PRODUCTION PERFORMANCE AND ECONOMICS OF LARGE WHITE YORKSHIRE AND CROSSBRED (Large White Yorkshire x Desi) PIGS UNDER DIFFERENT MANAGEMENT AND ENVIRONMENT CONDITIONS

By

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DECLARATION

I hereby declare that this thesis, entitled **"PRODUCTION PERFORMANCE AND ECONOMICS OF LARGE WHITE YORKSHIRE AND CROSSBRED (LARGE WHITE YORKSHIRE X DESI) PIGS UNDER DIFFERENT MANAGEMENT AND ENVIRONMENT CONDITIONS"** 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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Certified that the thesis entitled **"PRODUCTION PERFORMANCE AND ECONOMICS OF LARGE WHITE YORKSHIRE AND CROSSBRED (LARGE WHITE YORKSHIRE X DESI) PIGS UNDER DIFFERENT MANAGEMENT AND ENVIRONMENT CONDITIONS"** is a record of research work done independently by **Dr. K.S. ANIL**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

1. INTRODUCTION

The dramatic increase in human population results in many problems including malnutrition. It is well documented that a large population suffer from undernourishment partly due to insufficient production and uneven distribution of cereals and crop production. Apart from this, there is malnutrition of a 'qualitative nature' due to inadequate availability of some of the essential amino acids and vitamins which are commonly derived from food items of animal origin.

Acute scarcity of animal protein is reflected from the fact that the per capita consumption is only 9.6 g in India against the world average of 24 g and Indian Council of Medical Research's recommendation of 34 g (Shanmugasundaram, 1997). 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, 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 because of their rapid growth rate, high feed conversion efficiency, high prolificacy and short generation interval. And thus, pork being a valuable source of rich animal protein can play an important role in mitigating the protein shortage.

In organized farms, pigs are reared mainly on concentrate feed and are kept in well constructed sheds. But high grain diets for pig increases the cost of feeding as well as decreases the availability of grain for human population in developing countries. (Joseph and Abolaji, 1997). Therefore, the most logical step of saving the grains and reducing the cost of pork production is to replace grains with an alternative source of feed. Economical feeding is important for profitable swine production, since 75 to 80 per cent of expenditure incurred is for feeding of animals.

Majority of the pig farmers are feeding their animals on organic wastes of animal and plant origin. The swill feed thus fed include poultry slaughter waste, hotel waste or restaurant waste and vegetable wastes. The animals are housed in sheds where the standard recommendations for housing are not followed. Though this practice is found cost effective, not much information is available on the performance and productivity of pigs in this type of rural production systems. The economic feasibility of this production system is also a matter of concern. A comparative study between the performance of pigs in organized farms and rural sector will help to understand and identify problems in the field fattener production units. Research in this line are very limited and hence information in this aspect is meagre.

In this context the present study was undertaken with the following objectives.

1. To assess the production performance of Large White Yorkshire (LWY) and crossbred pigs in field vis-a-vis in the organized farm.

2. To estimate the field and farm level production cost of fattener pigs.

3. To identify the lacunae if any in feeding, housing and managemental aspects of rural pig production systems and to suggest appropriate recommendations.

Review of Literature

2. REVIEW OF LITERATURE

2.1 BODY WEIGHT GAIN AND BODY MEASUREMENTS

Berge and Indrebo (1959) investigated the regression of gain on age and on heart girth in Norwegian Landrace pigs from birth to 250 kg body weight. They observed that increases were not uniform throughout the period as at times body length increased to a greater extent than did heart girth. Growth is a complex set of metabolic events which are environmentally and genetically controlled (Hafez, 1968). However, Gruev and Machev (1970) was of the view that the sixth month body weight of both male and female pigs were significantly correlated with body length, height at withers and heart girth.

According to Mickwitz and Bobeth (1972) of the body measurements live weight was highly correlated with chest circumference in pigs. Deo and Raina (1983) concluded that the genetic correlation of body weights with each of the linear body measurements at most of the ages from birth to 32 weeks were positive.

Sahaayaruban *et al.* (1984) also reported the highly positive correlation between body weight, body length, chest girth, shoulder height and hip width.

Somayazulu and Agarwal (1985) concluded that the weight of pigs at slaughter can be predicted in advance using body weight upto 20^{th} week of growth when a uniform system of management is practised and growth rate of pigs increased from four to sixth month of age and decreased thereafter.

Dash and Mishra (1986) observed that there were no significant difference in body weight gain and body measurements between Large White Yorkshire and crossbred pigs and feed efficiency decreased with increase in slaughter age and it was higher in Large White Yorkshire than crossbred pigs. They also found that the heart girth in crossbreds and abdominal girth in Large

White Yorkshire were the important body measurements contributing towards increase in the body weight.

Kumar *et al.* (1990) reported that among three genetic groups viz., desi, Landrace x Desi (half bred) and Landrace pigs, the body weight of half bred was in between two pure breds (Landrace and desi pigs), and feed efficiency was 5.76, 4.79 and 4.16 respectively.

Sharma *et al.* (1990) concluded that the body weight of Large White Yorkshire half breds was almost equal to that of Large White Yorkshire pigs but much higher than that of desi at all the ages.

Leena (1992) found that the body weight at weaning was 8.5 ± 0.669 kg and at eight month of age was 67.0 ± 4.902 kg. As the age progressed the weight of the pigs also increased. The average rate of growth increased from birth to the fourth month and thereafter showed a declining tendency. The absolute daily gain increased from 218 g in the first month to a peak of 600 g in the fourth month and then declined to319 g from fifth month.

Pradhan (1993) found that the daily gain in weight increased from 131.62 ± .17 g at tenth week to a peak of 392.28 ± 9.34 g at 32nd week, and thereafter declined to 384.60 ± 6.98 g at 40th week of age.

Body weight of pigs have increased progressively from weaning (9.64 ± 0.82 kg) to eighth month of age (83.48 ± 2.70 kg) indicating that as age advanced the body weight also increased (Kannan, 1995).

Joseph (1997) reported that the body weight of pigs increased from weaning (12.6 ± 0.65 kg) to fifth month (42.813 ± 3.752 kg) of age, with an average daily gain of 237.70 ± 49.53 g.

Singh *et al.* (1997) found that the live weight of Large White Yorkshire pigs at birth (1.23 ± 0.03 kg) and at 16 weeks (18.62 ± 0.11 kg) were found to be significantly ($P<0.01$) higher than the crossbreds (1.03 ± 0.03 and 17.25 ± 0.05

kg) and the cumulative feed conversion ratio (feed/gain) were 3.38 and 3.62 respectively.

Sinthiya (1998) recorded the body measurements such as length, girth and height which ranged from 76.8 to 82.0, 86 to 88.5 and 54.3 to 57.3 cm respectively, for pigs maintained on rations containing varying proportions of carcass meal. Almost similar values are reported by Subramanian (1998).

2.2 PERFORMANCE OF PIGS ON CONVENTIONAL FEEDING

Aunan *et al.* (1961) found 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. Cunningham *et al.* (1973) observed that pigs fed the 10 per cent protein diet gained slower and were fatter than pigs fed with the 14 per cent protein diet.

Baird *et al.* (1975) also found greater efficiency of protein conversion on low protein diets for Poland China pigs. Improved growth rate and feed efficiency were reported by Fetuga *et al.* (1975) as the protein levels were increased from 16 to 20 per cent in the diets of Lardrace and L.W.Y. pigs. Similarly, Davey (1976) observed that growth rate of Duroc and Yorkshire pigs were decreased when the protein level in their diet was reduced to 11 per cent.

Ramachandran (1977) could not detect any significant difference in carcass characteristics of pigs maintained on different dietary protein levels. Pigs fed high protein diet showed higher feed efficiency, better average daily gain, yielded carcass containing a higher percentage of lean cut, less back fat and more loin eye area than pigs fed low protein diet (Cromwell *et al.*, 1978).

Shields and Mahan (1980) reported that temporary moderate protein restrictions in diets did not affect carcass quality and that gilts had leaner carcass than barrows.

Saseendran *et al.* (1981) compared the exotic pigs with indigenous pigs reared in university pig farm, Mannuthy and recorded a feed efficiency of 4.26, dressing percentage of 72.17 and back fat thickness 2.03 cm and loin eye area 25.25 cm^2 in exotic pigs and were much superior to indigenous pigs.

Prabhakar (1984) recorded a live weight of 78.43 ± 7.08, dressing percentage of 73.34 ± 1.40, carcass weight of 57.57 ± 5.89 kg, back fat thickness of 2.96 ± 0.29 cm in Large White Yorkshire pigs reared intensively.

Carcass length and loin eye area were higher in gilts than those of barrows, while the average back fat thickness was less in gilts than barrows indicating that carcasses obtained from gilts tended to produce lean carcasses when compared to barrows (Ramaswami *et al.*, 1984).

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

Feng *et al.* (1985) reported no significant difference in carcass dressing percentage among pigs given diets with high or with intermediate energy and protein.

Kumar and Bar Saul (1987) opined that the slaughter of pigs at 70 kg body weight would be better and more economical than at higher weights.

Mishra and Sharma (1991) reported an increasing trend in the dressing percentage, carcass length and back fat thickness with increase in carcass weight.

Deo *et al.* (1992) found that the genetic group had highly significant effect on weight at slaughter, carcass length, carcass weight, dressing percentage and loin eye area.

Jogi *et al.* (1993) found that the mean dressing percentage in desi pigs ranged from 58.91 to 59.45 per cent and the carcass length was 56.12 ± 0.66 cm with a backfat thickness of 2.82 ± 0.09 cm. There was not significant sex difference for the above traits, while the effect of sire, were observed to be significant on the above carcass traits.

Arora *et al.* (1994) reported that males had higher loin eye area, head weight and shoulder percentage than females, while females had significantly longer carcass length. The same group of authors also concluded a non significant effect of genetic group on carcass traits except the loin eye area.

Bhadoria (1996) found that dressing percentage of Large White Yorkshire pigs ranged from 61.58 to 73.38 and ham weight from 20.95 to 26.04 kg.

Joseph (1997) observed the carcass traits of Halothane sensitive pigs of Large White Yorkshire and Desi pigs of Kerala. The back fat thickness, loin eye area and dressing percentage were 2.47 ± 0.20 cm, 1.62 ± 0.72 cm, 20.97 cm^2, 15.68 ± 0.41 cm^2 and 66.76 per cent, 58.82 per cent respectively.

In a carcass study conducted in three breed crossbred pigs by Kawano *et al.* (1997) revealed that pigs fed with 74.5 per cent total digestible nutrients and 12% digestible crude protein slaughtered at 120 kg live weight had a higher carcass yield than those slaughtered at 110 kg body weight.

Singh *et al.* (1997) observed that in large white Yorkshire pigs slaughter weight, carcass length, hot carcass weight, backfat thickness, loin eye area and ham weight were 114.31 ± 1.01 kg, 87.32 ± 0.40 cm, 83.85 ± 0.88 kg, 30.45 ± 0.57 mm, 28.23 ± 0.65 cm^2 and 22.79 ± 0.25 kg respectively.

Jha *et al.* (1999) observed that pigs reared on concentrates had mean values for live weight, hot carcass weight, dressing percentage, backfat thickness, loin eye area and harn weight of 90.38 kg, 66.44 kg, 70.76 per cent, 25.55 mm, 28.38 cm^2 and 18.16 kg respectively.

Mili *et al.* (1999) studied the effect of slaughter weight on carcass measurements of Hampshine barrows. All the pigs were fed with adlibitum grower ration (18 to 20 per cent CP) upto 35 kg body weight and with finisher ration (15 to 16% CP) till slaughtered. They found that Hampshine barrows weighing 70 kg rendered the lowest carcass length (68.50 cm) and backfat thickness (2.04 cm), while barrows of 100 kg registered maximum carcass length (70.10 cm) and backfat thickness (3.50 cm). Loin eye area was smallest (18-28 cm^2) in 70 kg group and largest (32.85 cm^2) in 100 kg group.

The growth rate of pigs reared by small holder farmers in two areas of Philippines was 5.7 kg per month and 5.5 kg per month, respectively (More *et al.*, 1999). When pigs from one to seven generation bred in a closed system, Sheiko (1999) noticed an increase of 5.9%, 1.9% and 12.5 per cent in average daily gain, carcass length and loin eye area and a reduction of 5.7% in back fat thickness.

Singh *et al.* (1999) observed a average daily gain of 283.96 ± 6.14 gm in Large White Yorkshire pigs fed on concentrates during the period from eight to twenty weeks of age.

In Large White Yorkshire pigs fed on standard concentrate ration, Hati *et al.* (2000) recorded weight of liver as 1.12 ± 0.06 kg, lungs 0.71 ± 0.05 kg, heart 0.19 ± 0.09 kg and kidney 0.21 ± 0.02 kg.

The Large White Yorkshire pigs of North East Hill region of India obtained a slaughter weight of 54.75 ± 1.07 kg, growth rate 335.45 ± 7.45 g per day, hot carcass weight 35.58 ± 0.87 kg, dressing percentage 65.00 ± 0.58 and backfat thickness 2.28 ± 0.06 cm (Rohilla *et al.*, 2000).

Suraj (2000) recorded body weight of Large White Yorkshire pigs at eight months of age as 78.44 kg, body length as 86.78 cm, body girth as 97.37 cm and height as 60.97 cm. The average mean daily weight gain was 420 ± 63 g on concentrate ration and daily feed intake was 1.316 ± 0.17 kg. The feed conversion efficiency was 3.821 ± 0.21.

2.3 PERFORMANCE OF PIGS ON UNCONVENTIONAL FEEDING

Sasikala Devi (1981) observed that dried tapioca chips can be safely and profitably incorporated in practical swine ration at a level of 40% in place of conventional cereal grain like maize.

Prabhakar (1984) recorded a dressing percentage of 70.39 ± 1.15, loin eye area of 16.56 ± 4.89 cm^2 and back fat thickness 3.10 ± 0.63 cm in indigenous pigs reared traditionally on food wastes and scavenging.

Shyam Mohan (1991) observed that carcass characteristic like dressing percentage, carcass length, backfat thickness, loin eye area and weight of ham were adversely affected by the inclusion of prawn waste in the ratios as partial or complete replacement of unsalted dried fish.

According to Ravindran *et al.* (1995) some farm of swill feeding was practised in over 80 per cent of the small holder pig farms in Sri Lanka. About 55 per cent of the farmers cooked the swill prior to feeding and most of the farmers practiced adlibitum feeding of combination of energy-type bulky feeds swill and variable amounts of protein type feeds.

The cassava and its byproducts from Starch processing and Sugarcane Juice and/or molasses can replace cereals in the diets of growing pigs (LeDuc – Ngoan *et al.*, 1996).

Based on the trials conducted on pig feeding in China Li-Tiejian *et al.* (1996) reported that poultry wastes (droppings, offal), silage, agricultural byproducts and green feed could be incorporated in pig feed. They showed that 60 per cent fermented chicken droppings combined with basal feed for pig finishing saved feed cost.

Myer *et al.* (1996) suggested that dehydration of food residuals has the potential to produce a nutritious feed stuff for swine while offering a viable solid waste disposal option. The average composition of dehydrated food residues was

11.4 per cent moisture, 15 per cent crude protein, 13.8 per cent crude fat, 10.4 per cent crude fibre and 5.8 per cent ash.

Rivas *et al.* (1996) assessed Dehydrated Edible Restaurant Waste (DERW) as a feed stuff for swine by determining the nutrient composition and digestibility. The chemical composition of DERW was 92.1 per cent dry matter, 22.4 per cent crude protein, 23.2 per cent crude fat, 2.3 per cent crude fibre and 5.4 per cent ash.

Fanimo and Tewe (1996) suggested that chicken-offal meal with DM 88.2 per cent, CP 60 per cent, EE 8.46 per cent, CF 6.11 per cent, NFE 11.03 per cent and ME 2900 Kcal per kg can be effectively utilized in the ration of weaner piglets. The authors also observed an average daily gain of 287 g.

The carcass weight loin eye area, percentage lean and back fat thickness were higher in pigs fed on complete feed than swill fed group (Chen-YieShiurg *et al.*, 1997). It was also found that unsaturated fatty acid content was higher in swill fed pork.

Hsieh-Chia Hui *et al.* (1997) reported that in North Taiwan pigs were fed primarily on kitchen waste when body weight reached about 28 kg, after 41 kg of body weight they were fed only kitchen waste to the market weight of about 135 kg.

Poultry offal silage could be used to replace upto 300g per kg DM in commercial grower diet with out affecting performance or health of the pigs (Lallo *et al.*, 1997).

Mishra *et al.* (1997) reported that in local piglets raised upto 24 weeks of age after weaning showed the average daily gain of 169.87 ± 9.51 g in females and 149.11 ± 21.75 g in males under Scavenging system. He also recommended supplementation of 300 to 500 g concentrate to scavenger pigs.

An average daily weight gain of 114 g was estimated with a feed conversion of 5.49 kg on adlibitum feeding of dry garbage and 26.05 kg on fresh garbage basis in Large White Yorkshine pigs (Ravi and Krishna Reddy, 1997).

Somanadha Sarma and Subba Reddy (1997) studied carcass characteristics of Large White Yorkshire pigs reared on garbage in Andrapradesh. The characters studied included dressing percentage, proportion of harm, under cut and bacon over dressed weight and the estimates were found to be 71.46 to 73.05 per cent, 17.53 to 18.81 per cent, 0.82 to 0.94 per cent and 10.12 to 12.03 per cent respectively.

Duru *et al.* (1999) identified feed as the mayor single item in the cost of production. They observed that 28.3 per cent of the farmers fed offal alone to their pigs, 20 per cent fed offal and kitchen waste, 40 per cent fed offal, kitchen waste and vegetable and the rest 11.7 per cent used offal and brewers residue for feeding their pigs.

Jha *et al.* (1999) obtained carcass length 63.06 ± 1.11 cm, dressing percentage with head 70.41 ± 0.11 per cent, back fat thickness 19.28 ± 0.68 mm, loin eye area 15.31 ± 0.68 cm^2 in pigs reared on kitchen waste and grazing.

Ashok Kumar *et al.* (2000) found that feed conversion efficiency of ration containing soybean by replacing fishmeal completely was equally good.

Hati *et al.* (2000) observed that when maize from conventional feed was replaced by marva 33.3%, 66.6 and 100% levels there was significant weight gain in last two groups from 16^{th} to 28^{th} wks of age. However difference between maize feed and 33.3% substituted by marura and between 66.6 and 100%

substitution were non significant at all ages. The values recorded with respect to back fat thickness, carcass length and loin eye area were nonsignificant among groups.

Bhar *et al.* (2001) reared pigs on wheat bran based diets and Deoiled rice bran diets. They found that on feeding DORB based diets all the responses were adversely affected and the animals could attain only 16.5 to 26.3 kg body weight by 112^{th} day of feeding in comparison to 35.24 to 37.15 kg in wheat bran based diets after 105 day of feeding. The overall digestibility of organic nutrients, except for CF, was significantly higher in wheat bran based diets then DORM. The authors concluded that crossbred grower pigs can be fed on low grain or grainless wheat bran based diet, but not on DORB incorporated diet, without adversity affecting growth and nutrient utilization.

Shoremi and Adana (2001) studied the utilization of wheat offal as substitute for maize grain at 25, 50, 75 and 100% level. No significant difference was observed in feed conversion ratio. The authors concluded that replacement of maize grain by wheat offal in the diet of weaver pigs was beneficial and cost effective at 50% level.

Yadav *et al.* (2001) studied different levels of incorporation of rice polish in pig ration. He concluded that on incorporating 80 per cent of rice polish in the diet the average daily weight gain was 275.19 ± 10.22 g.

Ranjan *et al.* (2003) studied on Tamsworth and desi bred of pigs with different feeding practices of hotel waste and rice fermented wastes. The CP and EE of hotel waste was 26.23 ± 0.90 and 6.12 ± 0.29 and that of rice fermented waste 18.76 ± 0.58 and 6.12 ± 0.27 respectively. The average daily weight gain obtained on hotel waste was 248.42 g and that for rice fermented waste 230.67 g.

2.4 EFFECT OF QUANTITY AND QUALITY OF PROTEIN ON GROWTH AND CARCASS TRAITS

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. 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 Mohan (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 requirement of growing swine fed ad libtium as cited by Ranjhan (1981) were 22, 18 and 14 per cent for body weights of 5 to 12, 12 to 50 and 50 to 100 kg respectively. Tyler *et al.*, (1983) showed that grower and finisher pigs fed diets with protein levels of 20% and 18% 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 seventeen per cent crude protein and 13.9 MJ DE when the feed was supplemented with the first two limiting amino acids lysine and tryptophan.

The diets of fattening pigs which contained 17 and 15% CP during the growing and finishing period respectively, showed increased average daily gain and improved feed: gain ratio (Barac *et al.*, 1996). Oldenberg and Heinrich (1996) showed the finisher pig diets which contained 17 per cent and 13.5 per cent CP had no significant effect on finishing and slaughter performance.

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). Boomgart and Baker (1967) stated that the expression of amino acid requirement as percentage of dietary protein is preferable to that as a protein 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.

Robbins and Baker (1977) found out that phenylalanine can meet the total requirement for phenylalanine and tyrosine because it can be converted to tyrosine. Tyrosine can satisfy at least 50 per cent of the total need for these two amino acids, but it cannot serve as the sole source, because it cannot be converted to phenylalanine.

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).

Most of the amino acids occur in plants and animal protein as L Isomer. Reifshyder (1984) found that when crystalline amino acid supplements are provided, DL – methionine can replace the L form in meeting the need for methionine. His research also indicated that on a molar basis DL-methionine and DL-methionine hydroxy analog have the same methionine activity for young pigs.

Edmonds and Baker (1987b) established that excess lysine does not seem to increase the arginine requirement in pigs. However in poultry excessive dietary lysine increases the requirement for arginine.

Fuller *et al.* (1989) indicated that for one gram 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.

Glutamine is considered to be a conditionally essential amino acid in some species (Lacey and Wilmore, 1990), because it prevents intestinal atrophy under certain conditions.

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.*, 1993 and Valaja *et al.*, 1995). Brudevoid and Southern (1994) have observed that additions of excessive supplements of crystalline amino acids, such as arginine, leucine, and methionine can reduce feed intake and growth rate. Williams (1994) observed that methionine and cystine undergo oxidation to multiple derivatives, and controlled oxidation of methonine to methionine sulfone and of cystine to cystic acid must be carried out with performic acid before acid hydrolysis. Similarly tryptophan analysis is difficult because of the relatively low concentration in most feed stuffs and because tryptophan is partially destroyed during standard acid hydrolysis. Consequently special precautions are necessary, such as hydrolysis with barium hydroxide, sodium hydroxide or lithium hydroxide, or protection against oxidation in acid.

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.

Wu *et al.* (1996) reported that addition of one per cent glutamine to a corn-soybean meal diet prevented jejunal atrophy in pigs weaned at 21 days during the first week post weaning and increased feed efficiency during the second week post weaning.

Mroz *et al.* (1997) reported that addition of calcium benzoate (2.4%) to the diet of pigs enhanced the ileal digestibility of arginine, isoleucine, leucine, phenyl alanine, alanine, aspartic acid and tyrosine.

Tossenberger *et al.* (1998) conducted a study in weaned piglets by supplementing the diet with two levels of formic acid. They observed that the apparent ileal digestibility of CP was improved from 76.5 to 79.3 per cent, lysine from 77.6 to 82.2 per cent and that of methionine from 86.2 to 88 per cent. A similar improvement in digestibility was also found for other amino acids.

Chandrasekharaiah *et al.* (2003) conducted studies to determine the essential amino acids content in commonly used feed ingredients such as soybean extraction, broken rice, rape seed extraction, sunflower extraction, rice polish, pearl millet grain, silkworm pupae, maize gluten meal (40% CP and 60% CP), safflower cake and copra cake. The essential amino acid content of feed stuffs ranged from 0.03 to 9.12% on dry matter basis. Highest level of EAA was observed in soybean extraction followed by maize gluten meal.

Omogbenigun *et al.* (2003) found that the addition of microbial phytase and organic acids increased the apparent ileal digestibility of isoleucine, histidine and aspartic acid whereas those of dry matter and crude protein were unaffected.

2.5 SERUM MINERALS

Ferreira Neto and Vieira (1979) sampled blood at birth and from then monthly to 15 months old from 57 male Yorkshire pigs. Calcium in blood was 10.57 mg/100 ml at birth. It fell to at 1 month and remained low up to 4 months after which it increased to a maximum of 12.21 mg/100 ml at 5 months. From 10 to 15 months Ca was from 8.2 to 10.8 mg/100 ml. Phosphorus was 7.95 mg/100 ml at birth and was greatest, 14.57 mg/100 ml, at 9 months.

Mahan (1981) suggested that the total dietary Ca and P concentration necessary for weaned pigs to attain maximum bone ash from 7 to 20 kg bodyweight is 0.80 and 0.68%, respectively, with diets based on maize and soya bean meal, whereas 0.1% less P is needed to maximize performance traits. It was calculated that the requirement of available P was about 0.35%.

Miller *et al.* (1981) estimated growth and serum zinc concentration in young growing pigs given a basal diet with Zn 20 mg/kg supplemented with Zn 25 or 50 mg/kg from either zinc oxide or metallic Zn dust from the metal smelting and refining industry. Growth was not sensitive to either source or amount of supplemental Zn, but serum Zn concentration increased linearly with increases in supplemental dietary Zn from either source. Equations for the linear regression of serum Zn concentration on supplemental dietary Zn were calculated from the results on blood samples after 2 and 5 weeks of the trial. The ratio of the slope of the regression line for metallic Zn dust to that for zinc oxide was 1.30 and 1.33 for the 2-week and the 5-week results, respectively. The availability of Zn from this metallic Zn dust to young growing pigs was therefore estimated to be about 30% greater than that from zinc oxide powder.

Reinhart and Mahan (1986) evaluated the effects of various Ca:P ratios (1.3:1, 2.0:1, 3.0:1, 4.0:1) at two dietary P levels (0.05% below US NRC, 0.10% above NRC) in starting, growing and finishing pigs. Diets had maize and soyabean meal with total dietary Ca and P adjusted using limestone and dicalcium phosphate at the expense of maize starch. Pigs fed on low-P diets displayed a trend toward lower daily gains and higher feed conversions after the Ca:P ratio exceeded 1.3:1, whereas when high dietary P was provided, adverse effects on performance were not observed until the Ca:P ratio exceeded 2.0:1. Serum Ca concentrations were higher ($P < 0.01$) and serum P lower ($P < 0.01$) with increasing Ca:P ratio, with the response more pronounced at low dietary P.

Bires *et al.* (1987) gave deep intramuscular application of a Czechoslovak-made fine oil suspension of 150 mg/ml zinc oxide in the neck to the experimental group at 30 mg/kg of body weight. The zinc level in blood serum was examined again in all animals 7, 12, 20, 40 and 60 days later. No adverse effects of the zinc oxide were detected. The results in the control group (in µmol/litre) were 9.59 ± 4.85, 11.50 ± 3.08, 10.58 ± 2.51, 8.71 ± 3.70, 8.08 ± 2.02, 12.11 ± 2.10 (on the sampling days above); the treated group averaged: 9.81 ± 3.06, 19.11 ± 3.65, 23.04 ± 4.90, 17.17 ± 3.05, 17.26 ± 2.94, 16.29 ± 2.83, indicating significantly higher values from day 12 to day 40 in the groups given zinc oxide.

Kirchgessner *et al.* (1987) found that when German Landrace X Pietrain pigs, 55-95 kg body weight, were given a grain-rich feed supplemented with trace elements and vitamins had a 60% higher growth rate, 20% higher feed intake and 30% better feed utilization than pigs given the basic, unsupplemented feed. Similar effects were seen in pigs given feed supplemented with either the trace elements or the vitamins. Pigs on the unsupplemented feed had distinct parakeratotic skin lesions of the type seen in extreme Zn deficiency. Zn concentration in serum samples of deficient pigs was reduced 60%, Cu and Fe were slightly reduced and Mn significantly increased. Absence of trace elements led to elevated vitamin A and lower Cu concentration in pig serum; absence of vitamins resulted in lowered vitamin A and Cu concentrations. Addition of Zn to the feed led to a 17% increase in growth rate, vitamin A to a 9% increase and Zn + vitamin A to a 19% increase, with increases in feed intake and feed utilization efficiency.

A total of 64 crossbred pigs initially 75 kg were used by Ward *et al.* (1991) to investigate the effect of 0 or 0.5% dietary sodium zeolite-A (NZA) in combination with copper 0 or 250 mg/kg (as CuSO4:5H2O). Diets based on maize/soyabean meal were given alone or with 0.5% NZA, Cu 250 mg/kg or 0.5% NZA plus Cu 250 mg/kg for 144 days. Overall rate and efficiency of gain, dressing percentage, carcass weight, percentage of muscling, 10th rib fat, loin eye area and bone calcium, phosphorus, manganese, iron, nickel, sodium and aluminium concentrations were not affected by treatment. Cu 250 mg/kg increased liver ($P<0.01$), serum ($P<0.06$) and bone ($P<0.07$) Cu concentrations, but decreased mean backfat thickness ($P<0.09$), bone ash percentage ($P<0.03$) and serum ($P<0.09$) and bone ($P<0.01$) Zn concentrations.

Yao *et al.* (1994) measured cell-mediated immunity (serum r-Ig percentage, stimulation index) haemoglobin values, packed cell volume and erythrocyte counts were greater after 10 piglets had been given an iron injection than in 10 untreated, anaemic controls.

Apgar *et al.* (1995) in two 5-week trials, 176 weanling pigs were fed on diets supplemented with copper sulphate (CuSO4) or a copper lysine complex (CuLys) at 0 (15 mg/kg of Cu in basal diet), 100, 150 or 200 mg/kg. Average daily gain and average daily feed intake increased linearly with increasing dietary levels of Cu during weeks 1-2, 3-5, and 1-5, with no difference between the Cu sources. Overall gain:feed ratios were not consistently affected by Cu source.

Zhou *et al.* (1998) concluded that the optimum concentrations of Zn and Fe in a diets for pigs containing Cu 250 mg/kg should be 142 and 153 mg/kg, respectively.

Singh (1998) reported that in 25 repeat breeding sows there were significantly decreased serum levels of phosphorus, magnesium and glucose, but significantly increased protein levels compared with those in 10 cyclic sows.

Sheng and Xia (2000) conducted feeding trial using 180 weanling pigs randomly assigned to 6 groups receiving the same basal diet supplemented with different chemical forms and doses of copper to study the effect of copper on growth performance. Among the treated groups, pigs of 50 mg/kg copper casein proteinate group and 240 mg/kg copper sulfate group grew fastest, whose ADGs were increased by 13.5% ($P < 0.05$) and 12.4% ($P < 0.05$).

Tang *et al.* (2001) conducted a five-week trial to evaluate the effect of organic chromium from different sources on growth performance of weaned pigs. Pigs were fed corn-soybean-whey-fish meal basal diets with either no supplemental Cr, 200 µg/kg Cr as chromium picolinate (CrPi), or 200 µg/kg Cr as chromium yeast (Cr-yeast). The results indicated that diets with Cr-yeast increased average daily gain (ADG, $p < 0.05$) and tended to increase average daily feed intake (ADFI, $p < 0.10$).

Based on the good correlation between the changes in zinc concentration in serum and activities of zinc-dependent enzymes, Cepelak *et al.* (2002) proposed the use of reliable and simple analytical procedures like determination of alkaline phosphatase or 5-nucleotidase activity for the assessment of zinc status. They found that a decreased zinc concentration in serum correlated well with the decreased total alkaline phosphatase activity ($r=0.94$) and the decreased 5-nucleotidase activity ($r=0.67$).

Lin-YingCai *et al.* (2002) supplemented the feed with CaCO3 to obtain Ca levels of 0.28, 0.54, 0.80, 0.90, 1.00 and 1.10%, respectively. Piglets were fed until 35 days of age. With increasing Ca level, average daily live weight gain and feed intake increased and then decreased, whereas feed conversion efficiency decreased and then increased. With lower Ca level, the ash, Ca and P contents in defatted dry thigh-bone (DDT) was significantly increased and then decreased.

Liesegang *et al.* (2002) conducted studies to examine if substantial bone loss occurs in growing pigs fed a vegetarian diet(V) in comparison with a diet containing fish meal (F). The digestibility of P was significantly decreased in group V. Significant changes in bone-specific alkaline phosphatase (bAP) activities and osteocalcin (OC) concentrations occurred with time during the 6 weeks. Total Bone mineral content (BMC) and Bone mineral density (BMD) in the tibia and BMD in the phalanx significantly decreased in vegetarian group. The results show that a vegetarian diet induces a significant loss of bone and a higher bone formation in group V compared with group F.

Liu *et al.* (2003) fed basal diets supplemented with 0, 100, 150, 200, 250, 300 mg/kg copper for 80 days, respectively to weaned piglets. The average daily gain (ADG), growth hormone (GH), insulin-like growth factor 1 (IGF- I) and insulin-like growth factor binding protein 3 (IGFBP3) levels in serum were increased significantly in the pigs fed on diets added with 100, 150, 200, 250, 300 mg/kg Cu. The results showed that the effects of copper supplemented in diets on growth in pigs were related to the increasing levels of GH, IGF- I and IGFBP3 in serum which were induced by copper.

2.6 SERUM LIPID

Kim *et al.* (1978) fed pigs on a high-fat, high-cholesterol diet. In the first experiment, a group was given 42% butter (by energy) and 1055 mg cholesterol daily, with casein as the source of protein, for 6 weeks; this diet produced moderately high serum cholesterol concentrations (219 plus or minus 33 mg/100 ml). Another group, on the same diet with soya protein product as the protein source instead of casein, showed almost normal serum cholesterol at the end (107 plus or minus 3 mg/100 ml). DL-Methionine added to a diet with soya protein did not change the hypocholesterolaemic effect of soya protein indicating that the effect was not the result of methionine deficiency.

Pedersoli (1978) used healthy miniature pigs in 4 groups of 11 each: groups A and B were sows and boars exercised for 5 min daily for 5 days a week; groups C and D were control sows and boars. All the pigs were fed on the same atherogenic diet for 30 min 3 times daily. Blood was taken monthly for 7 months for estimation of serum total cholesterol, total lipids and triglycerides. Total cholesterol and total lipids were more at the end than at the beginning of feeding in all groups; groups A, B and C had also more triglycerides, but group D had slightly less triglycerides in serum at the end. Sows had significantly more cholesterol, total lipids and triglycerides than boars. There was no significant difference between groups A and C and between groups B and D in cholesterol, total lipids and triglycerides.

Ritzel *et al.* (1979) as part of a study of the hypocholesterolaemic factor in milk, effects on blood lipids of feeding sweet whey to pigs, the authors concluded that serum cholesterol levels were significantly lower ($P < 0.02$) when the whey diet was fed. Similarly serum high density lipoprotein cholesterol content was significantly reduced ($P < 0.001$) by 20% during whey feeding. The proportion of beta -lipoprotein was higher and that of alpha -lipoprotein lower in serum of pigs fed whey than in control pigs.

Singh and Mukherjee (1979) gave groups of piglets weighing 3-6 kg diets enriched in cholesterol (300-750 g per day, according to age). Cholesterol values and coronary arteriosclerosis were more pronounced in those given three i/v methyl palmitate injections in addition to the cholesterol diet. Compared with controls given only the high cholesterol diet, or only buffalo serum, animals given buffalo serum or methyl palmitate and cholesterol showed enlargement of adrenal glands and liver, histopathological changes in heart, aorta, liver and adrenal glands and increased histochemical staining reactions of anterior pituitary granulated basophilic cells.

Kim *et al.* (1980) studied the hypocholesterolaemic mechanism of soya bean protein when added to a high-fat high-cholesterol (HC) diet, compared with casein, in young male Yorkshire pigs. The authors concluded that effect of soya bean protein in decreasing serum cholesterol concentrations in pigs on a high-fat, high-cholesterol diet seems to be due to the increases in faecal steroid excretions not counterbalanced by a concomitant increase in cholesterol synthesis.

Stahelin *et al.* in (1980) studied the effect of whey on serum lipids in swine on high fat and low fat feed. Groups of 12 pigs were fed for 10 wk on the following diets: low-fat control diet (i) containing 1.8% fat; low-fat diet (ii) containing 50% whey and 2.1% fat; high-fat diet (iii) containing 12.1% butterfat; high-fat diet (iv) containing butterfat + 50% whey. Growth was identical on all 4 diets. In group (i) pigs, serum total cholesterol (TC) increased by 15% and high density lipoprotein cholesterol (HDL-C) by 35%; in (iii) and (iv) TC increased by

44 and 34% and HDL-C by 56 and 44% resp. The presence of whey in the diet reduced by 10% the increase in TC and HDL-C in serum of pigs on both high- and low-fat diets.

Reitman *et al.* (1982) used 10 to 12 months old 9 female Yucatan miniature pigs as a model for experimental atherosclerosis studies. Cholesterol feeding increased serum cholesterol and accelerated atherosclerosis development. Controls given a diet low in fat and cholesterol had little gross or microscopic atherosclerosis. All the pigs given cholesterol had more extensive atherosclerosis than any of the controls by gross inspection of the Sudan-stained arterial tissue. There was individual variation suggesting the interaction of factors in addition to the plasma cholesterol which determine the extent and severity of atherosclerosis.

Royce *et al.* (1984) fed weanling pigs for 6 months on high-fat diets containing as fat source a high oleic acid safflower oil, lard or a partly hydrogenated soya bean oil blended with soya bean oil. There was no significant difference in the extent of atherosclerosis or the synthesis of thromboxane A2. Significant effects were observed on serum cholesterol, which was increased in the group fed on lard, serum triacylglycerol, which was highest in the safflower oil group, and prostacyclin synthesis, which was depressed by the lard and hydrogenated soya bean oil diets compared with the safflower oil diet.

Kim *et al.* (1984) fed three groups of young pigs on semipurified diets enriched in fat and cholesterol for 90 days. In one group 40% of energy was from butter, in another 40% was from maize oil and in the third group 20% was from maize oil. Mean serum cholesterol values were respectively 530, 458 and 400 mg/100 ml. Incidence of atherosclerosis in the abdominal aortae expressed as mean number of nuclear profiles per cross-section was respectively 1611, 734 and 585; expressed as mean lesion area per cross section it was 46.7, 21.4 and 19.4 mm2 X 102. It was suggested that estimates of comparative atherogenic risk of food fats based on response of serum cholesterol may mask important atherogenic differences.

Pond and Mersmann (1991) concluded that dietary cholesterol deprivation of pigs during the first 4 weeks of postnatal life reduced the serum cholesterol response to a high cholesterol diet fed from 4 weeks to 20 weeks old, but had no effect on concentrations of cholesterol in liver at 20 weeks old.

Wise *et al.* (1993) concluded that the high and low cholesterol lines differed in ovulation rate and litter size, and that the mechanism resulting in this difference related to altered pituitary secretion of gonadotropins and feedback effects on steroid and/or inhibin synthesis, much of which may be associated with altered cholesterol availability.

Rodas *et al.* (1996) suggested that L. acidophilus and Ca can enhance reduction of serum cholesterol in pigs fed on a high-cholesterol diet, probably through alteration in the enterohepatic circulation of bile acids.

Tagliaferro and Ronan (2001) evaluated the biological role of dehydroepiandrosterone (DHEA) and its less active sulphated conjugate DHEAS in two experiments using Yucatan miniature swine. Plasma levels of both DHEA(S) among males were greater than female pigs. In males, DHEA(S) were related inversely to serum triglycerides; DHEA was positively related to triglycerides in females ($P < 0.01$). The authors concluded that DHEA and/or its hormone products are important in modulating energy expenditure and lipid utilization for energy in male animals.

Qureshi *et al.* (2001) evaluated the effects of novel tocotrienols on lipid metabolism in swine expressing hereditary hypercholesterolaemia. Fifteen 4-month-old genetically hypercholesterolaemic swine were divided into five groups and four groups were fed a corn-soyabean control diet, supplemented with 50 µg of either TRF25, gamma-tocotrienol, d-P21-T3 or d-P25-T3 per g for 6 weeks. Group five was fed the control diet for 6 weeks. After 6 weeks, serum total cholesterol was reduced 32-38%, low density lipoprotein cholesterol was reduced 35-43% and triglycerides were reduced 15-19% in the treatment groups relative to the control.

Norman and LeVeen (2001) suggest that gestational diet may alter the body's management of cholesterol later in life, possibly providing a protective effect from atherosclerosis. They came to this conclusion after conducting feeding trials on sows with an atherogenic diet and standard diet throughout gestation

2.7 BIOCHEMICAL PARAMETERS

Southern and Clawson (1979) found that in pigs with an average weight of 53 kg at the start of the trial, average daily gain was reduced linearly by aflatoxin in feed at 385-1480 mu g/kg. Feed efficiency was significantly reduced by 1480 mu g/kg but not by lower levels. Total serum proteins, albumin and IgG fraction were not affected by aflatoxin, but IgM fraction was increased in pigs given 750 and 1480 mu g/kg. Liver weight was increased in pigs given 385-1480 mu g/kg.

Travnicek and Mandel (1982) found that total serum proteins were lower in germfree than in conventionally reared piglets for the first four weeks of life, but reached the same level at seven weeks. Serum albumin was higher for the first three days, decreased to the fourth week, and then rose above that of conventional piglets by the end of the 98-day experiment. Alpha globulins appeared in conventional pigs for the first 14 days only, but persisted for 49 days in germfree animals. No gamma globulins were found in germfree piglets, but levels rose rapidly in normal animals after ingestion of colostrum.

Reference values of serum constituents were determined in 33 gestating and 13 lactating swine by Reese *et al.* (1984). Serum concentrations of calcium, glucose, cholesterol, total protein, and globulin were lower during gestation than during lactation. Concentrations of triglycerides was higher during gestation than during lactation.

Results from 29 litters of pigs were analysed by Stone and Leymaster (1985) to estimate the relationships of birth weight and pre-nursing concentrations of serum albumin to survival and daily gain from birth to 14 days and from 14 to 28 days. Means and standard deviations of birth weight and serum albumin were calculated within each litter and used as analytical units. Positive linear partial regression coefficients were detected for effects of serum albumin on birth weight ($P < 0.01$) and daily gains ($P < 0.05$). Fitting birth weight and serum albumin simultaneously into the statistical model accounted for 57% of the variation in survival. It was speculated that use of a marker of physiological maturity, such as pre-nursing concentrations of serum albumin, might facilitate selection for survival.

Vitic *et al.* (1988) studied the concentrations of total proteins and relative contributions of the protein fractions separated by paper electrophoresis and concluded that they do not differ between gilts, sows and boars (with the exception of gilt albumin and gamma globulin) under physiological conditions. Pigs have concentrations of total lipoproteins, beta lipoproteins, serum cholesterol and phospholipid significantly lower than man, but they are within the normal limits for lipid and lipoprotein in domestic animals.

Heath *et al.* (1991) collected blood samples from 88 healthy, conventionally managed sows from 6 breeding herds of known disease status in eastern England, representing appropriate ranges for this class of swine. The samples were collected throughout the year. The values differed from earlier reports principally in higher mean values for total bilirubin (5 µmol/litre), and more particularly of total plasma (82.4 g/litre) and serum proteins (88.0 g/litre). The authors concluded that the latter may be due to higher immunoglobulin concentrations than those previously reported.

Zuric and Stankovic (1992). examined blood samples from 50 pigs at 30, 135 and 217 days of age. Increases in total bilirubin to 6.4-9.1 µmol/litre were found in 3, 6 and 15 pigs at these ages, respectively. The total protein concentrations remained within physiological limits. Moderate to severe pathological changes were found at slaughter in all pigs; these included interstitial hepatitis, disseminated miliary hepatitis, hyperaemia, atherosclerosis, bile duct hyperplasia, and lobular atrophy

Gao DeYi *et al.* (1996)concluded that total serum protein and globulin concentrations increased at the end of transportation, but were reduced 1-5 days later. The changes in serum albumin, glucose, cholesterol, inorganic phosphorus, cortisol and lactic acid were not significant.

Taranu *et al.* (2001) fed weaned piglets for 35 days on a basal diet. Aflatoxin (from Aspergillus niger) was given to some groups with or without supplementation with vitamins and selenium to counteract the effects of the mycotoxin. No clinical signs or adverse effects on growth or development were seen in the piglets given aflatoxin, but food intake was slightly lower, irrespective of feed supplementation. Piglets given the feed containing aflatoxin had increased serum albumin levels.

2.8 HOUSING

Skoknic *et al.* (1969) reported that there was no significant difference in live weight gain, feed consumption and feed conversion efficiency due to floor space restriction. Cornego *et al.* (1971) also found no significant difference among different stocking density groups in weight gain, food intake or efficiency of food conversion, during autumn and winter period.

Plumlee *et al.* (1976) found that gains up to 68 kg were not affected by floor space per pig (0.43 vs 0.63 m^2) but were reduced at 0.43 m^2 level during 68 to 100 kg phase. Increasing pig density reduced feed conversion efficiency after pig reached 68 kg.

Mitchel *et al.* (1983) reported that there were no significant difference in growth rate and feed conversion efficiency due to differences in stocking rate. It was concluded that a stocking rate of 10 pigs per pen was found to be best (0.49 m^2 per pig).

Several workers have reported that as space is restricted, it gives only lesser chance for the animal to move around and therefore less energy was utilized for body activity and hence increased feed conversion efficiency (Morrison, 1984; Mc Donald *et al.*, 1987).

Hunt (1988), reported a non significant effect of floor space and feed intake, body weight, weight gain, feed: gain ratio whereas a significant difference in feed consumption per kg live weight on two levels of stocking rate was reported by Jacob *et al.* (1988).

The partitioning of dietary energy away from tissue deposition and towards the metabolic processes occurring during exercise reduces the rate of average daily gain (Petherick, 1989).

In a study related to the floor space requirements of pigs, Leena (1992) observed no significant difference in the performance of pigs having floor space as per ISI specifications and where the floor space reduced to the extent of 50 per cent.

Joseph Mathew (1997) suggested that environmental enrichments were found to be beneficial for most of the traits such as body weight, daily weight gain, feed conversion efficiency, conception rate, live litter size at birth, litter weight at weaning and average weaning weight.

Ramesh (1998) observed that reproductive performance of pigs maintained under sprinkler and range system was found to be better than the pigs maintained under conventional system. But the range system may not be practical and economically feasible always when compared to sprinkler system.

In a study conducted among pig farmers in peri-urban settings of Zaria, in Northern Nigeria, Duru *et al.* (1999) observed that 65 per cent of them used mud houses for pig production.

In a comparative study between the conventional housing systems and deep litter systems of pigs, Weghe *et al.* (1999) found no significant difference between growth performance and other characteristics. Pigs in deep litter system spent a large portion of time manipulating parts of the pen, but in fully slatted pen pigs spent more time manipulating the other pigs and had significantly higher injury scores.

Jain and Bajpai (2000) noted that Kachcha or paddy husk flooring may be preferred over cement concrete or paddy straw flooring for raising piglets as it resulted in significantly faster growth, lowest incidence of mange and minimum hoof abnormalities with higher feed efficiency.

2.9 ECONOMICS

Feed cost formed the major component in pig production (Selvakumar *et al.*, 1993). They accounted 72.25 per cent in small units with sows less than six and 79.58 per cent in large units with sows more than six. They also observed that return per rupee of investment was Rs.1.17 for small unit and Rs.1.38 for large unit.

Ravi and Krishna Reddy (1997) reported that compared to balanced ration, cost per kg of gain in crossbred Large White Yorkshire pigs can be reduced by 40 per cent on garbage feeding.

The total economic cost was negatively correlated and net return positively correlated with the farm size (Sharma *et al.*, 1997). The average net return for large herds (more than 75 sows) was higher than for small (less than 25 sows) and medium herds (25 to 75 sows).

Rajiv Jain and Pandey (1998) found that in different systems of feeding pattern, the net return per pig under exclusively hotel waste feeding category was the highest in medium and large size farms. They also concluded that amongst different systems of feeding, the annual total working cost per pig was the highest under cereals-vegetables-fodder, molasses category in small farmers, cereals-vegetables-fodder in medium farmers category and exclusively hotel waste under large farmer category.

Ashok Kumar *et al.* (2000) found that the feed cost per unit gain in body weight was lowered by 9.5% on diet containing soybean and 6.08% on soybean supplemented with lysine and methionine compared to fishmeal containing diet.

The cost of production of one kg live weight in Khasi local, Hampshire and upgrading pigs as Rs.61.75, Rs.35.75 and Rs.35.75 respectively (Bujarbaruah and Rohilla, 2000).

Hati *et al.* (2000) used marua (Eleusine coracana) at different levels to substitute maize as a source of energy from conventional feeds to bring down cost of production. The cost per kg of weight gain when standard diet (18.19% protein with 60% maize) was given was Rs.15.05. In the other groups when maize was replaced with marua at 33.3, 66.6 and 100% w/w the cost per kg of weight gain was Rs.13.57, 11.19 and 9.79 respectively.

Rearing pigs entirely on concentrate feed was uneconomical, but the integration of fish and vegetable to the production could improve the productivity of such systems with the improvement in overall economic efficiency (Suraj, 2000).

Yadav *et al.* (2001) supplemented conventional feed with different levels of rice polish to bring down cost of production. Control group (T1) was fed with conventional concentrate mixture. The experimental group T2, T3 and T4 were fed diets containing 70, 75 and 80% of rice polish. The protein of T2 was met through both GNC and Soya flake where as T3 from GNC alone and T4 Soyflake alone. The cost per kg gain in rupees was 34.55 for the control group and 34.99, 36.39 and 40.06 for the other three treatments.

Materials and Methods

3. MATERIALS AND METHDOS

3.1 LOCATION

The research work to assess production performance and economics of Large White Yorkshire and crossbred (75% Large White Yorkshire x 25% Desi) pigs under different management conditions was carried out at Centre for Pig Production and Research (CPPR), Mannuthy, Thrissur and Kaiparambu and Kuzhoor panchayats in Thrissur district of Kerala. Both these panchayats have field piggery units supplied through National Agricultural Technology Project (NATP). The Kaiparambu panchayat is eight kilometer away from Thrissur town towards north and Kuzhoor panchayat is located about 45 km south west to Thrissur town. The geographical location of Thrissur is as follows:

Longitude	-	76.16"E
Latitute	-	10.32" N
Altitude	-	22.25 meter above MSL

The duration of the study was for a period of six months from June 2002 to November 2002.

3.2 EXPERIMENTAL ANIMALS

Samples of Large White Yorkshire (LWY) and crossbred pigs (CB) belonging to Centre for Pig Production and Research (CPPR) were utilized for the study.

Forty two weaned piglets each from Large White Yorkshire and crossbreds were selected uniformly as far as possible with respect to age, sex and body weight. Male piglets were castrated before the study.

Twelve piglets were randomly selected from each of the above mentioned two genetic groups and were maintained in the feeding and management conditions prevailing in CPPR for a period of six months formed the control group of the study.

The remaining thirty weaned piglets from each genetic group were randomly allotted to 10 farmers in the field in such a way that each farmer got a minimum of three Large White Yorkshire and three crossbred piglets. These animals were also maintained for the same period of time of six month.

Thus the four treatment groups were:

T1 - CB piglets (75% LWY) maintained in CPPR Mannuthy under the existing feeding and management conditions prevailing in the farm.

T2 - LWY piglets maintained in CPPR Mannuthy under the existing feeding and management conditions prevailing in the farm.

T3 - CB piglets (75% LWY) maintained under feeding and management conditions prevailing in the field. The feed consisted mainly of chicken offal from slaughter houses, restaurant/hotel wastes and vegetable wastes. The pig sties had concrete floors and side walls with cement bricks.

T4 - LWY piglets maintained under feeding and management conditions prevailing in the field. The feed consisted mainly of chicken offal from slaughter houses, restaurant/hotel wastes and vegetable wastes. The pig sties had concrete floors and side walls with cement bricks.

On attaining eight months of age all the pigs from control group (T1 and T2) and representative sample from the field group (T3 and T4) were slaughtered at the Meat Technology Unit, College of Veterinary and Animal Sciences, Mannuthy. Growth performance, carcass characteristics and economics were assessed in all the four groups.

Table 3.1. Quantity of feed given to farm animals at CPPR (T1 and T2)

Age group (months)	Quantity (kg)	CP (%)
2-3	1.00	18
3-4	1.25	18
4-5	1.50	18
5 and above	1.75	14

Table 3.2. Ingredient composition of grower and finisher ration given to farm animals

Ingredients	Grower ration (weaning to 5 months)	Finisher ration (5 months to slaughter)
	18% CP	14% CP
Maize	42	31
Rice polish	17.5	26.5
Wheat bran	17	7
Groundnut cake	12	7
Fish	10	8
Mineral mixture	1	1
Salt	0.5	0.5

Note: Vitamin supplement added @ 10 gram per 100 kg feed mixed

INDOMIX – A, B2, D3, K (Nicholas Piramal India Ltd., Mumbai) containing Vitamin A – 40,000 IU, Vitamin B2 – 20 mg, Vitamin D3 – 5,000 IU per gram

3.3 GROWTH PERFORMANCE OF PIGS

3.3.1 Monthly Body Weights

Body weights were measured by using a spring balance in field units and by a platform balance with a built in cage in farm units.

3.3.2 Monthly Calculated Body Weight

During the fifth month after weaning some of the animals in the field could not be weighed using a spring balance and hence a formula was developed based on the length and girth and known body weight of the corresponding animals in the farm.

3.3.3 Monthly Body Measurements

Body measurements like body length, girth and height were measured monthly.

3.3.3.1 Body Length

An imaginary line was projected from the anterior border of the shoulder joint of one side to the same border of the other side and the point of bisection of this line in the mid dorsal line was taken as the anterior land mark. Similarly an imaginary line was projected from the mid point of the external aspect of the hock joint of one side to the same point of the other side and point of bisection of this line in the mid dorsal line was taken as the posterior land mark. The distance in centimeter between these two land marks was taken as the body length.

3.3.3.2 Body Girth

The circumference of the body just behind the elbow joint was taken in centimeter as the body girth.

3.3.3.3 Height

Height of the animal was measured in centimeters at the dorsal border of the scapula.

3.3.4 Average Daily Weight Gain of Pigs

Average daily weight gain of pigs were calculated by the following formula (Brody, 1945).

$W = W_2 - W_1/T_2 - T_1$ where

W_1 – Initial body weight T_1 – Initial time unit

W_2 – Final body weight T_2 – Final time unit

3.3.5 Average Daily Feed Intake

Average daily feed intake was calculated by considering the feed consumed and the number of days fed in both fresh weight and dry matter basis.

3.3.6 Feed Conversion Efficiency of Pigs

Feed conversion efficiency of pigs in the four treatments were worked out on dry matter basis of feed.

3.3.7 Proximate Analysis of Feed Sample

Representative pooled samples from all types of feed viz. Hotel waste, concentrate ration, chicken offal and vegetable waste were analysed for proximate principles (A.O.A.C. 1990).

3.3.8 Amino Acid Analysis of Feed Sample

The amino acid content of feed stuffs were determined in a high pressure liquid Chromatography (HPLC) using pre-column derivatisation with Phenyl isothiocyanate (PITC).

3.3.9 Carcass Characteristics of Pigs

All the animals of control group and representative sample from field groups were slaughtered at the end of the experiment for evaluation of their carcass traits. Pigs were given sufficient rest prior to slaughter and they were slaughtered by standard procedure at Meat Technology Unit, College of Veterinary and Animal Sciences, Mannuthy.

3.3.9.1 Slaughter Weight

Slaughter weight of pigs at eight months of age was measured.

3.3.9.2 Dressing Percentage

Dressing percentage was calculated using the formula

$$\frac{\text{Carcass weight}}{\text{Live body weight}} \times 100$$

3.3.9.3 Carcass Length

Carcass length was measured as the straight line distance from the anterior edge of the first rib to the pubic symphysis from the shackled carcass (Krider and Carroll, 1971).

3.3.9.4 Loin Eye Area

The loin eye area or the area of the longissimus dorsi muscle of 10^{th} intercostal space was cut and traced on a transparent paper and the area was measured by plotting the trace surface on graph paper.

3.3.9.5 Back Fat Thickness

The back fat thickness was estimated as an average thickness of fat measured at first rib, last rib and last lumbar vertebral region and expressed in centimeters as backfat thickness.

3.3.9.6 Meat Bone Ratio

Ratio between deboned meat and bone was measured to calculate the meat bone ratio.

3.3.9.7 Weight of Offals

Weight of offals like kidney, lungs, stomach and intestine, liver and spleen were recorded separately.

3.3.10 Serum Lipid Profile

Twelve hours after fasting the animals serum was analysed for Triglycerides, cholesterol and HDL (high density lipoproteins) cholesterol using Agappe kits, spectrophotometer (Spectronic 1001 plus, Milton Roy, USA).

3.3.11 Biochemical Parameters

Serum total protein, Albumin, globulin and bilirubin total and direct were analysed by calorimetry using spectrophotometer.

3.3.12 Serum Minerals

Serum calcium, magnesium, copper and zinc were found out by Atomic Absorption Spectrophotometry (Perkin Elmer 3/10) using hollow cathode tubes. Serum phosphorus content was analysed by calorimetry using spectrophotometer.

3.3.13 Housing of Pigs

Type of housing in the field conditions was analysed.

3.3.14 Economics

Cost of production per kilogram live body weight of pigs and economics in all the four treatment groups were worked out.

3.3.15 Statistical Analysis

The data were statistically analyzed using the standard procedure suggested by Snedecor and Cochran (1985).

Results

4. RESULTS

Results obtained in the study are presented in Tables 4.1 to 4.22 and Fig.1 to 17.

Table 4.1 Mean monthly body weight of pigs under different management conditions

Age (months)	Farm		Field	
	T_1 (CB)	T_2 (LWY)	T_3 (CB)	T_4 (LWY)
2	10.2 ± 0.91	11.4 ± 0.67	10.87 ± 0.82	10.87 ± 0.47
3	15.3 ± 1.05	17 ± 0.62	18.2 ± 0.94	16.87 ± 0.67
4	22.53 ± 1.92	24.8 ± 1.27	25.69 ± 0.69	25 ± 0.89
5	28.7^{A} ± 1.82	33.45 ± 1.21	37.87^{B} ± 1.12	36.81 ± 0.10
6	38.55^{Aa} ± 2.63	43.1^{A} ± 1.51	46.06^{b} ± 1.13	51.69^{Ba} ± 2.09
7	44.5 ± 2.69	50.9 ± 1.78	55.06 ± 1.25	60.81 ± 2.43
8	55.4^{A} ± 3.45	60.1^{A} ± 2.08	66.37^{B} ± 1.46	72.25^{B} ± 2.77

Figures having different superscript in upper case in a row are significantly different (P<0.01)
Figures having different superscript in lower case in a row are significantly different (P<0.05)

Table 4.2 Average monthly gain of pigs under different management conditions in kilogram

Age months	Farm		Field	
	T_1 (CB)	T_2 (LWY)	T_3 (CB)	T_4 (LWY)
3	5.1 ± 0.4	5.8 ± 0.28	6.13 ± 0.39	6.0 ± 0.31
4	7.23 ± 0.04	6.6 ± 1.11	8.69 ± 0.74	8.13 ± 0.25
5	6.17^{A} ± 0.51	8.65^{A} ± 1.2	11.18 ± 0.31	11.81^{B} ± 0.62
6	9.85^{A} ± 1.13	9.65 ± 0.38	9.19 ± 0.83	14.86^{B} ± 1.52
7	5.95 ± 0.62	7.8 ± 0.28	9.0 ± 0.56	9.13 ± 0.36
8	10.9 ± 0.84	9.2 ± 0.32	11.31^{B} ± 0.89	11.44 ± 0.39
Mean	7.53 ± 0.24	7.95^{A} ± 0.44	9.25 ± 0.28	10.23^{B} ± 0.34

Figures having different superscript in upper case in a row are significantly different (P<0.01)

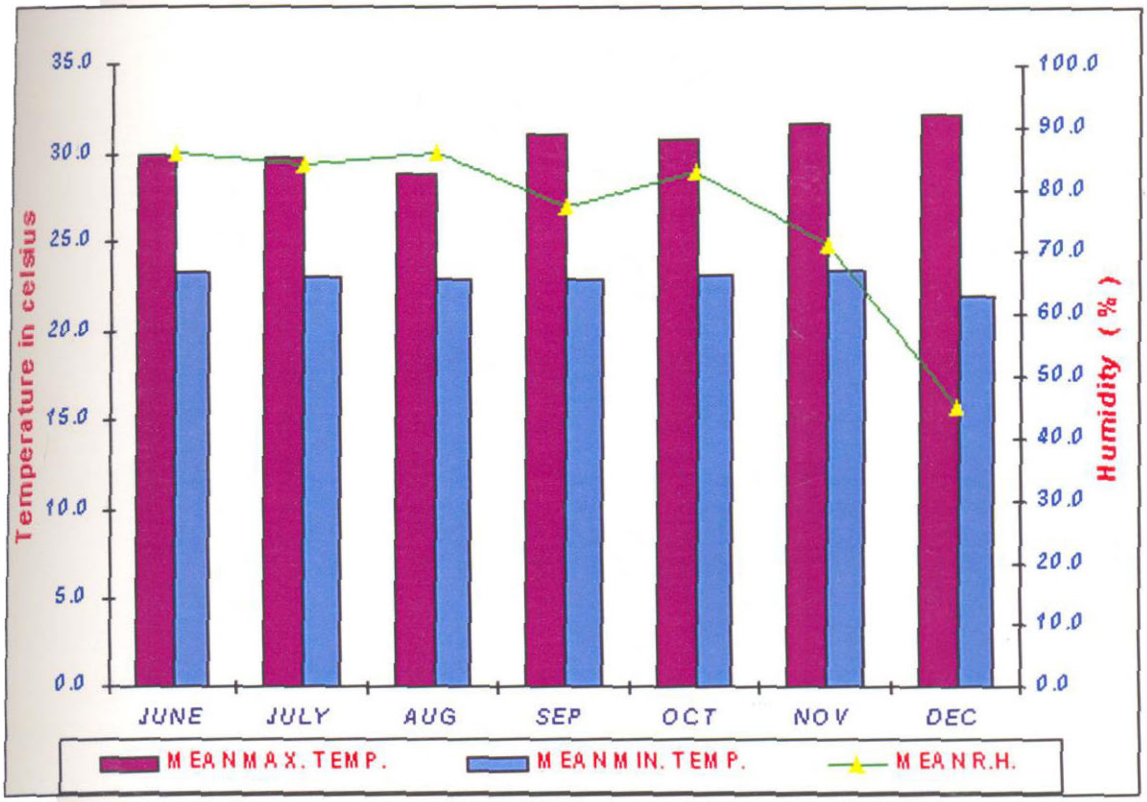

Fig 1. Mean temperature and humidity during the study period

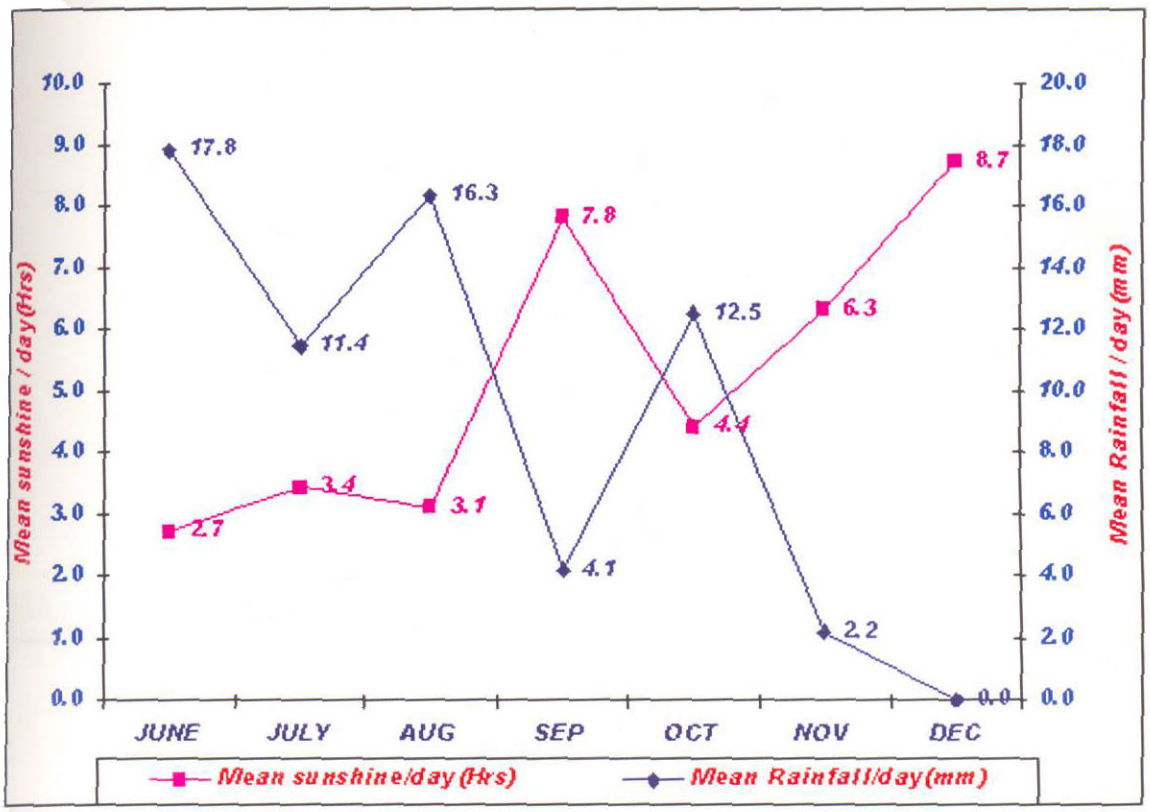

Fig 2. Mean rainfall and sunshine during the study period

Fig 3. Weighing of a pig under field condition.

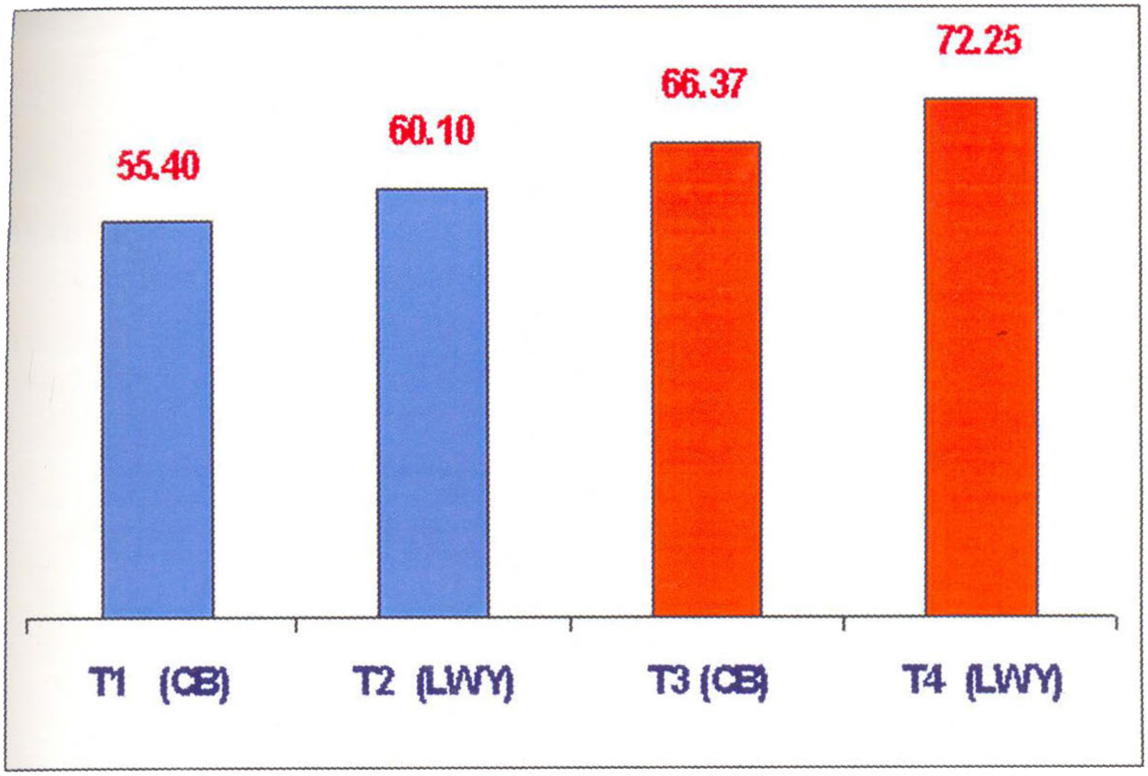

Fig 4. Slaughter weight of pigs in four treatment groups

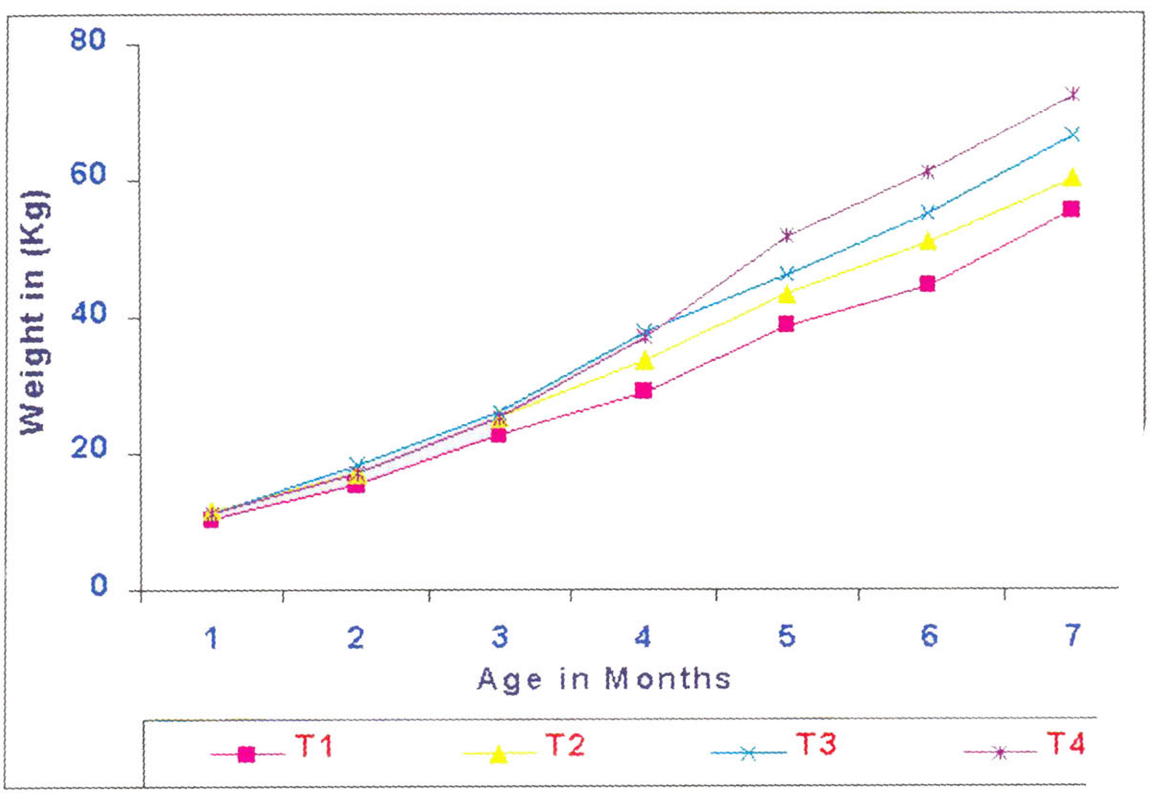

Fig 5. Mean monthly body weight of pigs in four treatment groups.

Table 4.3 Growth rate expressed as percentage of previous months

Age (months)	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
3	50	50.8	56.4	55.2
4	47.2	38.8	47.7	48.2
5	34.3	34.8	43.5	47.2
6	27.3	28.8	24.2	40.3
7	15.4	18	19.5	17.6
8	24.5	18	19	18.7

Table 4.4 Average daily gain of pigs under different management conditions in grams

Age (months)	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
3	170 ± 12.12	193 ± 15.9	204 ± 12.01	200 ± 36.12
4	241 ± 11.22	220 ± 14.80	290 ± 10.12	271 ± 34.12
5	206^A ± 20.00	288^A ± 12.22	377^B ± 24.22	394^B ± 44.22
6	328^A ± 14.12	323 ± 10.88	306^A ± 16.48	495^B ± 14.25
7	198 ± 20.22	260 ± 11.12	300 ± 12.24	304 ± 43.22
8	363 ± 10.12	307 ± 10.22	373 ± 22.22	381 ± 44.12
Mean	251 ± 11.09	265^A ± 13.23	308 ± 16.04	341^B ± 14.24

Figures having different superscript in upper case in a row are significantly different ($P<0.01$)

Table 4.5 Daily average feed in take

Age (months)	Concentrate feed (farm)		Swill feeding (field)			
			(T_3) C.B. pigs		(T_4) L.W.Y. pigs	
	FW	DM	FW	DM	FW	DM
3	1.00	0.89	1.08	0.29	1.12	0.30
4	1.25	1.11	3.00	0.81	3.10	0.84
5	1.5	1.33	4.00	1.08	4.11	1.11
6	1.75	1.56	5.8	1.57	6.2	1.67
7	1.75	1.56	6.5	1.76	6.7	1.81
8	1.75	1.56	7.22	1.95	7.7	2.07
Mean	1.5 ± 0.1	1.34 ± 0.20	4. 60 ± 0.86	1.24 ± 0.21	4. 83 ± 0.88	1.30 ± 0.12

FW - Fresh weight basis in kg
DM - Dry matter basis in kg

Table 4.6 Feed conversion efficiency of pigs under different management conditions on dry matter basis

Age (months)	Concentrate feed (farm)		Swill feeding (field)	
	CB	LWY	CB	LWY
3	5.24 ± 0.10	4.62 ± 0.21	1.42 ± 0.33	1.51 ± 0.21
4	4.62 ± 0.10	4.56 ± 0.22	2.79 ± 0.34	3.09 ± 0.24
5	6.46 ± 0.24	4.63 ± 0.87	3.53 ± 0.48	2.24 ± 0.31
6	4.74 ± 0.56	4.82 ± 0.28	4.19 ± 0.52	4.25 ± 0.22
7	7.85 ± 0.20	5.98 ± 0.34	5.85 ± 0.55	5.95 ± 0.42
8	4.28 ± 0.67	5.06 ± 0.58	5.16 ± 0.61	5.94 ± 0.50
Mean	5.53^{A} ± 0.22	4.94^{A} ± 0.52	4.02^{B} ± 0.85	3.91^{B} ± 0.59

Figures having different superscript in upper case in a row are significantly different (P<0.01)

Table 4.7 Mean monthly body length of pigs under different management conditions (cm)

Age months	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
2	28.78 ± 0.95	30.61 ± 0.74	30.25 ± 0.55	31 ± 1.21
3	38.28 ± 1.26	40.11 ± 1.19	39.06 ± 1.06	39.78 ± 1.34
4	48.33 ± 1.13	50.5 ± 1.00	50.12 ± 0.85	50.93 ± 1.22
5	54.11^{a} ± 1.40	57.89 ± 1.19	58.75^{b} ± 1.16	57.86 ± 1.32
6	60.05^{a} ± 1.40	65.39^{b} ± 1.19	63.94^{b} ± 1.12	65.43^{b} ± 1.32
7	64.11^{a} ± 1.56	70.17^{b} ± 1.31	69.37^{b} ± 1.29	70.07^{b} ± 1.46
8	68.44^{a} ± 1.61	74.89^{b} ± 1.49	74.25^{b} ± 1.26	74.43^{b} ± 1.59

Figures having different superscript in lower case in a row are significantly different ($P<0.05$)

Table 4.8 Mean monthly body height of pigs under different management conditions (cm)

Age months	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
2	30.89 ± 0.89	31.57 ± 0.78	34.28 ± 1.27	33.5 ± 0.92
3	35.88 ± 0.58	36.14 ± 0.98	39.57 ± 0.84	38.06 ± 0.89
4	40.4 ± 1.16	42.21 ± 1.04	45.85 ± 1.70	44.81 ± 1.22
5	45 ± 1.31	48.07 ± 1.24	52.42 ± 1.90	51.19 ± 1.44
6	47.55 ± 1.43	50.86 ± 1.33	55.64 ± 2.07	54.64 ± 1.66
7	49.85^{A} ± 1.45	53.14 ± 1.32	57.71^{B} ± 2.05	56.56^{B} ± 1.47
8	51.35^{A} ± 1.80	54.93 ± 1.11	59.43^{B} ± 2.17	58.94^{B} ± 1.45

Figures having different superscript in upper case in a row are significantly different ($P<0.01$)

Fig 6. Poultry slaughter waste fed to pigs.

Fig 7. Plastic cans for transporting hotel waste.

Table 4.9 Mean monthly body girth of pigs under different management conditions (cm)

Age (months)	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
2	42 ± 0.79	41.8 ± 0.24	45.25 ± 0.46	45.5 ± 0.76
3	52.1 ± 0.94	51.55 ± 0.54	56.19 ± 0.63	56.25 ± 1.00
4	59.45 ± 1.17	59.1 ± 0.9	64.69 ± 0.58	65.5 ± 1.36
5	70.4 ± 1.52	68.8^{A} ± 0.61	74.69^{B} ± 0.73	75.31^{B} ± 1.46
6	74.8 ± 1.45	74.15 ± 0.86	81 ± 0.83	81.69 ± 1.54
7	81.3 ± 1,45	81.15 ± 0.70	87.56 ± 0.80	87.94 ± 1.51
8	85.4 ± 1.63	84.6 ± 0.87	92.37 ± 0.91	92.87 ± 1.64

Figures having different superscript in upper case in a row are significantly different ($P<0.01$)

Table 4.10 Proximate analysis of feed samples (dry matter basis)

Proximate principle	Concentrate	Chicken offal	Hotel waste	Vegetable waste
Moisture	10.21 ± 0.08	68.77 ± 0.2	74.69 ± 0.22	87.13 ± 0.33
Crude protein	16.85 ± 0.44	20.18 ± 4.65	9.22 ± 3.82	10.25 ± 2.22
Crude fibre	8.16 ± 0.20	7.2 ± 1.22	4.12 ± 0.83	8.82 ± 0.88
Ether extract	8.20 ± 0.47	40.2 ± 2.48	21.2 ± 1.88	22.32 ± 1.22
Ash	10.12 ± 0.18	4.82 ± 0.22	7.03 ± 0.21	7.38 ± 0.32
N.F.E	56.57 ± 0.8	27.6 ± 0.11	58.43 ± 0.24	51.23 ± 0.24
Acid insoluble ash	4.10 ± 0.08	1.24 ± 0.12	0.34 ± 0.88	1.79 ± 0.08

Table 4.11 Amino acid composition of different feeds fed to the animals (g/100 g crude protein)

Amino Acids	Concentrate feed	Chicken offal	Hotel waste	Vegetable waste
Aspartic acid	7.78	7.57	6.82	9.36
Glutamic acid	12.94	9.20	13.55	11.43
Serine	6.05	5.67	5.76	6.05
Glycine	11.76	12.57	11.12	9.49
Histidine	1.68	1.32	1.91	1.70
Arginine	5.25	4.44	5.19	3.29
Threonine	3.36	4.61	3.97	4.47
Alanine	8.14	10.46	8.35	12.50
Proline	9.77	7.81	8.03	7.11
Ammonia	1.07	1.37	1.02	1.87
Tyrosine	3.66	1.82	4.11	3.37
Valine	4.70	6.13	5.16	5.70
Methionine	1.51	1.65	1.18	1.16
Cystine	0.43	0.48	0.45	0.15
Isoleucine	3.19	4.67	3.71	4.21
Leucine	8.23	7.71	8.38	7.35
Phenylalanine	4.66	3.44	5.20	4.36
Lysine	5.87	9.13	6.15	6.49
Tryptophan	4.27	3.51	7.68	9.88

Table 4.12 Essential amino acids concentration of different feed stuffs on dry matter basis, %

Amino Acids	Concentrate feed	Chicken offal	Hotel waste	Vegetable waste
Histidine	0.28	0.27	0.18	0.17
Arginine	0.88	0.90	0.48	0.49
Threonine	0.75	0.68	0.43	0.41
Valine	0.79	1.24	0.48	0.58
Methionine	0.25	0.33	0.11	0.14
Methionine + cystine	0.45	0.43	0.15	0.14
Isoleucine	0.54	0.94	0.34	0.43
Leucine	1.39	1.55	0.77	0.82
Phenylalanine	0.79	0.69	0.48	0.44
Phenylalanine + Tyrosine	1.40	1.06	0.86	0.79
Lysine	0.99	1.84	0.57	0.78
Tryptophan	0.72	0.71	0.71	1.01

Table 4.13 Excess/deficiency of essential amino acids of different feed stuffs

Amino Acids	NRC standards (20 to 50 Kg)	Excess/deficiency in percentage			
		Concentrate feed	Chicken Offals	Hotel waste	Vegetable waste
Histidine	0.25	13.23	6.55	**-29.56**	**-33.79**
Arginine	0.31	185.09	189.03	54.21	59.12
Threonine	0.46	63.74	47.40	**-7.60**	**-11.54**
Valine	0.51	55.12	142.56	**-6.81**	13.40
Methionine	0.21	20.76	58.08	**-48.41**	**-31.18**
Methionine + cystine	0.44	2.27	**-2.31**	**-65.84**	**-68.32**
Isoleucine	0.42	27.78	124.38	**-18.56**	2.26
Leucine	0.8	73.34	94.36	**-3.48**	3.01
Phenylalanine	0.46	70.70	50.69	4.23	**-3.79**
Phenylalanine + Tyrosine	0.72	94.71	47.43	19.22	10.05
Lysine	0.77	28.34	139.15	**-26.36**	1.67
Tryptophan	0.13	453.46	444.86	444.69	679.00

Table 4.14 Excess/deficiency of essential amino acids of different feed stuffs

Amino Acids	NRC standards (50 to 80 Kg)	Excess/deficiency in percentage			
		Concentrate feed	Chicken Offals	Hotel waste	Vegetable waste
Histidine	0.20	41.54	33.19	**-11.95**	**-17.23**
Arginine	0.22	301.72	307.27	117.30	124.22
Threonine	0.37	103.57	83.26	14.88	9.98
Valine	0.41	92.95	201.72	15.92	41.06
Methionine	0.17	49.17	95.27	**-36.27**	**-14.99**
Methionine + cystine	0.36	25.00	19.40	**-58.25**	**-61.28**
Isoleucine	0.34	57.84	177.18	0.61	26.32
Leucine	0.64	116.68	142.95	20.65	28.77
Phenylalanine	0.37	112.22	87.35	29.58	19.61
Phenylalanine + Tyrosine	0.58	141.71	83.01	48.00	36.61
Lysine	0.61	62.01	201.87	**-7.04**	28.34
Tryptophan	0.10	619.50	608.32	608.10	912.70

Table 4.15 Carcass characteristics of CB and LWY pigs in different management conditions

Characters	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
Slaughter weight (kg)	55.09 ± 2.31^{A}	57.75 ± 2.21^{A}	66.38 ± 2.71^{B}	72.13 ± 2.71^{B}
Carcass length (cm)	56.30 ± 1.12	58.21 ± 1.03	58.61 ± 1.18	60.58 ± 1.18
Back fat thickness (cm)	$2.61^{A} \pm 0.17$	$2.47^{A} \pm 0.16$	$3.70^{B} \pm 0.18$	$3.60^{B} \pm 0.18$
Loin Eye area (cm^2)	21.76 ± 1.21	20.73 ± 1.11	17.84 ± 1.35	20.64 ± 1.35
Hot carcass weight (kg)	$38.24^{A} \pm 1.62$	$38.41^{A} \pm 1.48$	$47.48^{B} \pm 1.81$	$50.65^{B} \pm 1.81$
Dressing percentage	67.92 ± 1.86	$65.76^{A} \pm 1.46$	$71.41^{B} \pm 2.12$	69.82 ± 1.12
Hot de boned meat (kg)	28.77 ± 1.88	29.08 ± 0.88	39.50 ± 1.46	42.30 ± 2.01
De boned meat (%)	$52.25^{A} \pm 0.56$	$50.62^{A} \pm 0.42$	$59.57^{B} \pm 0.75$	55.72 ± 0.44
Meat bone ratio	$5.37^{A} \pm 1.88$	$5.44^{A} \pm 0.88$	$6.72^{B} \pm 1.46$	$6.30^{B} \pm 0.24$

Figures having different superscript in upper case in a row are significantly different ($P<0.01$)

Table 4.16 Weight of offal in different groups expressed as percentage of body weight

Organ	Farm		Field	
	T_1	T_2	T_3	T_4
Kidney	0.29 ± 0.14	0.28 ± 0.23	0.26 ± 0.21	0.28 ± 0.17
Spleen	0.21 ± 0.19	0.20 ± 0.18	0.22 ± 0.23	0.21 ± 0.11
Lungs	1.45 ± 0.21	1.42 ± 0.29	1.42 ± 0.21	1.20 ± 0.18
Stomach and intest	14.16 ± 0.19	15.09 ± 0.15	11.19 ± 0.19	11.11 ± 0.20
Liver	1.42 ± 0.22	1.44 ± 0.21	1.54 ± 0.18	1.53 ± 0.25
Bone	9.83^{A} ± 0.21	9.35 ± 0.17	8.86^{B} ± 0.12	8.80^{B} ± 0.23

Figures having different superscript in upper case in a row are significantly different (P<0.01)

Table 4.17 Serum mineral concentration under different management conditions after 12 hour fasting

Minerals	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
Calcium (mg/dl)	8.23 ± 0.54	8.54 ± 0.51	8.62 ± 0.51	8.64 ± 0.49
Phosphorus (mg/dl)	7.34 ± 0.44	7.26 ± 0.42	6.50 ± 0.49	6.31 ± 0.46
Magnesium (mg/dl)	2.00 ± 0.16	1.73 ± 0.15	1.58 ± 0.18	1.60 ± 0.17
Copper (ppm)	1.85^{A} ± 0.18	1.68^{A} ± 0.17	0.94^{B} ± 0.20	1.00^{C} ± 0.20
Zinc (ppm)	1.25 ± 0.09	1.23 ± 0.09	1.00 ± 0.10	1.00 ± 0.10

Figures having different superscript in upper case in a row are significantly different (P<0.01)

Table 4.18 Serum lipid profile of pigs under different management conditions after 12 hours fasting

Item	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
Cholesterol (mg/dl)	80.33 ± 6.29	78.25 ± 5.99	86.10 ± 7.03	97.77 ± 6.63
Triglycerides (mg/dl)	65.54^{A} ± 23.99	44.08^{B} ± 22.87	140.86^{C} ± 26.82	200.59^{D} ± 26.82
HDL (mg/dl)	25.98 ± 0.84	26.53 ± 0.80	27.15 ± 0.80	25.76 ± 0.77

Figures having different superscript in upper case in a row are significantly different ($P<0.01$)

Table 4.19 Biochemical parameters under different management conditions after 12 hours fasting

Item	Farm		Field	
	T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
Bilirubin (direct) (mg/dl)	0.17^{A} ± 0.08	0.12^{A} ± 0.08	0.51^{B} ± 0.08	0.38^{B} ± 0.07
Bilirubin total (mg/dl)	0.25^{A} ± 0.06	0.22^{A} ± 0.05	0.60^{B} ± 0.05	0.47^{B} ± 0.05
Albumin (g/dl)	4.27 ± 0.13	4.21 ± 0.13	4.24 ± 0.13	4.00 ± 0.12
Total protein (g/dl)	6.65 ± 0.23	6.58 ± 0.22	7.01 ± 0.22	6.59 ± 0.21
Globulin (g/dl)	2.39 ± 0.17	2.37 ± 0.16	2.77 ± 0.16	2.59 ± 0.15
A/G ratio	1.79	1.79	1.53	1.54

Figures having different superscript in upper case in a row are significantly different ($P<0.01$)

Table 4.20 Comparison of housing of animals under different management conditions

	Farm	Field
Covered area per animal (m^2)	1.5	1.4 ± 1.22
Uncovered area per animal (m^2)	3.5	Absent
Wallowing tank	Present	Absent
Concrete floor/side wall	Present	Present
Manger	Present	Absent
Roof	Asbestos sheets	20% tiles and 80% thatched roof

Formula to calculate body weight from body measurements

A formula was developed to calculate the body weight of pigs from the body length and girth at seventh month of age (five months after weaning) when it was difficult to weigh some animals in the field. Formula was derived based on the assumption that the shape of the pig resembles a cylinder. Volume of a cylinder is $\Pi r^2 h$, where r is the radius and h is the height of the cylinder. For the pig height of the cylinder is its length and radius is proportional to the chest girth (G). Hence the volume of a pig is proportional to G^2L. The weight of the pig therefore can be written as

$$W = a + b\,G^2L$$

The coefficient of correlation (r) and regression equation are given in Table 4.21.

Table 4.21 Coefficient of correlation and regression equation

Age (month)	r	Regression equation
7	0.88	$W = 5.05 + \dfrac{LG^2}{9335}$

Fig 8. Pig house with tiled roof

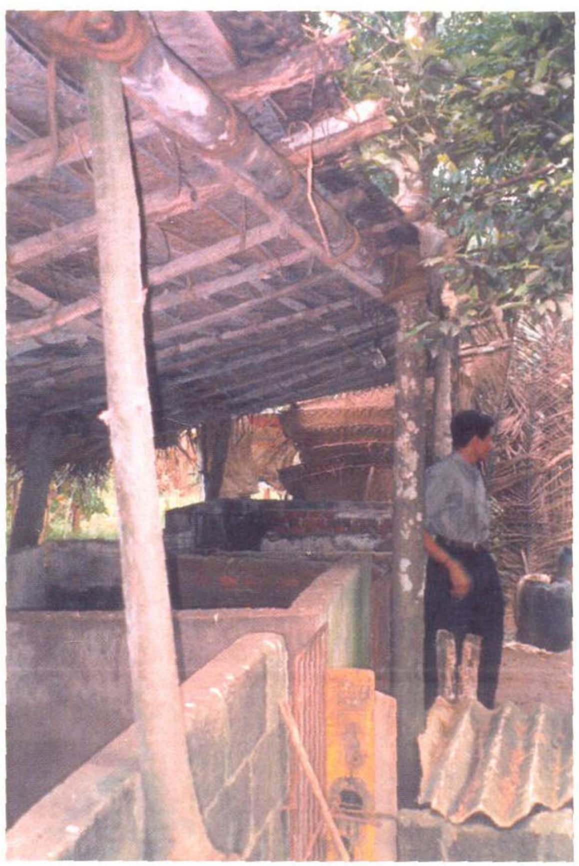

Fig 9. Pig house with thatched roof

Fig 10.

Fig 11.

Fig 10 & 11 Pig house with poor roofing

Fig 12.

Fig 13.

Fig 12 & 13 Pig houses with well-maintained thatched roof covered with polythene sheets

Fig 14.

Fig 15.

Fig 14 & 15 Field Pig houses without uncovered area.

Table 4.22 Cost of production of pigs (6 nos) each in different treatment groups in rupees

	Item	Farm		Field	
		T_1 CB	T_2 LWY	T_3 CB	T_4 LWY
	Capital Cost				
1.	Cost of housing	58,500	58,500	12,600	12,600
2.	Interest on capital @ 9%	2,632.5	2,632.5	567	567
	Operational Cost				
1.	Cost of piglets	4,800	7,200	5,280	6,600
2.	Cost of feed	11,666.8	11,666.8	2,482.2	2,602.8
3.	Labour charges	2,160	2,160	-	-
4.	Treatment charges	200	200	250	250
5.	Transportation charges	-	-	150	150
	Receipts				
1.	Sale of pigs @ Rs.30/kg live weight	9,972	10,818	11,946.6	13,005
2.	Cost of manure	250	250	100	100
	Cost of production				
1.	Total production cost	21,459.3	23,859.3	8,729.2	10,169.8
2.	Cost of production (per kg live weight)	64.56	66.16	21.92	23.45
3.	Profit/loss	**-11,237.3**	**-7,279.3**	3,317.4	2,935.2

Assumptions for calculating cost of production

1. In farm conditions cost of construction of covered area is Rs.300/sq.ft. and uncovered area Rs.150/sq.ft.
2. In field conditions cost of construction of shed is Rs.150/sq.ft.
3. Interest rate calculated at the rate of 9%
4. Cost of piglet is Rs.80/kg live weight for crossbreds and Rs.100/kg live weight for Large White Yorkshire piglets.
5. Cost of concentrate feed in farm is Rs.7.34/kg for grower ration and Rs.6.63/kg for finisher ration.
6. Cost of feed in field conditions is worked out at the rate of 50 ps./kg.
7. Labour charges is at the rate of Rs.120/men/day. He can take care of 60 piglets.

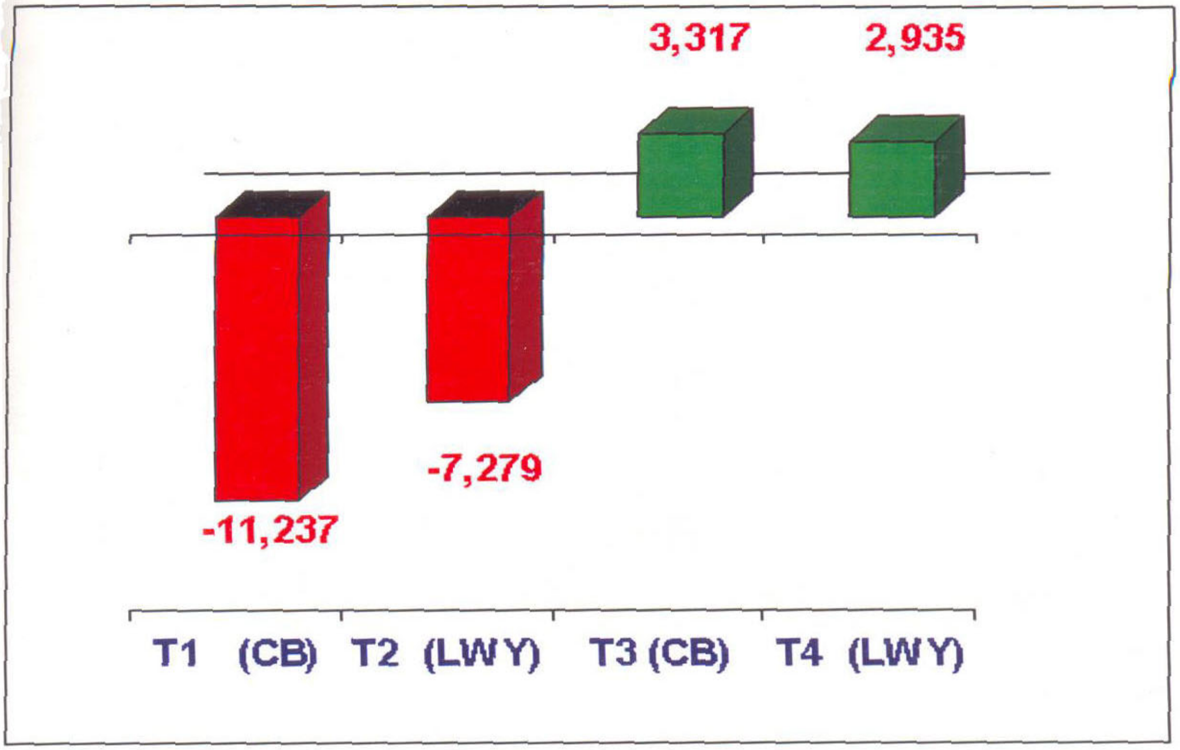

Fig 16. Economics of rearing six animals each in different treatment groups

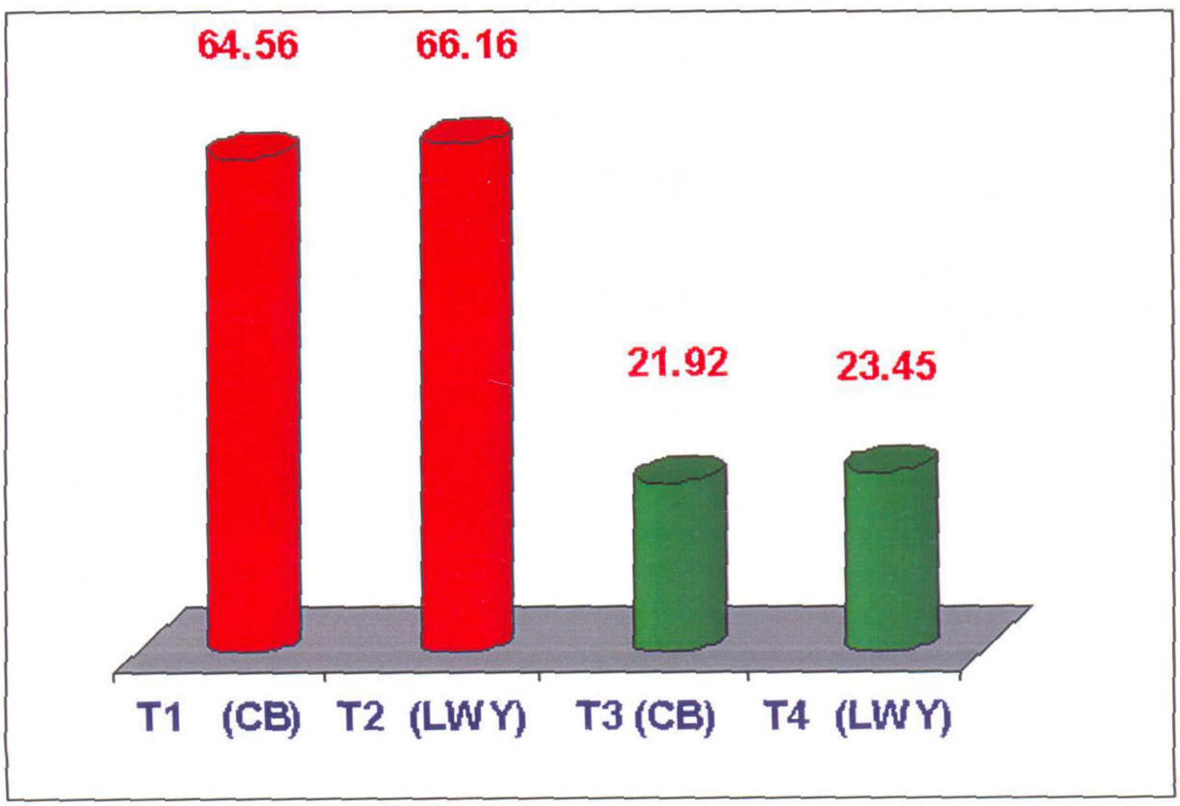

Fig 17. Cost of production of one Kg live weight in different treatments

Discussion

5. DISCUSSION

5.1 BODY WEIGHT

From table 4.1 it can be seen that both CB (T3) and LWY (T4) in the field attained more weight at slaughter ($P<0.01$) than their counterparts CB (T1) and LWY (T2) maintained in the farm on concentrate feed and the CB (T3) in the field had significantly ($P<0.01$) more weight than LWY (T2) in the farm conditions at slaughter. This is in agreement with Harikumar (2001) who has also recorded a higher slaughter weight for LWY pigs maintained on chicken offal and restaurant waste than those on concentrate feed. There was no significant difference between the genetic groups at slaughter in the farm as well as field.

At five months the CB (T3) in the field weighed significantly higher ($P<0.01$) than the CB (T1) in the farm and the trend continued in the sixth month also ($P<0.05$). On fifth month the CB (T3) performed better than the LWY (T2) on the concentrate feed eventhough there was no significant difference in the weight gain. But at the end of sixth month the LWY (T4) in the field weighed ($P<0.05$) more than the CB (T3). It can also be seen that the CB (T3) adapted faster with the new feeding after weaning and attained more body weight than CB (T1) and LWY (T2) of farm throughout the growth period. It was from sixth month LWY (T4) in the field showed an increased body weight ($P<0.01$) than CB (T3) and the trend continued till slaughter but without significant difference. This may be due to the improved genetic potential of LWY pigs.

Pigs were fed with chicken offal in the field which had a high CP of 20.18 ± 4.65 and the ether extract value was also higher 40.2 ± 2.48. Control pigs in the farm were not fed concentrate feed *ad libitum* but were maintained on CPPR ration. These might be the reasons for improved performance of T3 and T4 groups.

Since the final slaughter weight did not differ significantly between the two genetic groups under field managemental conditions it can be reasonably presumed that 75 per cent LWY cross is equally good as pure bred LWY pigs.

The LWY (T4) group had the highest average monthly gain of 10.23 ± 0.34 kg (Table 4.2) and was significantly higher ($P<0.01$) than 7.93 ± 0.44 kg LWY (T2) in the farm. The maximum monthly gain observed among the four groups was for LWY (T4) 14.86 ± 1.52 kg during the sixth month. The average monthly gain obtained in this study was higher than that of (More *et al.*, 1998) who recorded a growth rate of 5.7 kg and 5.5 kg for pigs reared in two areas of Philippines.

Growth rate expressed as percentage of previous month's weight (Table 4.3) was maximum in the third month (first month after weaning) in all the four groups. It declined gradually towards eighth month in all the treatments except for the CB (T1) in the farm which showed an increased (24.5%) growth during the eighth month than seventh month (15.4%). From fourth month to seventh month the LWY (T4) pigs in the field maintained a high percentage of growth rate. This supports the fact that the LWY pigs in the field attained more weight at slaughter.

5.2 AVERAGE DAILY GAIN

The mean average daily body weight gain of CB (T1) and LWY (T2) maintained on concentrate feed was 251.00 ± 11.09 and 265 ± 13.23 g respectively and that for CB (T3) and LWY (T4) in the field was 308 ± 16.04 and 341 ± 14.24 g (Table 4.4). The LWY (T4) in the field had significantly higher ($P<0.01$) average daily weight gain than LWY (T2) in the farm. There was no significant difference in the mean daily gain of CB (T3) in the field and CB (T1) in the farm. Similarly no significant difference was noticed between the two genetic groups in field and farm.

The CB (T3) in the field attained maximum daily gain of 377 ± 24.22 g during the fifth month and was significantly higher than ($P<0.01$) T1 and T2 during the same month. LWY (T4) in the field attained the maximum daily gain of 495 ± 14.25 g during the sixth month end. The data reveals that CB (T3) in the field attained maximum daily weight gain earlier than the LWY (T4). This trend can be supportive to the fact that crossbreds adapts faster than purebreds under field management conditions.

Harikumar (2001) recorded average daily gain of 318.98 ± 11.09 g and Rohilla *et al.* (2000) 335.45 ± 17.45 for LWY pigs which was higher than the values obtained in concentrate fed pigs in the present study. Whereas Singh *et al.* (1999) observed almost the same average daily gain for pigs on concentrate diet as this study.

The average daily gain obtained for pigs fed on unconventional feeds T3 and T4 in this study was higher than the values reported by Bhar *et al.* (2000) (294 ± 28.68 g) for wheat bran based diet, Yadav *et al.* (2001) (275.19 ± 10.22) for rice bran based diet and Ranjan (2003) (248.42 g) for hotel waste based diet. The high mean daily gain in the field may be due to high CP percentage and the fat available especially from chicken offal.

5.3 DAILY FEED INTAKE

The daily feed intake presented in Table 4.5 is same for T1 and T2 groups since both were fed on fixed CPPR rations. In the field both T3 and T4 groups showed a gradual increase in the dry matter intake from weaning to slaughter weight. On an average LWY (T4) pigs in the field consumed maximum feed at the rate of 4.83 ± 0.88 kg per day on fresh weight basis and on fresh basis LWY (T4) pigs consumed more feed than (T3) pigs throughout the period of study. This may be because the animals were exposed to *ad libitum* feeding whereas the controls were not. The gut capacity of the LWY pigs are high as reported by Joseph (1997) which may also have contributed to more fed intake than CB (T3). On dry matter basis the difference noted in daily feed intake between the treatment groups and between the breeds are found to be non significant. This result is in agreement with Shields and Mahan (1980) who observed no significant difference in feed intake fed with different levels of protein in the ration.

In the present study unconventional feed used mainly were chicken offal, hotel waste and vegetable waste. In the first two the dry matter content varied from 25 to 30 per cent whereas for vegetable waste it was as low as 13 to 15 per cent. The composition of the feed also changed daily and hence the animals consumed more to meet the dry matter requirement, which explains the high values of feed intake in T3 and T4 groups. The high intake of feed on fresh basis in the field is in agreement with results obtained by Harikumar (2001).

5.4 FEED CONVERSION EFFICIENCY

The average feed conversion efficiency was highest for the LWY (T4) in the field, 3.91 ± 0.59 and the lowest for CB (T1) in the farm 5.53 ± 0.22. Both the genetic groups had a significantly higher ($P<0.01$) feed conversion efficiency in the field than the animals fed on concentrate feed. The CB (T3) also had a high feed conversion efficiency of 4.02 ± 0.85 than T1 and T2 in the farm. But no significant difference in feed conversion efficiency was noticed between the two genetic groups in farm and field management conditions (Table 4.6).

The feed conversion efficiency observed in this study for the pigs maintained on concentrate feed was lower than the reports of Feng *et al.* (1985), Suraj (2000), Harikumar (2001), Ramakrishnan (2001) and Dinesh (2001).

The unconventional feed contained high CP, NFE and ether extract. This might be the reason for better FCR of field animals. Almost same FCR was reported by Harikumr (2001) on a 60 per cent chicken and 40 per cent hotel waste and Bhar *et al.* (2001) on deoiled rice bran based diets. Yadav *et al.* (2001) reported a much lower feed conversion efficiency than this study for a rice polish based ration.

5.5 BODY MEASUREMENTS

The average body length, height and body girth of the four groups are presented in Table 4.7, 4.8 and 4.9 respectively.

Significant difference in length was observed from fifth month onwards and the trend continued till slaughter. The crossbreds (T1) was short in length than ($P<0.05$) T2, T3 and T4 from 6^{th} to 8^{th} month. Height of the experimental animals showed significant difference during the last two months. During the seventh and eighth months the CB (T1) had less height ($P<0.01$) than CB (T3) and LWY (T4) in the field. Body girth showed significant difference on the fifth month where CB (T3) and LWY (T4) had significantly (P<0.01) more girth than LWY (T2) pigs.

On the whole, a linear increase in all body measurements are seen with increase 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 measurements was also reported by several other authors (Deo and Raina, 1983; Sinthiya, 1998; Ramakrishnan, 2001 and Suraj, 2001). A combined study on body weight and body dimensions in different genetic groups may help to assess the relative body density and effective surface area per unit weight for heat dissipation. This may also help for ascertaining actual floor space requirement based on biometrics.

5.6 PROXIMATE ANALYSIS OF FEED SAMPLES

The chemical composition of various diets concentrate, chicken offal, hotel waste and vegetable waste are presented in Table 4.10. Moisture content of vegetable waste was the highest 87.13 ± 0.3 followed by hotel waste 74.69 ± 0.22 and chicken offal 68.77 ± 0.2. The crude protein content of chicken offal was the highest 20.18 ± 4.65. Vegetable waste had a slightly higher CP of 10.25 ± 2.22 than hotel waste 9.22 ± 3.82. This may be due to the presence of pulses in the vegetable waste. Fanime and Tewe (1996) reported a lower moisture for chicken waste than the present study but the crude protein per cent was 60 which was almost thrice of the observations in this study. Harikumar (2001) observed same moisture percentage for chicken offal but the crude protein per cent was higher, 35.63 when compared to this study. Ranjan (2003) observed 35 per cent dry matter and 26.3 per cent crude protein in the hotel waste whereas Harikumar (2001) observed a crude protein per cent of 10.25 for hotel waste which is in agreement with the present study. Low CP per cent of hotel waste may be due to presence of cooked rice as the major ingredient of hotel waste in this study. Rivas *et al.* (1996) also reported a high CP of 22.4 per cent for dehydrated edible restaurant waste.

The crude fibre content in this study was 7.2 for chicken offal and 4.12 and 8.82 for hotel waste and vegetable waste. The values are in agreement with observations of (Farimo and Tewe, 1996; Harikumar,2001 and Ranjan, 2003). Rivas *et al.* (1996) has reported a much lower 2.3 per cent crude fibre for dehydrated restaurant waste.

The ether extract value for the present study was highest for chicken offal 40.2 ± 2.48, 21.2 ± 1.88 for hotel waste and 22.32 ± 1.22 for vegetable waste. Harikumar (2001) has reported EE of 30.9 per cent for chicken offal and the same value as this study for hotel waste. But Farimo and Tewe (1996) recorded a very low 8.46 per cent of EE for chicken offal and Ranjan (2003) 7.63 per cent of EE for hotel waste. Chicken offals in the present study included alimentary tract and skin. Subcutaneous fat of the skin may be the reason for a higher EE of chicken offals in the present study.

NFE for all the feed stuffs were more than 50 per cent except for chicken offal 27.6 ± 0.11. Acid insoluble ash was highest 4.10 ± 0.08 for the concentrate feed and lowest for hotel waste 0.34 ± 0.88.

5.7 AMINO ACID COMPOSITION OF FEED STUFFS

The amino acid composition (g/100 g crude protein) of different feeds like concentrate, chicken offal, hotel waste and vegetable waste is presented in Table 4.11. The essential amino acid concentration of different feeds expressed in percentage, on dry matter basis is presented in Table 4.12.

The essential amino acid concentration of individual feeds was compared with the NRC requirements (1998) for 20 to 50 kg animals in Table 4.13. The concentrate feed fed to the animals was found to have all essential amino acids in excess than the requirements. Chicken offals was found to be 2.31 per cent deficient in methionine plus cystine whereas all other amino acid were in excess than the requirements. Hotel waste with an average crude protein of 9.22 was found to be deficient in all amino acid except arginine, phenylalanine, phenylalanine plus tyrosine and tryptophan. The deficiency was 29.56 per cent for histidine, 7.6 per cent for threonine, 6.81 per cent for valine, 48.41 per cent for methionine, 65.84 per cent for methionine plus cystine, 18.56 per cent for isolencine, 3.48 per cent for leucine and 26.36 per cent for lysine when compared with NRC requirement (1998) for 20 to 50 kg body weight group. The findings indicate that growing pigs cannot be maintained on hotel waste alone due to their poor amino acid content.

Vegetable waste was found to be better than hotel waste but still deficient in Histidine (33.79%), Threonine (11.54%), Methonine (31.18%), Methionine plus cystine (6.83%) and Phenylalanine (3.79%).

The protein requirement for finishing pigs is less when compared to growers (Ranjan, 1981). National Research Council (NRC, 1988) also recommends a low protein of 13 per cent for the pigs above 50 kg body weight. The amino acid content of the same feed stuffs where compared with NRC requirement (1998) for 50 to 80 kg category (Table 4.14). Here, not only the concentrate feed but chicken offal was also found to have excess of all amino acids than the requirements. Hotel waste and vegetable waste were found to be deficient in Histidine 11.95 and 17.23 per cent, Methionine 36.27 per cent and 14.99 per cent and Methionine plus cystine 58.26 and 61.28 per cent respectively. Over and above this hotel waste was also 7.04 per cent deficient in Lysine whereas vegetable waste had excess lysine.

From the above results the following conclusions can be derived for swill feeding (1) chicken offals alone can be fed to growing and finishing pigs without encountering any deficiency of amino acids except for a two per cent deficiency of methionine plus cystine in the growing stock. (2) Chicken offal contain 20.18 per cent crude protein on an average which is in excess (NRC, 1988) for finishing stock (3) Hotel waste and vegetable waste when fed alone accounted for shortage of a number of amino acids and the intensity was high for growing stock between 20 to 50 kg than finisher stock above 50 kg.

Table 5.1 Excess/deficiency of essential amino acids of different feed combinations for 20-50 kg body weight group

Amino Acids	NRC standards (20 to 50 Kg)	Different feed combinations			
		70% Chicken Plus 30% Hotel	60% Chicken Plus 40% Hotel	50% Chicken Plus 50% Hotel	40% Chicken Plus 60% Hotel
Histidine	0.25	**-4.28**	**-7.89**	**-11.50**	**-15.12**
Arginine	0.31	148.58	135.10	121.62	108.14
Threonine	0.46	30.90	25.40	19.90	14.40
Valine	0.51	97.75	82.81	67.88	52.94
Methionine	0.21	26.13	15.48	4.83	**-5.82**
Methionine + cystine	0.44	**-21.37**	**-27.72**	**-34.08**	**-40.43**
Isoleucine	0.42	81.50	67.21	52.91	38.62
Leucine	0.8	65.01	55.22	45.44	35.66
Phenylalanine	0.46	36.75	32.11	27.46	22.81
Phenylalanine + Tyrosine	0.72	38.96	36.14	33.32	30.50
Lysine	0.77	89.49	72.94	56.39	39.84
Tryptophan	0.13	444.81	444.79	444.77	444.76

Table 5.2 Excess/deficiency of essential amino acids of different feed combinations for 50-80 kg body weight group

Amino Acids	NRC standards (50 to 80 kg)	Different feed combinations			
		60% Chicken Plus 40% Hotel	50% Chicken Plus 50% Hotel	40% Chicken Plus 60% Hotel	30% Chicken Plus 70% Hotel
Histidine	0.2	15.13	10.62	6.11	1.59
Arginine	0.22	231.28	212.28	193.29	174.29
Threonine	0.37	55.90	49.07	42.23	35.39
Valine	0.41	127.40	108.82	90.24	71.66
Methionine	0.17	42.65	29.50	16.34	3.19
Methionine + cystine	0.36	**-11.66**	**-19.43**	**-27.19**	**-34.96**
Isoleucine	0.34	106.55	88.89	71.24	53.58
Leucine	0.64	94.03	81.80	69.57	57.34
Phenylalanine	0.37	64.24	58.46	52.69	46.91
Phenylalanine + Tyrosine	0.58	69.01	65.50	62.00	58.50
Lysine	0.61	118.31	97.41	76.52	55.63
Tryptophan	0.1	608.23	608.21	608.18	608.16

From the observations in the field during the period of study, it was found that the farmers were not restricting to one type of feed in rural pig production systems. Feeding strategies and feeds fed were more dependent on the availability of the feeding materials. Even when all the feeds were available no specific ratios for mixing the different rations were followed by the farmers. Both the growing stock and finishing stock were fed on same lines. To overcome this lacunae in the feeding strategy of rural pig rearing, the two commonly used swill feeds (hotel waste and chicken waste) combined in different proportions if fed to growing stock is analysed and presented in Table 5.1. Proportion of chicken offal has been reduced from 70 to 40 per cent and correspondingly the hotel waste proportion increased from 30 to 60 per cent in four simple combinations. It can be seen from Table 5.1 that in all the combinations there was deficiency of Histidine and Methionine plus cystine. The deficiency increased when the chicken offal concentration was decreased from 70 to 50 per cent. When 40 per cent chicken offals was combined with 60 per cent hotel waste the limiting amino acid methionine was also found to be 5.82 pr cent deficient. From the above discussion it can be meaningfully concluded that for the growing stock below 50 kg body weight a minimum of 50 per cent chicken offal has to be incorporated in the diet to meet its essential amino acid requirement. Above 50 per cent of chicken offal will ensure less histidine and methionine plus cystine deficiency.

Different feed combination for finishing stock (50-80 kg) have been presented in Table 5.2. All the combinations had excess of essential amino acids except for methionine plus cystine. Their deficiency increased when the hotel waste percentage was hiked from 40 to 70 per cent. But when compared to growing stock the intensity of deficiency of the above amino acid was less in finisher ration.

As a recommendation it can be concluded that for the growing pigs a minimum of 50 pr cent chicken waste has to be incorporated to avoid deficiency of methonine. For finisher stock since the requirement of protein is less the proportion of hotel waste can be increased upto 60 to 70 per cent. In a more practical sense a

50 per cent chicken offal plus 50 per cent hotel waste for all class of pigs is an advisable combination.

5.8 CARCASS CHARACTERISTICS/TRAITS

Slaughter weight of pigs in the field T3 and T4 were significantly higher ($P<0.01$) than their counterparts T1 and T2 in the farm. No significant difference was observed between the genetic groups in the farm or field.

Eventhough no significant difference was observed in the carcass length between the four groups, the length increased as body weight increased. The carcass length of pigs fed on concentrate T1 and T2 was found lesser than that reported by Mili *et al.* (1999). The values observed in this study is in agreement with Harikumar (2001) who got a carcass length of 65 ± 0.83 cm for pigs maintained on hotel waste and chicken offals.

The CB (T3) and LWY (T4) in the field had a significantly higher ($P<0.01$) back fat thickness of 3.70 ± 0.18 and 3.60 ± 0.18 than their counterparts on concentrate feed 2.61 ± 0.17 and 2.47 ± 0.16. Eventhough not significantly different the crossbreds had a higher back fat thickness than pure breds both in field and farm which is in agreement with findings of Suraj (2000). This was against the findings of Ramakrishnan (2001). Prabhakar (1984); Jha *et al.* (1999) and Rohilla *et al.* (2000) also reported almost same back fat thickness for LWY pigs maintained on concentrate feed. The back fat thickness of LWY pigs maintained in the field had a higher value than the report of Prabhakar (1984) who reported a back fat thickness of 3.1 ± 0.63 cm for indigenous pigs reared in food wastes and scavenging; Jha t al. (1999) 1.92 ± 0.68 cm for pigs reared on kitchen waste and grazing, Hati *et al.* (2000) 2.37 to 2.59 cm for pigs reared on different levels of marua and 3.2 cm by Harikumar (2001) for pigs reared on chicken offals and hotel waste. The higher level of fat content and metabolisable energy of the chicken offal may be the reason for increased back fat thickness in pigs from the field units as evidenced by high protein and fat content (Table 4.10).

The loin eye area showed no significant difference between the four groups. The lowest recorded value was for CB (T3) in the field (17.86 cm^2) followed by LWY (T4) 20.64 ± 1.35 cm^2 in the field. Both T1 and T2 in the farm showed higher values eventhough significantly not different. Saseendran (1979) obtained a loin eye area of 25.25 cm^2, Singh *et al.* (1997) reported loin eye area of 28.23 ± 0.64 cm^2 and Singh *et al.* (1999) observed 26.33 ± 0.55 cm^2 in LWY pigs on conventional feeding. These values were higher than the T1 and T2 group in the present study. In unconventional type of feeding the values obtained in this study are in agreement with the findings of Prabhakar (1986); Jha *et al.* (1999) and Hati *et al.* (2000).

The hot carcass weight of CB (T3) and LWY (T4) in the field was significantly higher ($P<0.01$) than T1 and T2 in the farm. The comparison is not in agreement with the findings of Chen Yie Shiung *et al.* (1997) who reported that carcass weight of pigs fed on complete feed was higher than swill fed group.

A maximum dressing percentage of 71.41 ± 2.12 per cent was recorded for CB (T3) in the field and was significantly higher ($P<0.01$) than LWY (T2) 65.76 ± 1.46 in the farm. The dressing percentage of animals in the field were higher than that of farm. The dressing percentage of pigs in T1 and T2 groups were found to be lower than the reports of Bhadaria (1996); Singh *et al.* (1998) and Jha *et al.* (1999) whereas Rohilla *et al.* (2000) reported almost same dressing percentage for LWY pigs reared on concentrate in North Eastern Region of India. Pigs reared on unconventional feed in the field had almost same dressing percentage as reported by Somanadha Sarma and Subba Reddy (1997) and Jha *et al.* (1999). Whereas Harikumar (2001) had reported a higher dressing percentage for LWY pigs on hotel waste and chicken offals.

Hot deboned meat when expressed as percentage of slaughter weight was highest (59.57%) for CB (T3) in the field. This was significantly lower ($P<0.01$) than CB (T1) and LWY (T2) in the farm. No significant difference was noticed in the deboned meat between CB (T3) and LWY (T4) in the farm as in the case of slaughter weight.

Maximum meat bone ratio was for CB (T3) in the field 6.72 ± 1.46 followed by LWY (T4) 6.30 ± 0.24. The ratio for crossbreds and LWY pigs in the farm was found to be significantly lower ($P<0.01$) than CB (T3) and LWY (T4) in the field. This may be because the field animals were slaughtered at a weight of 65 to 75 kg body weight whereas the weights for farm animals were only 55 to 57 kg.

5.9 WEIGHT OF OFFALS

Weight of lungs, liver, kidney and spleen did not vary considerably between treatments when expressed as percentage of body weight (Table 4.16). Eventhough the weight of stomach and intestine did not vary significantly the values were higher for animals in the farm. Weight of bone expressed as percentage of slaughter weight in CB (T1) animals were significantly higher than CB (T3) and LWY (T4) in the field. Change in meat bone ratio of pigs in the farm might have contributed towards this.

5.10 SERUM MINERALS

The serum mineral concentration of different genetic groups in the two different management conditions is presented in Table 4.17. Serum calcium concentration in mg/dl ranged from 8.23 ± 0.54 mg/dl in CB (T1) to 8.64 ± 0.49 mg/dl in the LWY (T4) group. The values were towards the lower side of normal range (7.1 to 11.6 mg/dl) as reported by Kaneko *et al.* (1997). Serum phosphorus values also showed no significant difference between the two management systems. The readings were within the normal range of 5.3 to 9.6 mg/dl as reported by Kaneko *et al.* (1997). Serum values observed for magnesium concentration also was in agreement with the normal value reported by McDowell (1992). Eventhough there was no significant difference, the animals in the field were found to have serum magnesium levels more towards the lower range of normal.

The trace minerals copper was also present within the normal range (0.5 to 1.5 ppm) as reported by the above authors. The copper concentration of CB (T1) and LWY (T2) was significantly higher than ($P<0.01$) (T3) and (T4) in the field. In the field crossbreds had significantly lower ($P<0.01$) copper concentration than the LWY pigs. The trace mineral zinc was in excess for all the groups when compared with standards of Underwood (1979) who has reported an average value of 0.6 ppm for pigs.

Serum values of major and minor minerals in the farm animals were found to be on the higher side of normal range. This may be due to addition of mineral supplements in the concentrate diet of control group.

Trend for lower serum values of field in fattener pigs warrants a detailed investigation, whether supplementation is needed in situation of higher physiological needs like lactation and pregnancy.

5.11 SERUM LIPIDS

Serum lipid profile after 12 hour fasting is presented in Table 4.18. There was no significant difference among the different groups in the serum cholesterol values. The serum cholesterol concentration in all the groups were found to be more than the values given by Kaneko *et al.* (1997) 28-48 mg/dl and lower than that reported by Brar *et al.* (2000), 115 to 120 mg/dl. The cholesterol concentrations depends mainly on the type of feed. Kim *et al.* (1978) had found the cholesterol concentration as 219 ± 33 mg/dl for pigs fed on 42 per cent butter and the same author in a soya based diet reported 107 ± 3 mg/dl of cholesterol.

There was significant difference ($P<0.01$) in the triglycerides level among all the four groups. Maximum triglycerides levels was for (T4) 200.59 ± 26.82 mg/dl followed by (T3) 140.90 ± 26.82 mg/dl then (T1) 65.54 ± 23.99 and (T2) the least 44.08 ± 22.87 mg/dl. Both the genetic groups had a high triglyceride level in the field. This may be because of high fat content of chicken offals fed to the animals. High EE levels obtained in hotel and vegetable waste during the proximate analysis also supports this view. The HDL concentration showed no significant difference among the groups.

5.12 BIOCHEMICAL PARAMETERS

From Table 4.19 it can be seen that both direct and total bilirubin in mg/dl was found to be significantly different in farm and field condition. In the field the animals were found to have significantly higher ($P<.01$) levels than the control group in the farm. Bilirubin levels in the farm animals were found to be in the normal range of 0.1 to 0.3 mg/dl (Kaneko *et al.*, 1997). Corresponding values in the field were found to be slightly higher than the normal range. Decayed and putrified feed materials find their way into the field level feeding practices might have contributed to this. Eventhough bilirubin levels were higher, liver problems in the field can be ruled out because albumin, total protein and A/G ratio was found to be normal. The total protein, albumin and globulin levels did not significantly differ between the four groups and were within normal range. Globulin levels presented in Table 4.19 confirm the fact that both experimental and control pigs have not been exposed to any infectious diseases during the period of study.

5.13 HOUSING

Differences in the housing system adopted in the farm and field level pig production during the period of study is presented in Table 4.20. Covered area provided in both the systems were found to be more than ISI specification (1 m^2/pig). Uncovered area was not provided in any of the field units whereas in farm conditions 3.5 metre square per animal was provided. Presence of uncovered area has not given any added advantage to the farm animals with regard to weight gain as revealed by earlier discussions in the present study. This is in agreement with findings of Morrison (1984); Mc Donalad *et al.* (1987) and Petherick (1989) who have reported that as space is restricted, it gives only lesser chance for the animal to move around and therefore less energy was utilized for body activity and hence increased feed conversion efficiency and average daily gain. In tropical climate during summer months when uncovered area is provided the concrete floor gets heated up and emits radiation, which add to the thermal load of the animal. Exotic breeds of pigs are susceptible to hoof problems and walking on these hot floor may aggravate the situation further. Moreover from economic point of view wasteful expenditure in shed construction if avoided will reduce initial capital investment. These observations indicate that uncovered area in pig housing for fattener units may not be a necessity.

Wallowing tanks were not part of the field units but still they attained more slaughter weight and performed better than farm animals. Joseph (1997) reported a lower daily weight gain for LWY pigs with wallowing tank due to the fact that habitual wallowing (wallowing for the sake of wallowing even during cold hours of the day) have lead to certain degree of body depletion for maintenance of body temperature resulting in less body weight gain. The above facts call for re-consideration of recommending wallowing tanks for fattening stock from hygienic and economic point of view.

Both the system of housing had concrete floor but manger was absent in field level pig houses. Control group was kept under asbestos sheets. In the field 20% of sties had tile roof (Fig.8) and 80 per cent of them had thatched roof (Fig.9). Thatched roof was covered with polythene sheets to increase its life period.

Anil and Saseendran (2004) have reported that for cattle sheds with tile roof because of the thickness of the tile it absorbed and stored more heat during the day hours. And during the night the stored heat is radiated back on the animals. Taking the above fact into consideration and better performance of pigs in thatched roof as observed in this study, it is advisable to recommend thatched roof for field level fattener units. This can also bring down the cost of construction of sheds and thus the initial investments.

5.14 FORMULA TO CALCULATE BODY WEIGHT FROM BODY LENGTH AND GIRTH.

Length and girth was used to derive a formula to calculate body weight of pig in the field at seven month of age when weighing was not possible for some animals. The coefficient of correlation was 0.88.

5.15 ECONOMICS OF PIG PRODUCTION SYSTEMS

The cost of production for rearing six LWY pigs (T2) in the farm was Rs.23,859 and for rearing six CB pigs (T1) Rs.21,459. When the economics was worked out rearing six units of LWY pigs on concentrate feed resulted in a cumulative loss of Rs.11,237 and for same number of CB pigs Rs.7,293. This is in agreement with findings of Harikumar (2001) who has also reported a loss of Rs.9,415 on rearing six LWY pigs on concentrate. The total production cost for rearing six number of CB (T3) and LWY (T4) in the field was Rs.8,729 and Rs.10,169 and resulted in a net profit of Rs.3,317 and Rs.2,935 respectively. This is also in agreement with findings of Harikumar (2001).

The cost of production of one kg live weight was Rs.64.56 and Rs.66.16 for T1 and T2 maintained on concentrates and Rs.21.92 and Rs.23.45 for T3 and T4 maintained on swill feeding. Yadav et al. (2001) reported a higher cost of production of Rs.34 to 40 per kg live weight than this study for animals reared on different proportions of rice polish. The cost of production of one kg live weight reported by Ashokkumar et al. (2000) and Bhar et al. (2001) were lower than the present study.

Pigs reared on concentrate feed in the farm ended up in loss because of the initial investment on housing was high and the cost of concentrates also added up the loss. In the field initial investment was less and feeding cost which contributes 80 per cent of rearing cost was also less and hence resulted in profit.

5.16 RECOMMENDATIONS FOR FATTENER PIG PRODUCTION IN RURAL AREAS (SWILL FEEDING)

Based on the findings of the present study the following recommendations are putforth.

I. Genetic groups

Both purebred and 75 per cent LWY were found to be equally good in field conditions.

II. Feeding

- For growing pigs upto fifty kg body weight a minimum of fifty per cent chicken waste has to be incorporated.
- For finisher stock above fifty kg body weight proportion of hotel waste can be increased upto 60 to 70 per cent.
- In a practical sense, fifty per cent chicken waste and fifty per cent hotel waste is the best proportion for all body weight groups.

III. Housing

- Covered area required per pig is 1.4 square metre.
- Concrete floors with side walls of one metre height made of brick and plastered is a must.
- Uncovered area is not an absolute necessity.
- Preferable to have thatched roof.
- Sties should be constructed under tree shade.

Summary

6. SUMMARY

The research work was conducted to assess production performance and economics of Large White Yorkshire (LWY) and crossbred (75% LWY x 25% Desi) pigs under different management and environment conditions. Weaned piglets of LWY and CB pigs belonging to Centre for Pig Production and Research (CPPR) were utilized for the study.

Forty two weaned piglets each from LWY and CB were selected uniformly as far as possible with respect to age, sex and body weight. Male piglets were castrated before the study. Twelve piglets randomly selected from each of the above mentioned two genetic groups CB (T1) and LWY (T2), maintained in the feeding and management conditions prevailing in CPPR for a period of six months formed the control group of the study. The remaining thirty weaned piglets from each genetic group CB (T3) and LWY (T4) were randomly allotted to ten farmers in Thrissur district in such a way that each farmer got a minimum of three LWY and three CB piglets. These animals were fed on swill feed by the farmers and were maintained for the same period of six months.

On attaining eight months of age all the pigs from control group (T1 and T2) and representative sample from the field group (T3 and T4) were slaughtered. Growth performance, carcass characteristics and economics were assessed in all the four groups. Proximate analysis of pooled samples of different feeds fed to the animals were done. The amino acid concentration of different feeds were also analysed. The average daily feed intake and feed conversion efficiency of different groups were worked out. Serum lipid profile, biochemical parameters and serum mineral concentration of the four groups were determined and compared. Type of housing in the field conditions was also analysed.

The CB (T3) and LWY (T4) in the field attained more weight, 66.37 kg and 72.25 kg at slaughter ($P<0.01$) than their counterparts T1 and T2 which

attained an average slaughter weight of 55.4 kg and 60.1 kg. During the period of study CB (T3) attained significantly higher weight 37.87 kg than the other group (T1) during the fifth month and LWY (T4) attained significantly higher weight 51.69 kg during the sixth month than all other groups. The mean average daily body weight gain of CB (T1) and LWY (T2) maintained in farm was 251 g and 265 g respectively and that for CB (T3) and LWY (T4) in the field was 308 and 341 grams. T4 had higher ($P<0.01$) average daily gain thanT2 in the farm.

The average feed conversion efficiency for T3 and T4 were 4.02 and 3.91 which was significantly higher ($P<0.01$) than T1 (5.53) and T2 (4.94).

Significant difference in length was observed from fifth month onwards and the trend continued till slaughter. Height of the experimental animals showed significant difference during the last two months. At slaughter the CB (T1) had less height 51.35 cm ($P<0.01$) than T3 and T4 which measured 59.43 cm and 58.94 cm respectively. Body girth showed significant difference in the fifth month where CB (T3) and LWY (T4) had 74.69 cm and 75.31 cm significantly higher ($P<0.01$) than the girth of LWY (T2) pigs with 68.8 cm.

Proximate estimation of different feed stuffs revealed that moisture content of vegetable waste was the highest at 87.3 per cent followed by hotel waste at 74.69 per cent and chicken offal 68.77 per cent. The crude protein content of chicken offal was the highest (20.18%). Vegetable waste had a slightly higher CP of 10.25 per cent than hotel waste at 9.22 per cent. The ether extract value for the present study was highest for chicken offal (40.2), 21.2 for hostel waste and 22.32 for vegetable waste.

The essential amino acid concentration of individual feeds were compared with NRC requirements (1998) for growing stock. Concentrate feed and chicken offals were found to have excess of all essential amino acids, whereas hotel waste was deficient in eight and vegetable waste in five amino acids. While feeding finishing stock the same trend continued for concentrate feed and chicken offal, whereas hotel waste was deficient in four and vegetable waste in three essential amino acids.

Carcass characteristics did not vary significantly among the four groups with regard to carcass length, loin eye area and hot deboned meat. The T3 and T4 in the field had a significantly higher ($P<0.01$) back fat thickness of 3.7 cm and 3.60 cm than their counterparts on concentrate feed at 2.61 cm and 2.47 cm for T1 and T2 respectively. A maximum dressing percentage of 71.41 per cent was recorded for CB (T3) in the field and was higher ($P<0.01$) than LWY (T2) at 65.76 per cent in the farm. Maximum meat bone ratio was for T3 in the field (6.92) followed by T4 (6.30) and both the values were higher than ($P<0.01$) their counterparts in the farm.

Serum mineral concentration of calcium, phosphorus, magnesium, copper and zinc of all the four treatment groups were within the normal range. Copper concentration of field animals was significantly lower than ($P<0.01$) farm animals.

Serum lipid profile showed no significant difference for cholesterol and HDL values. Triglycerides were significantly higher ($P<0.01$) for field animals. Serum albumin, globulin and total protein were within normal range and there was no significant difference between the treatments. Bilirubin (direct and total) was significantly higher ($P<0.01$) for field animals.

Comparison of housing pattern revealed that in the field, pig houses were not provided with uncovered area, wallowing tank and manger. Eighty per cent of field sties had thatched roof and twenty per cent tile roofs.

The average cost of production for one kg fattener pig was Rs.64.56 and Rs.66.16 for T1 and T2 maintained on concentrates and Rs.21.92 and Rs.23.45 for T3 and T4 maintained on swill feeding.

From the overall assessment of results obtained in the present study, it could be concluded that both the genetic groups of CB and LWY are equally good for field level production and fifty per cent chicken waste with fifty per cent hotel waste is the best proportion of swill feed for all body weight groups. Regarding housing, uncovered area is not a necessity for fattener pig production but the floor should be of concrete. It is preferable to have thatched roof and the sties constructed under shade.

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PRODUCTION PERFORMANCE AND ECONOMICS OF LARGE WHITE YORKSHIRE AND CROSSBRED (Large White Yorkshire x Desi) PIGS UNDER DIFFERENT MANAGEMENT AND ENVIRONMENT CONDITIONS

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ABSTRACT

Detailed investigation was conducted to assess production performance and economics of Large White Yorkshire (LWY) and crossbred (75% LWY x 25% Desi) pigs under different management and environment conditions with respect to growth, carcass characteristics, biochemical parameters, serum lipid profile, serum mineral composition and the economic feasibility of farm and field level pig production systems.

Twelve weaned piglets each from two genetic groups, CB (T1) and LWY (T2) selected uniformly as far as possible with respect to age, sex and body weight maintained in the feeding and management conditions prevailing in Centre for Pig Production and Research for a period of six months constituted the control group. Thirty weaned piglets each from the two genetic groups, CB (T3) and LWY (T4) randomly allotted to ten farmers to get a minimum of three piglets from both group, formed the field unit. The field animals were maintained on swill feed for the same period of six months.

The T3 and T4 groups in the field attained more body weight 66.37 kg and 72.25 kg at slaughter ($P<0.01$) than their counterparts T1 and T2, which attained an average slaughter weight of 55.4 and 60.1 kg. At five months,CB (T3) in the field weighed significantly higher ($P<0.01$) than the CB (T1) in the farm and the trend continued in the sixth month also ($P<0.05$). But at the end of sixth month, LWY (T4) in the field weighed ($P<0.05$) more than the CB (T3). The mean average daily body weight gain of LWY (T4) in the field was 341 gram, significantly higher than LWY (T2) in the farm ($P<0.01$) which attained only 265 grams. Both the genetic groups in the field registered a higher feed conversion efficiency than farm animals.

Body weight was well correlated with body measurements. Significant difference in length was observed from fifth month onwards and the trend

continued till slaughter. Height of the experimental animals showed significant difference during the last two months. Body girth showed significant difference in the fifth month where CB (T3) and LWY (T4) had significantly ($P<0.01$) more girth than LWY (T2) pigs.

Proximate analysis of different feed stuffs fed to animals in the field revealed a high moisture content for vegetable waste followed by hotel waste and chicken offal. Chicken offals had the highest CP followed by vegetable waste and hotel waste. The ether extract value was highest for chicken offal (40.2) followed by hotel and vegetable waste at 21.2 and 22.32 respectively.

When compared with NRC requirements (1998) for growing stock, concentrate feed and chicken offals had all essential amino acids in plenty whereas hotel waste and vegetable waste fed alone was deficient in eight and five essential amino acids respectively. In the case of finishing stock, hotel waste was deficient in four and vegetable waste in three essential amino acids.

Carcass characteristics did not vary significantly among the four groups with respect to carcass length, loin eye area and hot deboned meat. The field animals had a significantly higher ($P<0.01$) back fat thickness than animals in the farm. Maximum dressing percentage was observed for CB (T3) in the field and was higher than ($P<0.01$) LWY (T2) in the farm. Animals in the field also excelled in meat bone ratio.

Serum mineral concentrations were within the normal range for all the four treatment groups. Serum lipid profile also showed no significant difference except for triglycerides which was significantly higher ($P<0.01$) for the field animals. Biochemical parameters also showed no significant difference except for total and direct bilirubin which was significantly higher ($P<0.01$) in field animals.

Comparison of housing pattern showed that all pig houses in the field under study were not provided with uncovered area, wallowing tank and manger and more than 80 per cent of them had thatched roof.

The average cost of production of one kg fattener pig was Rs.64.56 and Rs.66.16 for CB (T1) and LWY (T2) in the organised farm and Rs.21.92 and Rs.23.45 for CB (T3) and LWY (T4) maintained on swill feeding in the field.