9 kg were selected from the Centre for Pig Production and Research, Mannuthy and were divided into three equal groups, viz., T1, T2 and T3 as uniformly as possible with regard to age, sex and body weight. The ten piglets in each treatment were randomly distributed into five replicates of two piglets each. The piglets in the three groups were fed on rations with 16 per cent crude protein but three different levels of energy, viz., T1 – 2800 kcal of DE/kg, T2 – 3000 kcal of DE/kg and T3 – 3200 kcal of DE/kg.

The experiment was conducted for six months. Each replicate consisted of piglets of opposite sex and were housed in separate but identical pens. The piglets were offered feed *ad libitum* twice a day. Records of daily feed intake and fortnightly body weights were maintained throughout the experimental period. A digestibility trial was carried out after the middle of the experiment to determine the digestibility coefficients of nutrients of the experimental diets. Though the period of experiment was for six months, animals that attained 70 kg body weight were slaughtered before the termination of the experiment. The carcass characteristics of six animals from each group were studied.

The animals fed diet containing 3200 kcal of DE/kg had a higher ($P<0.01$) average daily gain and showed better ($P<0.01$) feed conversion efficiency, the average daily gains being 262.9, 302.0 and 362.8 g and the feed conversion efficiencies 6.0, 5.2 and 4.1 for the three groups T1, T2 and T3, respectively.

The digestibility coefficients of nutrients were found to increase with increase in energy level in the diet, the animals in T2 group showing better digestibility than those in T1 and T3 being better than T2, except for the digestibility coefficients of crude fibre and crude protein. Significant differences in the digestibility coefficient of ether extract and nitrogen free extract were observed between the groups in the ascending order. Digestibility coefficient of dry matter in T3 animals was significantly higher ($P<0.01$) than that of T1 and T2 while no significant difference was observed between T1 and T2. The digestibility coefficients of crude protein and crude fibre were almost similar for the three groups.

Carcass characteristics like body weight at slaughter and dressed weight without head were found to improve as the energy content of the ration increased, whereas dressing percentage, carcass length and back fat thickness were not significantly influenced by the energy content of the ration.

The cost of feed per kg weight gain of animals maintained on different dietary treatments were found to be Rs.49.90, 43.30 and 34.10 for groups T1, T2 and T3 respectively. This decrease in the cost of feed per kg gain of

animals with increase in energy content of the ration is due to better average daily gain and feed conversion efficiency. Eventhough the energy content of the rations differed, the cost of feed remained almost the same.

From an overall assessment of the results obtained during the course of the present investigation, it is reasonably concluded that crossbred pigs require 3200 kcal of DE/kg of the ration for better growth performance provided the crude protein level in the ration is maintained at 16 per cent.

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INFLUENCE OF DIFFERENT LEVELS OF ENERGY ON GROWTH PERFORMANCE OF CROSSBRED PIGS

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ABSTRACT OF A THESIS

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ABSTRACT

An experiment was conducted to assess the influence of different levels of energy on the growth performance of crossbred (Large White Yorkshire x Desi) pigs.

Fifteen male (castrated) and fifteen female weaned crossbred piglets with an average body weight of 12.9 kg were divided into three equal groups as uniformly as possible with regard to age, sex and body weight. The three groups of piglets were maintained on three rations with 16 per cent crude protein but differing in their energy content, viz., 2800 kcal (T1), 3000 kcal (T2) and 3200 kcal (T3) of digestible energy (DE) per kg.

The average daily gains recorded for the three groups T1, T2 and T3 were 262.9, 302.0 and 362.8 g respectively. The cumulative feed conversion efficiencies were 6.0, 5.2 and 4.1 for the groups T1, T2 and T3 respectively. The values recorded for T3 were higher ($P<0.01$) than those for T1 and T2.

The digestibility coefficients of nutrients except that of crude fibre and crude protein were found to improve with increase in the energy content of the rations.

Study of the carcass traits revealed that the body weight at slaughter and dressed weight without head improved as the energy content of the rations

increased. However, dressing percentage, carcass length and back fat thickness were not significantly influenced by the energy content of the ration.

The cost of feed per kg weight gain of animals was significantly lower ($P<0.01$) for the dietary treatment T3 compared to that of T2 and T1, the values being Rs.49.90, 43.30 and 34.10 for T1, T2 and T3 respectively.

The above results indicate that crossbred pigs require 3200 kcal of DE/kg of the ration for better growth performance provided the crude protein level is maintained at 16 per cent.