COMPARATIVE STUDY OF GROWTH, CARCASS CHARACTERISTICS AND ECONOMICS OF CROSSBRED, INDIGENOUS AND EXOTIC PIGS

By
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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that this thesis entitled **"COMPARATIVE STUDY OF GROWTH, CARCASS CHARACTERISTICS AND ECONOMICS OF CROSSBRED, INDIGENOUS AND EXOTIC PIGS"** is a bonafide record of research work done by me during the course of research and that this 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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6.09.2001

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CERTIFICATE

Certified that this thesis, entitled **"COMPARATIVE STUDY OF GROWTH, CARCASS CHARACTERISTICS AND ECONOMICS OF CROSSBRED, INDIGENOUS AND EXOTIC PIGS"** is a record of research work done independently by **Dr. Ramakrishnan. S.,** 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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Dedicated
To My Beloved
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CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

1. INTRODUCTION

The world human population which was mere 2.5 billion in 1950, has reached 5.7 billion in 1996 and has been projected to become 7.9 billion by the year 2020. Dramatic increase in the human population results in many problems such as malnutrition and environmental destruction. It is well documented that over 900 million people in the world are suffering 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 percapita consumption is only 9.6 g in India against the world average of 24 g and Indian council of Medical Research's recommendation of 34g (Shanmuga-sundaram, 1997). The prejudice against beef and slow multiplication of sheep and goat to keep pace with the ever increasing demand for food had precipitated the need to find other sources to satisfy human requirements. Pigs as meat animals offer an immediate solution to this problem since they multiply rapidly at a low cost.

The pig has traditionally been a "Scavenger" and in early domestication it was raised as a means of utilising food wastes of man. Still in India and other countries pig performs this function as a "back yard" inhabitant. Pig is a versatile animal, able to adapt to a wide variety of circumstances imposed by man and yet retaining it's own peculiar individuality (Hazel, 1963).

Pigs thrive from arctic to tropical temperatures on highly concentrated or bulky feeds and produce high percentage of meat and fat.

According to FAO quarterly bulletin (1997), the total population of pigs in India were 15.41 million heads which contributed to 3.12 per cent of Indian Livestock population.

Pigs are ideal suppliers of good quality meat. Pigs excel all other meat producing animals except well kept broiler. Swine can effectively utilize agricultural by products and many other waste materials. Compared to other meat animals pigs yield higher dressing percentage. Pork has higher energy value than beef or mutton.

In India pig rearing is still not in a satisfactory state and almost entirely in the hands of people with little resources who continue to follow the primitive methods of rearing. There are three basic genetic groups of pigs in our country i.e., *desi* pigs, exotic pigs and a non-standardised crossbred of these two.

The common Indian *desi* pig is a scrub animal, slow grower, small sized and producer of small litters. These are rich in genetic variability and are endowed with many positive aspects like disease resistance and tolerance to climatic variables. But these animals are poor in reproductive and productive traits.

Exotic pigs are larger in size with superior feed efficiency. These animals are good converters of feed with low mothering ability. They outdo *desi* pigs in growth rate and carcass characteristics. Recognising the merits and potential of exotic pigs as a source of animal protein, the Government of India is paying considerable attention in the development of pig industry. A number of pig production centres have been established in several states and the farmers are being educated on pig raising on scientific lines.

There are not many reports comparing exotic breeds like Large White Yorkshire with indigenous *desi* pigs and the available reports indicate a significantly lower growth rate and a higher production cost in indigenous stock when compared to Large White Yorkshire pigs. (Saseendran and Rajagopalan, 1981, 1982).

While crossing the *desi* pigs with exotic animals, a substantiate increase in both productive and reproductive performance as well as disease resistance in the resultant crossbreds is yet to be ascertained.

The economy in swine production is influenced by factors such as (1) number of piglets farrowed per litter (2) Weight of the litter at weaning (3) Labour charges per 100 kg of meat produced (4) returns per amount of money spent and (5) cost per kg meat sold.

Feed contributes 70-80 per cent of the total cost of pig production. Scientific feeding of pigs had contributed much to better growth rate, feed efficiency and carcass quality in pigs and had helped in reducing production costs and increasing profits.

Growth rate, feed efficiency and carcass quality are vital factors influencing the cost of fattener production in swine industry. These factors are related to Live weight, age, quality and quantity of feed, genetic potential and environmental factors. Feed efficiency is maximum at the early stages of growth and it decreases with increasing age and live weight. (Field *et al.*, 1961; Kumar *et al.*, 1974; Ranjhan *et al.*, 1972).

Efficiency of production depends on the successful interaction of several factors. Of these, nutrition is by and large the most important. The efficiency of the pig in this respect can be divided into different categories on the following basis (i) biologic efficiency (ii) economic efficiency. When biologic efficiency is calculated, the feed consumed and the weight gained alone are considered. On the other hand, when economic efficiency is assessed, units of feed consumed, labour charges and equipment charges involved are also taken into account.

Protein is one of the most important nutrients required by all classes of Livestock and especially by pig for own body processes as well as to synthesise different products.

From the foregoing paragraphs, it is evident that informations on the level of dietary protein for fattening pigs for most efficient gains and on the most economic weight at which the pigs have to be slaughtered are conflicting.

Hence the present study was undertaken with the following objectives and to make suitable recommendations, which can be practiced by farmers.

1. To compare the merits and demerits of cross bred pigs over indigenous and exotic pigs with respect to growth and carcass characteristics.
2. To study the economic feasibility of rearing crossbred pigs.
3. To study the feasibility of reducing the digestible crude protein content of swine ration by 10 per cent from the ICAR standards.

Review of Literature

2. REVIEW OF LITERATURE

The nutrient requirements of pigs may not be the same under all environmental conditions. The extent to which the production performance and carcass characteristics are influenced by level of protein intake, energy, season, age, breed and sex are reported extensively from western countries. But reports of such nature are scanty and scattered from tropical climates. The literature reviewed in this aspect is presented under the following heads.

2.1 Growth

Brody (1945) defined growth as a constructive or assimilatory synthesis of one substance at the expense of other nutrient which undergo dissimilation. Growth is a complex set of metabolic events which are environmentally and genetically controlled (Hafez, 1968). Maynard *et al.* (1969) had estimated the average percentage of gross energy in the feed eaten by various kinds of animals, and converted into human food as follows; Pork 20 per cent; Milk (dairy cow) 15 per cent; egg seven per cent; Poultry five per cent and beef and Lamb four per cent. Morrison (1984) reported that well maintained and well fed pigs make more than twice weight gain per 100 lb body weight as compared with fattening calves and three times as compared with fattening lambs.

Influence of protein level on growth and feed efficiency had been studied. Several reports indicated that growth response and feed efficiency are significantly increased only during the growth period. Woodman *et al.* (1939) recorded significantly lower growth performance with pigs on low protein diets in the growing period but there was no significant difference between high and low protein rations, over the whole feeding period. High protein levels in the ration of growing swine did not have any significant effect on the average daily gain and feed efficiency (Washington and Cripp, 1980 and Feng *et al.*, 1985).

Klay (1964) reported that as the level of dietary protein increased from 10.61 to 26.36 per cent in the rations of pig, total intake of both protein and lysine increased while feed consumption and efficiency of protein and lysine utilisation showed linear decrease. It was also observed that the level of protein significantly affected the true nitrogen digestibility and retention of dietary nitrogen per unit of body weight. Similarly, lower weight gain and poor gain: feed ratio were observed by Meade *et al.* (1969) in starter pigs weighing between 5.9 and 23.5 kg, when fed 12 and 15 per cent protein diets.

Cunningham *et al.* (1973) observed that pigs fed the 10 per cent protein diet gained slower and were fatter than pigs fed with 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 Landrace and Large White Yorkshire 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.

Menge and Forbish (1976) reported that pigs weaned at three weeks of age could be fed a diet which contained 20 to 24 per cent protein with a Calorie: protein ratio of 15 to 18.

Lunchick *et al.* (1978) reported that maximum performance was attained when young growing pigs diet contained 16 per cent protein and 0.93 per cent of Lysine.

Comparative performance of Large White Yorkshire pigs and indigenous pigs of Kerala were studied and observed, a fortnightly gain of 6.21 kg and 1.618 kg and feed efficiency of 3.81 and 4.26 respectively (Saseendran, 1979).

According to Christian *et al.* (1980) ration with 16 per cent protein resulted in improved growth rate and feed efficiency of pigs when compared to 12 per cent protein diet. Similar results were reported by Campbell *et al.* (1984).

Shields and Mahan (1980) studied the effect of varying levels on performance and carcass characteristics of growing finishing swine. Animals were divided into three groups and one group received 16, 14.5 and 13 per cent protein diet from 22 to 54.4 kg, followed by 13 per cent protein diet to market weight and the third group received 14.5 per cent protein diet throughout the growing and finishing phase. They also found that feed intake, gains and feed conversion for the overall period from 22 to 95 kg were similar for pigs on all three protein requirements and suggested that temporary moderate protein restrictions had no adverse effects on overall gain or carcass quality.

The approximate crude protein requirements of growing swine fed ad-libitum as cited by Ranjhan (1981) were

22, 18 and 14 per cent for body weights 5 to 12, 12 to 50 and 50 to 100 kg respectively.

Skoryatina and Korop (1981) reported that in a concentrate based diet the optimum level of protein for Large White Yorkshire Pigs was 18 per cent for weaners, 16 per cent for pigs upto 6 months of age and 14 per cent from 6 to 8 months of age on dry matter basis.

Sharda and Yadav (1983) observed that middle White Yorkshire, cross and desi pig's daily gain in body weight from 8 weeks to 113 days of age, feed consumed per kg gain, carcass weight, dressing percentage, back fat thickness, proportion of lean cuts differed significantly between desi and the other groups.

Tyler *et al.* (1983) showed that grower and finisher pigs fed diets with protein levels of 20 per cent and 18 per cent respectively had improved average daily gain, feed conversion efficiency and back fat thickness. 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 40kg to slaughter weight, respectively.

Bao *et al.* (1987) suggested that 16 per cent protein diet was compared with 13 per cent protein diet in Xinhuai, Erhualian X xinhuai and Duroc X xinhuai pigs and average daily body weight gain (18 per cent), efficiency of feed utilization (15 per cent), meat yield (6 per cent) and lean meat content (3.6 unit) increased in 16 per cent protein diet groups over 13 per cent.

The landrace male pigs during their growing phase required about 20.18 per cent crude protein for maximum performance (Donzele *et al.*, 1993 a) and growing gilts required 19.74 per cent crude protein for maximum performance (Donzele *et al.*, 1993 b).

Latimier and Dourmad (1993) studied the effect of three protein feeding strategies for grower and finisher pigs and found that growth rate and feed conversion efficiency were similar in all groups, while the dressing percentage decreased with increased dietary protein.

Martin (1994) and Jost *et al.* (1995) observed that grower diet containing 16 per cent or less protein resulted in unprofitable performance. They also reported that satisfactory growth was obtained with 17 per cent dietary crude protein and 13.9 MJ digestible energy, provided the feed was supplemented with the limiting amino acids Lysine, Methionine or cystine, threonine and tryptophan.

According to Hata *et al.* (1995) the digestible energy intake and daily gain of castrated male pigs offered a low protein (120 and 140g/ kg) diet was lower than those pigs fed high protein (185, 169, 153 and 136g/ kg) diets.

Barac *et al.* (1996) reported that the diets for fattening pigs which contained 17 and 15 per cent crude protein respectively, during the growing and finishing period increased average daily gain and improved feed: gain ratio.

Moita *et al.* (1996) studied that 12 to 28 days old piglets required 23.42 to 23.13 per cent crude protein in their ration.

Oldenberg and Heinrich (1996) showed that finisher pig diets, which contained 17 per cent and 13.5 per cent crude protein, had no effect on finishing and slaughter performance.

Wu *et al.* (1996) found that the average daily gain and feed: gain ratio during the starter, grower and finisher phase increased when ideal protein intake was 129 to 130g/ day, 310 to 319 g/ day and 350 to 370 g/ day, respectively.

Das (1997) reported that the diets in growing and finishing crossbred female pigs which contained 16.9 per cent and 20.1 per cent crude protein had final live weight, total weight gain, average daily weight gain and average daily feed intake was higher on the high protein diet, while the protein efficiency ratio was higher in those on the low protein diet.

National Research Council (NRC, 1998) recommendation of protein for pigs of 3 to 5, 5 to 10, 10 to 20, 20 to 50, 50 to 80 and 80 to 120 kg body weights were 26, 23.7, 20.9, 18, 15.5 and 13.2 per cent, respectively.

Large White Yorkshire pigs fed with a ration containing 18 per cent crude protein during grower period and 14 per cent crude protein during finisher period had an average daily gain of 381 g and feed efficiency of 4.36 (Sinthiya, 1998).

Ravi *et al.* (1999) found that 30 cross bred pigs (15.0 kg body weight) were divided into three groups of 10 each of males, barrows and females and fed ad-libitum on a standard grower and finisher ration. The daily feed intake during growth and finishing stages was females (2.34 kg), barrows (2.05 kg) and males (1.96 kg). The average daily gain in corresponding group of animals was 397, 384 and 395 g, respectively. Vasudevan (2000) concluded that positive influence of fine grinding of maize on the growth performance, feed conversion efficiency and nutrient digestibility in cross bred pigs.

The dietary lysine requirements of pigs over the weight interval of 50 to 100 lb and 100 to 200 lb were 1.0 per cent and 0.5 to 0.6 per cent respectively (Costain and Morgan, 1961). Klay (1964) observed that decreased absorption of lysine was the major cause for the increase in lysine requirement with increased dietary protein level. He also stated that feed intake tended to decrease as level of protein increased, so that animals consumed nearly equal amounts of dietary lysine at all levels of dietary protein. The study conducted by Meade *et al.* (1966) showed that pigs fed the diet providing the greatest amount of protein demonstrated significantly more rapid gains. Efficiency of feed utilization, carcass length and back fat thickness were unaffected by level of dietary protein or supplementation of lysine and methionine. However, Clawson *et al.* (1962) reported that the addition of 0.4 per cent L – Lysine to 10 per cent protein diets, significantly increased the loin eye area.

Boomgaardt and Baker (1973) were of opinion that it was preferable to express the amino acid requirements of growing pigs as per cent of total dietary crude protein than as a percentage of the total diet. They also recorded the minimal level of tryptophan requirements of growing pigs for maximal weight gain as 0.71, 0.67 and 0.66 per cent of the protein, respectively at 10, 14 and 18 per cent dietary protein levels.

Easter and Baker (1980) reported that the lysine requirement could be reduced when crude protein levels were reduced by replacing Soyabean meal with Synthetic lysine.

Lewis *et al.* (1981) stated a tendency for growth rate to decrease when total dietary lysine concentration exceeds 1.25 per cent.

Taylor *et al.* (1984) demonstrated the interaction between leucine, isoleucine and valine. Lysine levels lower than that of the basal levels resulted in the reduction in body weight gain, feed intake and feed efficiency (Edmonds and Baker, 1987).

Fuller *et al.* (1989) indicated that for one gram body protein accretion growing pigs the dietary amino acid requirements should be threonine –47 mg, Valine –53 mg, Methionine + cystine –36 mg, Methionine – 19mg, isoleucine – 43 mg, leucine –78 mg, Phenyl alanine + tyrosine –84 mg, phenyl alanine –41 mg, Lysine – 68 mg and tryptophan – 12 mg.

Parsini *et al.* (1991) found that dietary protein could be decreased in finisher pig rations if lysine supplements were used.

Wu and Zhow (1992) observed 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.

Suhuttee *et al.* (1993) reported that in growing pigs, supplementation of lysine, methionine, threonine and tryptophan reduced the dietary crude protein requirement by about two per cent.

Valaja *et al.* (1993) observed that the crude protein content of the diet of growing pigs could be reduced upto 20 per cent, provided the concentrations of lysine and methionine were maintained.

Zollitsch *et al.* (1994) also found that supplementation of lysine, methionine and tryptophan could decrease the dietary crude protein of finisher pigs without affecting finishing and slaughter performance.

Han *et al.* (1995) reported that the nutrient excretion was the lowest in pigs fed low protein (16 per cent protein) diet with 0.2 per cent of synthetic lysine. They also found that supplementation of L – Lysine at the rate of 0.1 to 0.2 per cent in 16 per cent crude protein diet improved daily weight gain and feed efficiency and were comparable with those of pigs fed 18 per cent crude protein diet and nitrogen excretion was reduced by 19.3 per cent.

Kuhn and Burgstaller (1995) also concluded that low protein diets did not influence average daily gain, feed conversion efficiency, carcass yield and meat quality of finishing pigs when supplemented with lysine at 5 g/ 100g crude protein.

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

Trindade *et al.* (1995) observed that 16 per cent dietary crude protein was sufficient to meet the requirements in diets of pigs weaned at 28 days old if supplemented with lysine, methionine and cystine.

Lenis *et al.* (1996) reported that for maximum growth performance of growing and finishing pigs, the requirements for apparent ideal digestible methionine + cystine, threonine and tryptophan, relative to apparent ideal digestible lysine, should be 59, 63 and 19 per cent, respectively. With regard to the methionine + cystine requirement, the methionine: cystine ratio should not be below 50 per cent.

Jin *et al.* (1998) quantified the total lysine requirement of 21 days old pigs as 1.45 per cent. They also observed that the lowest digestibility of dry matter and crude fat were in pigs fed 1.15 per cent and highest in 1.65 per cent lysine group. The nitrogen digestibility increased with lysine levels while the digestibilities of gross energy, ash and phosphorus did not differ. Li and Guan (1998) showed that reducing protein level in swine diets can be reduced by supplementing the amino acids according to the ideal protein pattern. They observed better growth response when amino acids were added in higher levels. As per National Research

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

Several workers have studied the influence of energy level in the diet on growth rate and feed efficiency in pigs. Ranjhan *et al.* (1972) reported reduction in growth rate and feed efficiency when energy was restricted in the diet of pigs weighing more than 50 kg body weight.

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

Differences in daily energy intake affected growth rate. Restriction of the daily energy intake by 20 per cent reduced live weight gain (15 per cent), nitrogen retention (12 per cent), protein deposition (8 per cent) and fat deposition (20 per cent) in swine (Metz *et al.*, 1980).

Iliescu *et al.* (1982) observed the net efficiency of utilization of metabolizable energy as 73.8 per cent in young pigs of 10 to 50 kg body weight. They also found that for maintenance, the pigs required 103.4 kcal metabolizable energy/kg$^{0.75}$ or 76.3 kcal net energy/kg$^{0.75}$ for 24 hours.

Thomas and Singh (1984) concluded that diets have 90 per cent digestible energy level of National Research Council (NRC) standards promoted economical gains in pigs.

Indian Council of Agricultural Research (ICAR, 1985) recommended the digestible energy contents of 3100 and 3000 K cal/ kg feed for pigs weighing 5 to 10 and 10kg to slaughter weight respectively.

Balogun *et al.* (1988) reported that best results were achieved when Large White Yorkshire pigs, which weighed 22 and 36 kg, were fed diets, which contained digestible energy of 3.23 and 3.3 M cal/ kg respectively.

The National Research Council (NRC, 1988) specification for energy was shown to be 3220, 3240, 3250, 3260 and 3275 K cal Metabolizable energy/ kg feed for pigs of 1 to 5, 5 to 10, 10 to 20, 20 to 50 and 50 to 110 kg body weight, respectively.

Kyriazakis and Emmans (1992) stated that increased intake of energy increased the live weight, empty body weight and protein and lipid gains of pigs. The energy retention was not affected by stage of growth in pigs (Hata *et al.*, 1993)

Xie *et al.* (1994) found the optimum requirement of digestible energy as 13.81 MJ/ kg feed for pigs weighing from 20 to 90 kg. They also reported the crude protein and trace element requirements as 16 and 0.5 per cent, 14 and 0.5 per cent and 12.27 and 0.4 per cent respectively for pigs weighing 20 to 35 kg, 35 to 60 kg and 60 to 90 kg. The National Research Council (NRC 1998) recommended 3400 kcal of digestible energy or 3265 kcal of metabolizable energy for pigs of all age groups.

Tavares *et al.* (1999) also reported that increasing the dietary digestible energy levels improved feed: gain ratio linearly and increased the fat deposition rate quadratically in gilts without affecting digestible energy intake and protein deposition rate.

2.2 Calorie protein ratio: (Energy–protein: interrelationship)

Clawson *et al.* (1962) emphasized the need for a higher dietary protein level with increased energy content and observed that daily feed consumption and growth rate of pigs during the first 28 days were significantly influenced by energy – protein ratio.

Baird *et al.* (1975) found that efficiency of protein conversion was greater on the low protein high energy diets of pigs indicating that use of protein was more efficient at lower level of intake and high-energy diets have a protein saving effect by improving protein efficiency.

Campbell *et al.* (1985) showed the relationship between energy intake and the rate of protein deposition was linear with maximal protein deposition occurring at about 33 MJ digestible energy per day.

According to Feng *et al.* (1985) there were no significant differences in daily gain and feed conversion efficiency among pigs given diets with high or with intermediate energy and protein.

Sivaraman and Mercy (1986) observed that there were no significant differences in average daily gain, feed efficiency and carcass characteristics of pigs fed rations containing different energy – protein ratios. They further concluded that the animals maintained on 20 per cent crude protein and 3.3 Mcal of digestible energy/ kg feed had the lowest cost of production per kilogram live weight.

The different levels of energy had a greater effect on growth than the gradations in protein study in pigs (Oslage *et al.*, 1987).

Kyriazakis and Emmans (1992) observed that efficiency of protein utilization increased with an increase in energy intake.

Kulisiewicz *et al.* (1995) reported that raising dietary levels of protein and energy increased the feed conversion efficiency in crossbred pigs.

Lunen *et al.* (1998) stated that pigs given high energy diets (16.40 M cal/kg) were less sensitive to dietary lysine: digestible energy ratio than those given lower energy diets (14.25 M cal/kg).

Jung *et al.* (1999) opined that pigs fed high lysine digestible energy diet showed higher digestibility for most amino acids except glutamine and proline. The optimum lysine: digestible ratio appeared to be higher than 3.5mg/ k cal digestible energy.

2.3 Body weight 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 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) the body measurements most highly correlated with live weight was chest circumference in pigs. Deo and Raina (1983) concluded that the genetic correlations 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 correlations 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 practiced 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 as increase in slaughter age and it was higher in Large White Yorkshire than crossbred pigs.

Dash and Mishra (1986) reported that the body length, height, heart girth and abdominal girth of Large White Yorkshire and crossbreds at the slaughter age of 24 weeks were 96.54 and 94.23 cm, 54.27 and 52.61cm, 71.27 and 68.23cm, 66.18 and 63.23 cm, respectively. 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.

Ensminger *et al.* (1990) observed the following relationship. Heart girth x heart girth x length ÷ 400 = weight in pounds. They also suggested that for hogs weighing less than 150 lb, 7 lb has to be added to the weight figure obtained from formula.

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 breeds (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.

Lakhani and Bhadoria (1991) reported that in desi pigs, weight at 24^{th} week and 32^{nd} week were 20.14 ± 0.292 kg and 32.47 ± 0.339 kg respectively at Jabalpur. The year had significant effect on post weaning growth rates.

Leena (1992) found that the body weight at weaning was 8.5 ± 0.669 kg and at eight months 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 the birth to the fourth month and thereafter showed a declining tendency. The absolute daily gain increased from 218 gm in the first month to a peak of 600 gm in the fourth month and then declined to 319 gm from fifth month.

Sebastian (1992) stated that pigs born in dry season were superior to animals born in rainy season in parameters like growth rate, feed efficiency, average daily gain and carcass characteristics.

Pradhan (1993) found the average body weight increased from 9.00 ± 0.34 kg at weaning to 74.98 ± 1.34 kg at 32^{nd} week of age. The daily gain in weight increased from 131.62 ± 17 gm at 10^{th} week to a peak of 392.28 ± 9.34 gm at 32^{nd} week, thereafter declined to 384.60 ± 6.98 gm at 40^{th} week of age.

The 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. Pigs showed progressive increase in the average daily gain in weight from 137.84 ± 23.7 gm at weaning to 439.28 ± 10.05 gm at eight months of age (Kannan, 1995).

The body weight of indigenous pigs at the end of 32 weeks were 40.43 ± 2.70 kg ± (Izatnagar), 31.78 ± 1.39 kg (Jabalpur), 42.91' ± 1.04 kg (Tirupati), 38.05 ± 1.44 kg (Khanpara), 31.32 ± 0.45 kg (Mannuthy), 33.01 ± 1.48 (Kattupakkam), respectively (AICRP Report, 1997).

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 the average daily gain of 237.70 ± 49.53 gm.

Singh, *et al.* (1997) found that the live weight of Large White Yorkshire pigs at birth (1.23 ± 0.03kg) 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 were reported by Subramanian (1998).

2.4 Rectal temperature, respiration and pulse rate

Homeo thermic animals maintain a constant body temperature with little fluctuation. The body temperature of mammals is seen affected by the age. The foetus is having a higher body temperature, which gradually declines after birth and through advancing age to attain the level characteristic to the species. Rectal temperature is usually taken as an index of body temperature.

Robinson and Klemm (1953) reported that there was a noticeable rise in rectal temperature above 95^{o}F and rise in rectal temperature parallelled rise in humidity.

Dukes (1955) found that rectal temperature of pigs begin to increase at an environmental temperature of 85–90^{o}F (29.4–32.2^{o}C). The pigs could not tolerate prolonged exposure (seven hours) to an environmental temperature of 95^{o}F (35^{o}C).

Findlay (1957) concluded that pigs were ill adapted to extremes of heat and cold. Bianca (1959) and Williams *et al.* (1960) stated that there is an increase in rectal temperature of animals exposed to high environmental temperature both in climatic chamber and outside.

Wrenn *et al.* (1961) opined that there is an elevation of rectal temperature of animals in the mid morning and afternoon which declines in early morning and evening.

Findlay (1961) had also reported that for all practical purposes rectal temperature appeared to be a very good measure of the temperature of animals, which was within 0.2 – 0.3^{0}C of the mean circulating blood temperature provided the heat content of the animal remained constant or changing very slowly. Body temperature was elevated during feeding, exercise, oestrus and at the terminal phase of pregnancy and depressed during starvation and immediately after intake of large quantity of cold water.

Stress of ambient temperature causes marked behavioural and physiological responses in young pigs (Mount, 1960, Holmes, 1968). Sutherland (1967) found that as ambient temperature rose above the upper critical temperature, the temperature of animals may begin to increase.

Hafez (1968) reported that there was a diurnal fluctuation of rectal temperature of animals, having minimum in the early morning and maximum in the afternoon.

Martin (1970) concluded that rectal temperature of pigs begin to show a sharp increase when the environmental temperature rose from 60 – 80^{0}F (15.6 – 26.7^{0}C). He had also found that the body temperature of swine appears quite variable with a range of 101.5^{0} – 104^{0}F (38.6 – 40^{0}C).

Campbell and Lasley (1977) opined the rectal temperature of swine as 102.5^{0}F (39.2^{0}C).

Sainsbury and Sainsbury (1979) stated that critical temperature of piglets were 35^{0}C at birth, 29^{0}C up to 5 kg live body weight and 24^{0}C at 10 kg body weight.

West (1985) also reported that pigs show a variation in body temperature between 100.9 to 104.0^{0}F.

Mathur (1990) concluded that the average temperature of pig vary from 101.7^{0}F to 105.6^{0}F (38.6^{0}C to 40.9^{0}C).

According to Sebastian (1992) Pigs show a variation in body temperature between 101.9 to 102.6^{0}F. Korthals *et al.* (1994) observed that peak body temperature occurred between 12.30 and 22.45 h during the days when environmental temperature were increased starting at (8.30) with an average peak temperature occurring near 16.00 h. It was also found that a producer has one to five hour to take action after severe heat stressors occur in order to reduce its effect on growing and finishing pigs.

Dinesh (2000) reported that the rectal temperature of Mannuthy Large White Yorkshire pigs was slightly higher than the three newly imported groups (Duroc, Large White Yorkshire, Landrace) and among the three imported breeds, Duroc pigs had the highest average monthly rectal temperature.

Increased respiratory activity is an important means of heat dissipation in domestic animals at high temperature. Kibler *et al.* (1949) stated that the respiratory rate was increased with an increase in air temperature and humidity. Increased respiratory rate is usually the visible sign of response to heat stress and is placed third in the sequence of adaptive reaction as the unnoticed vasodilatation and sweating usually occurred earlier (McDowell, 1972). Increase in the rate of respiration causes an increased dissipation of heat in two ways; first by warming the inspired air and secondly by increasing the evaporation from the respiratory passage and lungs. The greater the volume of air that could be breathed in, warmed and humidified the greater resultant heat loss. The reaction of breathing to heat stress fall in two phases. In the first phase respiratory rate is increased with shallow breathing. In the second phase the reverse occurs and the air turnover is increased.

Kamada and Notsuki (1987) found that respiration rate was increased with temperature rise and in still air. Sebastian (1992) concluded that the respiratory rate of swine was in the range of 19 to 28.

Joseph (1997) reported that a significantly higher respiration rate in Large White Yorkshire pigs required in open sties without facility for wallowing or water sprinkling and in open sties without facility for wallowing and water sprinkling, but are left out to a shaded range during day time. But this has not reached the level of growth impairment.

Herz and Steinhauf (1978) concluded that results on the effect of heat stress on cardiac rate are inconsistent. These findings can be partially explained by the fact that there is a positive correlation between cardiac rate and metabolic speed. High heat levels consequently cause a rise in pulse rate, while moderate heat levels over a long period cause a drop. The pulse rate reflects primarily the homeostasis of circulation along with the general metabolic level. It increases on exposure to high environmental temperature (Salem, 1980; Aboul Naga, 1987). This increased blood flow from core to surface gives a chance for more heat to be lost by sensible and insensible ways. At very high temperature, it may decrease (Yousef and Johnson, 1966) due to decrease in metabolic rate of animals under heat stress.

However, some studies showed that pulse rate does not always change appreciably under higher environmental temperatures (Marai *et al.*, 1991).

Sebastian (1992) found that the pulse rate of Large White Yorkshire pigs was in the range of 64 to 73.

Joseph (1997) reported higher pulse rate in pigs housed in open sties without facility for wallowing or water sprinkling than pigs housed in open sties with facility for wallowing and water sprinkling at hot hours of the day.

2.5 Digestibility coefficient of nutrients

Pond *et al.* (1962) found a significant reduction in apparent digestibility of dry matter, nitrogen free extract and crude protein by the addition of fibre to the low protein ration. Similarly, Eggum *et al.* (1982) reported that growth rate and digestibility of dry matter, organic matter, nitrogen, nitrogen free extract, crude fat, crude fibre, gross energy, metabolizable energy: gross energy ratio were decreased when high fibre diet was fed to pigs.

Yen *et al.* (1983) suggested that contemporary, lean and obese genotype had no effect on coefficients of digestibility of nitrogen and energy.

Saitoh and Takahashi (1985) observed that the digestibilities of dry matter, gross energy, crude protein and crude fibre were decreased with increased feed intake while nutrient digestibilities increased with increasing body weight. However, the variations in nutrient digestibilities were least in pigs weighing from 30 to 70 kg and when fed at three to four per cent of body weight.

Fernandez *et al.* (1986) conducted digestibility experiments with 26 feedstuffs and diets in growing pigs and reported a wide variation in the digestibility coefficients of nutrients.

Sikka *et al.* (1987) conducted metabolism trials to see the effect of protein level on nitrogen digestibility and found that in summer, the apparent nitrogen digestibilities at

14 and 16 per cent protein diets were lower (71.20 and 72.00) than those of 20 and 22 per cent protein diets (76.8 and 77.8). In winter also, the digestibility of nitrogen of the 14 per cent diet was lower than that of 20 and 22 per cent (71.3 against 76.8 and 77.8).

Devi (1981) recorded digestibility co-efficient of 79.6 to 82.4, 73 to 80.3, 66.9 to 69.0, 37.1 to 40.0 and 86.3 to 90.1, respectively, for dry matter, crude protein, ether extract, crude fibre and nitrogen free extract when different levels of dried tapioca chips were incorporated in swine ration, where as Mohan (1991) concluded digestibility coefficients of dry matter, crude protein, ether extract, crude fibre and nitrogen free extract as 48.9 to 61.8, 55.9 to 65.3, 52.9 to 68.2, 20.6 to 27.4 and 61.8 to 76.1, respectively, for rations containing levels of prawn waste.

2.6 Estimation of digestibility by indicator method

Yen *et al.* (1983) found that 4N Hcl insoluble ash may be used as a natural indicator for estimating apparent nutrient digestibility in pigs, especially at younger ages. Kohler *et al.* (1990) used Chromic oxide and titanium oxide as solid phase Markers and Co– EDTA as liquid phase marker in pigs. The recovery rate of markers depended on fibre content of diets and marker recoveries were lowered in the protein-rich and fibre-rich-diets.

Moughan *et al.* (1991) added chromic oxide and acid insoluble ash as faecal markers in young growing pigs. They reported that total faecal collection gave higher apparent digestibility coefficients than those calculated by reference to chromic oxide for dry matter, organic matter and gross energy.

Jagger *et al.* (1992) found that the most appropriate inert marker for the determination of ileal and faecal apparent digestibility in pigs was titanium di-oxide added at the level of 1g/ kg feed.

Saha and Gilbreath (1993) developed a modified chromic oxide indicator ratio technique for accurate determination of nutrient digestibility. The method considered analytical chromium recovery in diets and faeces and faecal recovery of dietary chromium when used as a marker. The indicator most commonly added to feed to determine the digestibility coefficients of nutrients was chromium in the form of chromic oxide as cited by McDonald *et al.* (1995).

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

Leeuwen *et al.* (1996) evaluated chromic oxide and Hcl insoluble ash as markers of the determination of apparent ileal dry matter and crude protein digestibility of rations fed to pigs and concluded that chromic oxide was more suitable as a marker than Hcl insoluble ash.

Schiavon *et al.* (1996) compared total collection and chromic oxide techniques for the evaluation of apparent digestibility in pigs fed different diets and with different adaptation and collection periods. They found that seven days adaptation and four days collection were sufficient to obtain constant digestibility coefficients for organic nutrients.

Garcia *et al.* (1999) used microwave digestion and atomic absorption spectrophotometry to determine chromic oxide as a digestibility marker in feed, faeces and ileal contents.

2.7 Carcass characteristics

The nutritional factors concerned with the carcass quality are of prime importance when compared to other factors such as breed and sex (Sharda and Vidyasagar, 1986).

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. This report is in concordance with that obtained by Clawson *et al.* (1962). Higher levels of protein in the diet of pigs was reported to enhance lean growth (Cunningham *et al.*, 1973; Baird *et al.*, 1975 and Irwin *et al.*, 1975). 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.

Body measurements indicate body weight, which is having definite effect on carcass characteristics. Studies by Christian *et al.* (1980) in 288 pigs for the effect of sex, breed cross, dietary protein level and their slaughter weight and their first order interaction on performance and carcass traits noted that barrows grew faster than gilts but had low percentage of ham and loin, shorter carcass, shorter loin eye area and more back fat. Lean cross pigs had higher average daily gain, lower marbling and colour scores, less back fat, longer loin eye area and higher ham and loin percentage. Compared with 12 per cent protein diet 16 per cent protein diet decreased marbling scores and increased feed efficiency. Pigs slaughtered at 113.5 kg body weight was faster in gain but less efficient when compared to pigs of 98.5 kg body weight. High weight animals produced carcass with less ham and loin percentage, more back fat and increased carcass length. It was further concluded that there was no difference between gilts and barrows to high protein diets and there is no need of feeding gilts and barrows separately.

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

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

Latimier and Dourmad (1993) studied the effect of three protein feeding strategies for grower and finisher pigs and found that growth rate and feed conversion efficiency were similar in all groups, while the dressing percentage decreased with increased dietary protein.

An increase in dietary crude protein or lysine: energy led to a significant improvement in lean content (Castell *et al.*, 1994). Kuhn and Burgstaller (1995) concluded that when low protein diets were supplemented with lysine for heavy finishers, there was no significant difference in carcass yield and quality.

Xie *et al.* (1995) found that the back fat thickness was affected by energy level and the lean percentage by crude protein level.

Various methods are practiced by restricting the energy intake at the finishing time in order to have leaner carcasses. Higher energy level increased carcass back fat thickness (Baird *et al.*, 1970) and lower energy level decreased carcass back fat (Talley *et al.*, 1976 and Sinacek and Prokop., 1983). Robinson (1976) studied that with an increase in the dietary level of energy, there is a faster growth rate and lower lean content. Significant difference was observed in some loin fat measurement and fat overlying the eye muscle on the lower levels of feed intake. The dressing percentage was significantly higher in case of animals on low plane of nutrition than those on high plane.

Metz *et al.* (1980) observed that restriction of the daily energy intake by 20 per cent caused eight per cent lower carcass muscle growth and a 28 per cent lower fatty tissue growth.

Increase in the intake of energy significantly increased empty body weight and protein and lipid gains of pigs slaughtered (Kyriazakis and Emmans, 1992).

Huegten and Stumpf (1996) reported that a metabolizable energy level of 3275 Kcal/ kg gain was sufficient to maximise average daily gain and a further increase in the level of energy resulted in increased back fat thickness in finishing pigs.

Effect of season has been found to influence the carcass quality. Baird *et al.* (1970) reported that winter fed pigs gained more slowly, had a higher dressing percent, yielded more lean and primal cuts with larger longissimus dorsi areas than the summer – fed pigs. In contrast, Baird (1973) stated that summer – fed pigs were significantly leaner than the winter – fed pigs and the winter – fed pigs required more feed per unit of gain. In summer, when pig diets were supplemented with nine per cent fat, the carcasses yielded had higher dressing percentage, more back fat thickness and lesser loin eye area. Sebastian (1992) reported that Large White Yorkshire pigs born in dry season carcass quality were superior to animals born in rainy season.

Carcass quality is influenced by crude fibre in the diet. The yields of lean cuts and primal cuts decreased with high fibre level (Baird *et al.*, 1970). There was a significant reduction in back fat thickness when the fibre level was increased and energy level was decreased in diet of pigs after they reached 50 kg body weight (Ranjhan *et al.*, 1972).

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

Varel *et al.* (1984) found that pigs fed the high fibre diet which contained 35 per cent alfalfa meal, gained 17.3 per cent less had increased feed to gain ratio, less carcass weight, 35 – 42 per cent less back fat and 1.8 per cent less loin eye area than those fed the low fibre diet without alfalfa meal.

Effect of sex markedly influences carcass characteristics. Gilts yielded better carcasses with lesser back fat (Christian *et al.*, 1980 and Shields and Mahan, 1980). Russo (1973) found that male pigs grew faster and used feed more efficiently than the female from 90 kg onwards. The female pigs had a higher dressing percentage and a greater proportion of fat cuts and a smaller proportion of lean cuts than male pigs.

Shields and Mahan (1980) opined that barrows gained faster than gilts but gilts had leaner carcasses, as indicated by lean cut percentage, back fat thickness and longissimus muscle area.

Ramaswami *et al.* (1984) stated that carcass length and loin eye area were significantly higher in gilts than barrows at all weights. There was significant sex difference for dressing percentage and carcass weight. Values for all increased with increase in body weight. Differences between different slaughter weight groups were significant.

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 back fat thickness of 2.82 ± 0.09 cm. There was no significant sex difference for the above traits, while the effect of sires 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.

Bhadoria (1996) concluded that the dressing percentage ranged from 61.58 to 73.38 per cent and the ham weight ranged from 20.95 to 26.04 kg and the ham weight were not influenced by the sex of the animals in Large White

Yorkshire pigs. Sex and its interaction with genetic group had non significant effect on slaughter weight, back fat thickness, carcass weight and loin eye area (Singh *et al.*, 1997) but significant effect on post weaning body weight (Singh *et al.*, 1998b) and carcass length (Arora *et al.*, 1994).

Effect of breed is found to have marked influence on the quality of carcass. Aunan *et al.* (1961) found that there was a highly significant effect of breed on all measures of carcass leanness in pigs. Duroc pigs gained weight faster and more efficiently than Hampshire. Hampshire pigs produced longer carcass with less fat, larger loin area and higher yield of lean cut. Cerna *et al.* (1982) reported that effect of breed of dam, breed of sire, parity, litter size, sex, duration of fattening, body weight at slaughter, back fat thickness, carcass weight during gain and during finishing and feed conversion are the factors which will affect significantly the finishing performance and carcass characteristics in pigs.

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. But Arora *et al.* (1994) concluded a non significant effect of genetic group on carcass traits except the loin eye area.

Singh *et al.* (1997) stated that crossbred pigs had more dressing percentage when compared to pure breeds including exotic and desi pigs. He has also reported that among pure breeds Hampshire pigs had significantly higher ($30.43cm^2$) loin eye area than Large White Yorkshire crosses ($23.66cm^2$). The research conducted by Singh *et al.* (1998a) to assess the influence of age on carcass traits showed that the optimum slaughter age for Landrace and Large White Yorkshire pigs was 131 to 190 days and 371 to 430 days, respectively.

Age and Live body weight markedly influences carcass characteristics. Deo *et al.* (1980) did not observe significant influence of age at slaughter on dressing percentage and loin eye area.

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

Singh *et al.* (1997) reported progressive increase in carcass length, carcass weight and back fat thickness, with the advancement of age. He also reported that the amount of fat in the early age is comparatively lesser.

Grady (1966) Havorka *et al.* (1974) and Wajda (1975) had reported that because of decreasing percentage of lean content on optimum slaughter weight of 90 kg was indicated. Anjaneyulu *et al.* (1984) stated that the yield of head, hot and chilled carcass, dressing percentage, back fat thickness and loin eye area were significantly more in higher age groups while per cent of ham and lean cut of carcass were significantly higher in young animals. Ramaswamy *et al.* (1985) found that increase in slaughter weight was associated with significant increase in dressing percentage (77.93 ± 0.29 to 81.18 ± 0.26) and back fat thickness from 2.87 ± 0.05 cm to 4.11 ± 0.07cm. There was significant decrease in carcass lean percentage. The total weight of lean cuts and the weight of lean cuts as percentage of carcass weight did not differ significantly between slaughter weight groups in Large White Yorkshire pigs.

The study carried out by Dash and Mishra (1986) in cross-breds in Orissa revealed that the carcass length and back fat thickness were 42.25 ± 0.25 cm and 0.90 ± 0.15 cm, respectively.

Bhattacharyya and Sundaram (1988) stated that the males maintained in field conditions under scavenging and supplementary feeding in Goa, the carcass length and dressing percentage of cross bred males were 63 ± 0.87 cm and 64.5 per cent respectively.

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

Cisneros *et al.* (1996) was also of the view that as the slaughter weight increased, feed intake, back fat thickness and loin eye area increased.

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, 2.97cm^2, 15.68 ± 0.41 cm^2 and 66.76 per cent, 58.82 per cent respectively.

Sharma and Reddy (1997) stated that the dressing percentage of Large White Yorkshire Pigs reared on garbage was 71.44 per cent. It was concluded that pigs of lesser weight gave more lean cuts than the pigs of heavier pigs.

Singh *et al.* (1998a) reported that pigs with lesser weight are more desirable for lean cuts as with advancing age and live weight above 70 kg, the proportion of ham was reduced and that of bacon was increased. Dressing percentage of crossbred pigs at Mannuthy was 69.11 ± 3.74 per cent (AICRP Report, 1999).

Fat characteristics are influenced by the nature of food. Fatty acids with a high proportion of low molecular weight and unsaturated fatty acids will have a low melting point. Subcutaneous fat contain higher proportion of unsaturated fatty acids and so are softer than deep body fat (Maynard *et al.*, 1969). Melting point gives a useful measure of hardness of fat and indirectly reflects the degree of unsaturation. Lard is having melting in the range of 36–48^{0}c, Iodine value in the range of 40 – 75 and saponification value in the range of 190 – 200 (Carton, 1965).

Maynard *et al.* (1969), Sebastian (1972) and Ramachandran (1977) also reported similar values in melting point, saponification value and Iodine value.

Tokoro (1984) stated that melting point of fat was significantly higher in pigs finished in winter than in summer.

Feeding experiments conducted by Yatsenko (1987) in Large White Yorkshire pigs fed with standard ration with 10 per cent and 15 per cent less protein reported an average of 53-63 for iodine value.

Sebastian (1992) reported that melting point, saponification value and Iodine value did not show any significant difference between seasons and sexes in Large White Yorkshire pigs.

2.8 Behaviour

Hunt *et al.* (1985a) and Hunt (1988) found that there was no obvious effect on floor space allowance on the welfare of pigs assessed by behavioural, productivity and health parameters.

Spicer and Aherne (1988) reported that different stocking densities did not seem to influence the time spent by pigs resting, active and non feeding or sitting.

On studying the implications of individual behavioural characteristics on performance in pigs, Hessing *et al.* (1994) reported that behaviour affected daily weight gain, carcass weight, meat percentage, carcass classification and financial benefits.

Labroue *et al.* (1995) observed differences in feeding behaviour with respect to daily feed intake, rate of feed intake and number of meals per day between Large White Yorkshire and pietrain pigs and these behavioural differences increased as body weight increased.

Dinesh (2000) found that the behaviour pattern manifested by the pigs was observed during the noon hours of the day and before, during and after feeding. In Mannuthy, Large White Yorkshire Pigs were the most aggressive, excited class followed by Duroc, Large White Yorkshire and Landrace pigs. During feeding time, the animals tried to displace the other animals from the manger. All the four breeds manifested this behaviour. During the noon hours stress signs like panting, salivation etc., were not noticed in the three newly imported breeds or in the existing Large White Yorkshire Pigs.

Heitman *et al.* (1961) indicated that the pigs at greater space allowance tended to spent more time sleeping or resting and less time standing or walking. The evidence of increased aggression due to crowding comes from several studies Bryant and Ewbank, 1972; Ewbank and Bryant 1972 and Kelly *et al.*, 1980. The above workers have noticed an increase in the number of agonistic interactions. Kelly *et al.*

(1980) did not find evidence to show that increasing stocking rate altered tail-biting behaviour among finishing pigs fed ad-libitum.

Cornelium *et al.* (1981) also observed that tail biting increased as stocking density increased and reduced with age.

Hajek (1984) noticed that pigs at lower stocking densities spent more time in resting than those in higher stocking densities.

Sather *et al.* (1995) concluded that the greatest amount of aggressive pen activity occurred, within the first hour of mixing, but the activity persisted for atleast 12 h after mixing. Disturbing the pigs by moving to the abattoir also caused high levels of activity. According to them mixed pigs were accounted for 75 per cent of aggressive activity.

2.9 Cost of production per kg live body weight

Cost of production per kg live body weight was lowest for Large White Yorkshire followed by crossbreds and Desi pigs from weaning to eight months of age as reported by Joseph (1997) and Suraj (2000).

Materials and Methods

3. MATERIALS AND METHODS

3.1 Animals

Three groups of twelve weaned female piglings each belonging to indigenous (Desi), Large White Yorkshire (LWY) and crossbreds (CB) (LWY x Desi) of Centre for Pig Production and Research (CPPR), Kerala Agricultural University, Mannuthy were selected as the experimental animals.

Animals for the study were selected as uniform as possible with regard to age and body weight.

All the animals were dewormed before the commencement of the experiment and maintained under similar managemental conditions of the farm during the experimental period of 210 days.

3.2 Experimental diets

The piglings were maintained on two planes of feeding with respect to crude protein (CP) as follows:

A. Treatment I – ICAR recommended Level of crude protein

- T1 → G1 – 6 indigenous piglings
- T1 → G2 – 6 exotic piglings
- T1 → G3 – 6 crossbred piglings

B. Treatment II – A Low Plane (LP) of 10 per cent less of crude protein with reference to ICAR level.

- T2 → G1 – 6 indigenous piglings
- T2 → G2 – 6 exotic piglings
- T2 → G3 – 6 crossbred piglings

All the pigs were fed iso-caloric ration as per ICAR recommendations.

Table 3.1 CP and DE content of the experimental diets

Treatment Group (Diet)	Body weight Group	Crude protein (%)	Digestible energy kcal/ kg
I	Weaning to 10 kg	18.0	3,100
	10 kg to 40 kg	16.0	3,000
	40 kg to slaughter weight	14.0	3,000
II	Weaning to 10 kg	16.2	3,000
	10 kg to 40 kg	14.4	3,000
	40 kg to slaughter weight	12.6	3,000

The method described in Association of Official Analytical Chemists (A.O.A.C, 1990) was followed to estimate the chemical composition of the diets.

The ingredient composition and the chemical comparison of the experimental diets are given in Table 3.2, 3.3, 3.4 and 3.5 respectively.

Table 3.2 Ingredient composition of diet – 1 (as per ICAR recommendation)

Ingredients (Parts/100)	CP 18 %	CP 16 %	CP 14 %
Yellow maize	40.0	49.0	60.5
Soyabean Meal	11.0	8.5	5.0
Rice polish	15.0	8.0	19.0
Wheat bran	20.5	24.5	6.0
Dried unsalted fish	12.0	8.5	8.0
Mineral Mixture	1.0	1.0	1.0
Common salt	0.5	0.5	0.5
Vitamin A B_2 D_3 (INDOMIX)	10 gm	10 gm	10 gm

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

INDOMIX ® vitamin supplement (Piramal) Health care, Mumbai).

Composition per gram

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

Table 3.3 Ingredient composition of experimental diet – 2 (10 per cent less crude protein)

Ingredients (Parts/100)	CP 16.2 %	CP 14.4 %	CP 12.6 %
Yellow maize	48.5	54.5	60.5
Soyabean Meal	8.0	5.0	4.0
Rice polish	8.0	21.5	21.0
Wheat bran	24.5	8.5	8.0
Dried unsalted fish	9.5	9.0	5.0
Mineral Mixture	1.0	1.0	1.0
Common salt	0.5	0.5	0.5
Vitamin A B_2 D_3 (INDOMIX)	10 gm	10 gm	10 gm

Note: Vitamin supplement added @ 10gram per 100 kg feed mixed. INDOMIX ® vitamin supplement (Piramal Health care, Mumbai)

Composition per gram

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

Table 3.4 Chemical composition of diet – 1 (as per ICAR recommendation)[a]

Ingredients	CP 18 %	CP 16 %	CP 14%
Dry matter	91.20	88.40	90.92
Crude Protein (Nx6.25)	18.01	16.02	14.01
Ether extract	4.80	5.10	5.82
Crude fibre	6.12	6.03	5.76
Nitrogen free extract	60.87	62.75	65.31
Total Ash	10.20	10.10	9.10
Acid Insoluble ash	5.01	5.61	5.30
Calcium	1.25	1.06	1.42
Phosphorus	0.70	0.70	0.70

a – on dry matter basis

Table 3.5 Chemical composition of experimental diet -2 (10 per cent less crude protein)[a]

Ingredients	CP 16.2 %	CP 14.4 %	CP 12.6%
Dry matter	88.90	90.52	88.00
Crude Protein (Nx6.25)	16.19	14.41	12.62
Ether extract	5.18	5.74	6.02
Crude fibre	6.08	5.86	5.60
Nitrogen free extract	62.42	64.87	66.71
Total Ash	10.13	9.12	9.05
Acid Insoluble ash	5.70	5.40	5.34
Calcium	1.10	1.30	1.02
Phosphorus	0.70	0.72	0.60

a – on drymatter basis.

3.3 Feeding trial

The piglets of each pen were group-fed throughout the experimental period. Every day at 09.00 hours and 14.30 hours animals were provided with the concentrate in the feed trough and allowed to consume as much as they could, within a period of one hour. Clean drinking water was provided in all the pens throughout the experimental period. Daily feed intake was recorded both in the morning and evening hours. Feed conversion efficiency and average daily gain were also recorded.

The growth parameters in terms of live weight, height, length and girth were recorded at fortnightly intervals. The body weight of the pigs were recorded using a platform balance having a built-in-cage. Body measurements such as length, girth and height were recorded as described below.

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 the point of bisection of this line in the mid dorsal line was taken as the posterior land mark. The distance in centimeters between these two land marks was taken as the body length.

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

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

Physiological variables like rectal temperature, pulse rate and respiratory rate were recorded at weekly intervals throughout the experimental period.

Digestibility trial was conducted at the end of the experiment to determine the digestibility coefficient of nutrients of the experimental diets. Chromic oxide was added @ 0.05 per cent to each experimental diet as an external indicator for measuring the digestibility coefficient of nutrients. Chromic oxide was mixed first with small quantity of feed and then with the already mixed feed in a vertical feed mixer for 10 minutes to ensure proper mixing.

The animals were fed Chromic oxide mixed rations for a period of four days. Faeces was collected for three days from the second day onwards.

Faecal grab samples, uncontaminated with urine, were collected from different places of each pen at 07.00, 13.00 and 16.30 hours, during the collection period of three days. The samples of faeces from each pen taken each day were pooled accordingly and were placed in double lined polythene bags, labelled and kept in the deep freezer for analysis. From the pooled feed and faecal samples, subsamples were taken and analysed for proximate composition as per standard methods (AOAC, 1990).

The chromium content was determined using Atomic Absorption Spectrophotometer. The digestibility coefficient was calculated using appropriate formulae (Maynard *et al.*, 1979)

3.4 Slaughter studies

Three animals from each treatment were selected randomly and 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.

The length of the carcass was measured from the anterior edge of the aitch bone (Os – Sacrum) to the anterior border of the first rib and expressed in centimetre as carcass length.

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

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

The dressing percentage was calculated using the following formula.

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

Saponification value, iodine number, and melting point of lard were estimated as per the method specified in A.O.A.C (1990).

3.5 Behaviour of pigs

Behaviour of pigs were studied for a duration of one hour in a day.

The observation on feeding behaviour in pigs was quantified by scores as described in Table 3.6 (Thomas and Joseph, 1994).

Table 3.6 Feeding Behaviour

Sl. No	Description	Score
1	Excitement, restlessness, eagerness, grunting, gnawing, drooling of saliva etc at feeding.	3
2	Moving around in the pen, grunting, drooling saliva etc.	2
3	Quiet with casual interest towards feed	1

Competition and aggressive behaviour manifested were noticed during eating. Number of threats and biting were counted during feeding time. The other behavioural observations were noted just before, during and after feeding to find out any change in pattern of behaviour. One group was observed for their behaviour pattern on one day and other five groups were observed on subsequent days. This pattern was repeated.

The cost of production from weaning to slaughter was calculated in all the treatment groups with assumptions that feed represented 75 per cent of the total cost of production.

The data collected during the course of the study were statistically analysed as per the method described by Snedecor and Cochran (1981).

Results

4. RESULTS

The results obtained during the course of the experiment are presented below.

4.1 Body weights and measurements

As the weaning weight of three breeds of pigs were different, covariance analysis was done to find the significant differences if any in the growth of the breeds studied. The adjusted mean body weight, body length, body girth and body height of pigs of treatment groups T_1 and T_2 recorded at fortnightly intervals are presented in Tables 4.1, 4.2, 4.3, 4.4 and Fig 4.1a-4.1c, 4.2a-4.2c, 4.3a-4.3c, 4.4a-4.4c respectively. At seven months of age for all the growth traits except body girth Large White Yorkshire excelled followed by Crossbred and Desi pigs.

4.2 Rectal temperature, pulse rate and respiratory rate

The average rectal temperature, pulse rate and respiratory rate are presented in Tables 4.5, 4.6, 4.7 and depicted in Fig 4.5a-4.5c, 4.6a-4.6c, 4.7a-4.7c respectively.

4.3 Feeding

The average daily feed intake of animals in each fortnight is given in Table 4.8 and depicted in Fig 4.8a-4.8b. In both the treatment groups, feed intake was more in crossbred than Yorkshire and least in Desi pigs.

4.4 Average daily gain and feed conversion efficiency

Average Daily Gain (ADG) and feed conversion efficiency (FCE) are presented in Tables 4.9, 4.10 and depicted in Fig. 4.9a-4.9b and 4.10. Average daily gain was highest in Yorkshire, followed by Crossbred and least in Desi pigs. The study showed that feed conversion efficiency was better in Yorkshire than the other two breeds.

4.5 Digestibility coefficient of nutrients

Data on digestibility coefficients of nutrients of the two experimental rations T_1 and T_2 are presented in Table 4.11 and Fig 4.11a-4.11c respectively.

4.6 Carcass characteristics

Data on carcass characteristics are summarised in Table 4.12.

4.7 Fat constants

The average melting point, saponification value and Iodine value of pigs are given in Table 4.13.

4.8 Behaviour of pigs

The feeding and agonistic behaviour of pigs are presented in Table 4.14 and 4.15.

4.9 Economics of production

Data on the cost of production (Rs.) per kg live weight gain of pigs maintained on the two dietary treatment groups T_1 and T_2 are presented in Table 4.16 and represented in Fig 4.12.

Table 4.1 Adjusted mean body weight of three breeds of pigs fed with two different rations

Fortnights	Adjusted Mean Body Weight (Kg)							
	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
1	10.943^{a}	11.299^{a}	10.981^{a}	11.074^{NS}	10.782^{a}	10.894^{a}	9.269^{a}	10.315
2	14.056^{a}	13.264^{a}	13.768^{a}	13.696^{*}	12.807^{a}	13.212^{a}	10.976^{b}	12.332
3	18.860^{a}	15.549^{a}	18.230^{a}	17.547^{**}	16.032^{a}	15.644^{a}	15.018^{a}	15.565
4	24.170^{a}	22.946^{ab}	20.168^{b**}	22.428^{**}	18.272^{a}	22.405^{b}	17.789^{a}	19.489
5	28.424^{a}	26.807^{a}	24.394^{b**}	26.541^{**}	20.620^{a}	25.069^{b}	21.603^{a}	22.431
6	38.599^{a}	31.113^{b}	28.691^{b**}	32.801^{**}	27.736^{a}	28.933^{a}	25.344^{a}	27.338
7	43.584^{a}	35.350^{b}	31.705^{b**}	36.879^{NS}	35.147^{a}	35.691^{a}	28.191^{b}	33.009
8	52.118^{a}	40.606^{b}	36.136^{b**}	42.953^{NS}	43.989^{a}	40.667^{a}	32.734^{b}	39.130
9	56.066^{a}	48.223^{b}	41.092^{c*}	47.725^{NS}	49.036^{a}	46.017^{a}	37.065^{b}	44.775
10	61.030^{a}	57.860^{b}	46.179^{b*}	52.387^{NS}	54.967^{a}	49.952^{a}	42.013^{b}	49.613
11	66.132^{a}	56.346^{b}	50.164^{b*}	56.565^{NS}	59.943^{a}	53.398^{ab}	46.184^{b}	54.158
12	70.926^{a}	60.905^{b}	54.585^{ab**}	61.331^{NS}	65.154^{a}	58.483^{a}	48.947^{b}	58.335
13	77.093^{a}	67.440^{b}	57.973^{c**}	65.672^{NS}	71.518^{a}	61.949^{b}	57.361^{c}	63.439
14	82.111^{a}	70.219^{b}	60.720^{c**}	69.154^{NS}	77.612^{a}	64.632^{b}	53.457^{c}	67.096

Means having the same superscript in a row do not differ significantly

NS – Non significant

* – Significant at 5 per cent

** – Significant at 1 per cent

Fig 4.1a ADJUSTED MEAN BODY WEIGHT OF PIGS FED WITH ICAR RATION

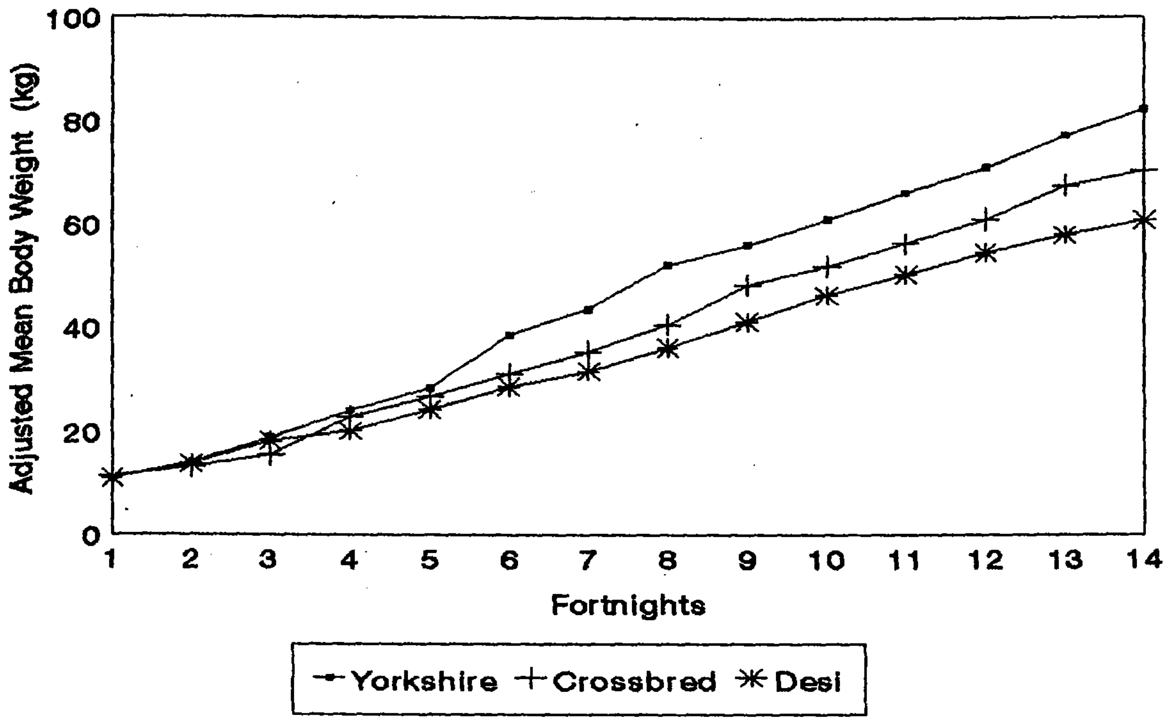

Fig 4.1b ADJUSTED MEAN BODY WEIGHT OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

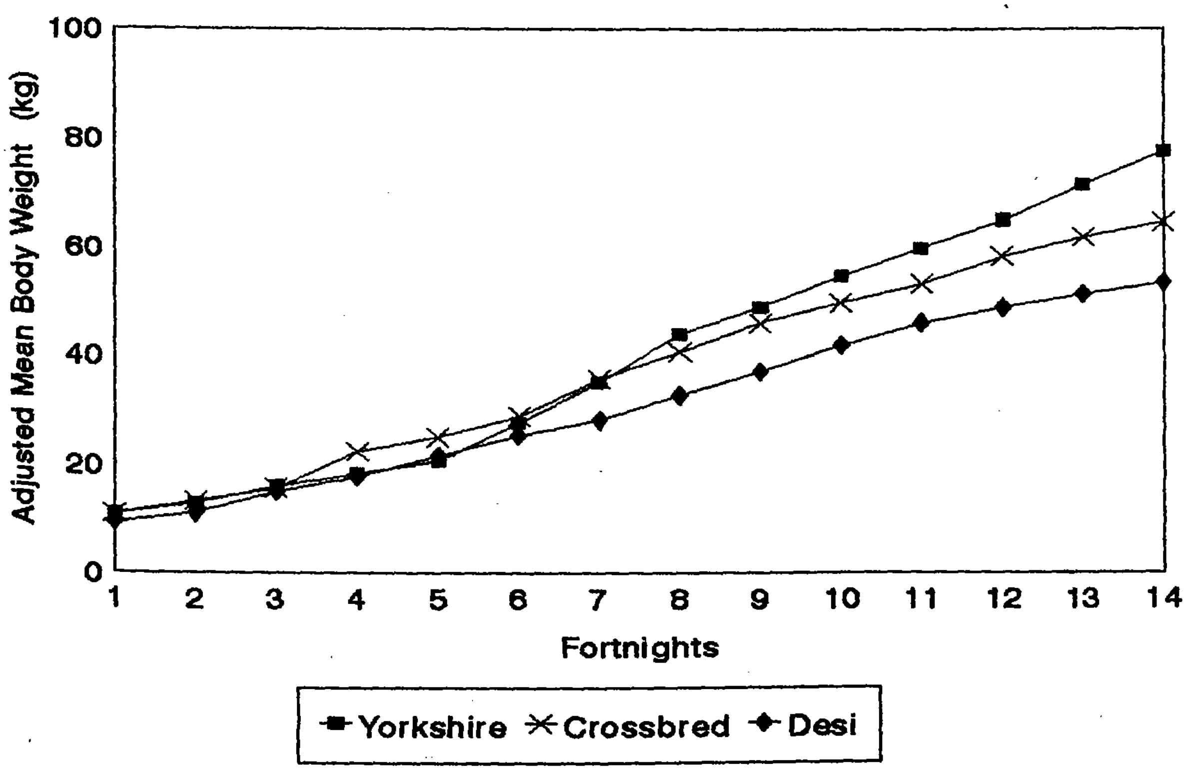

Fig 4.1c COMPARISON OF ADJUSTED MEAN BODY WEIGHT OF PIGS FED WITH TWO DIFFERENT RATIONS

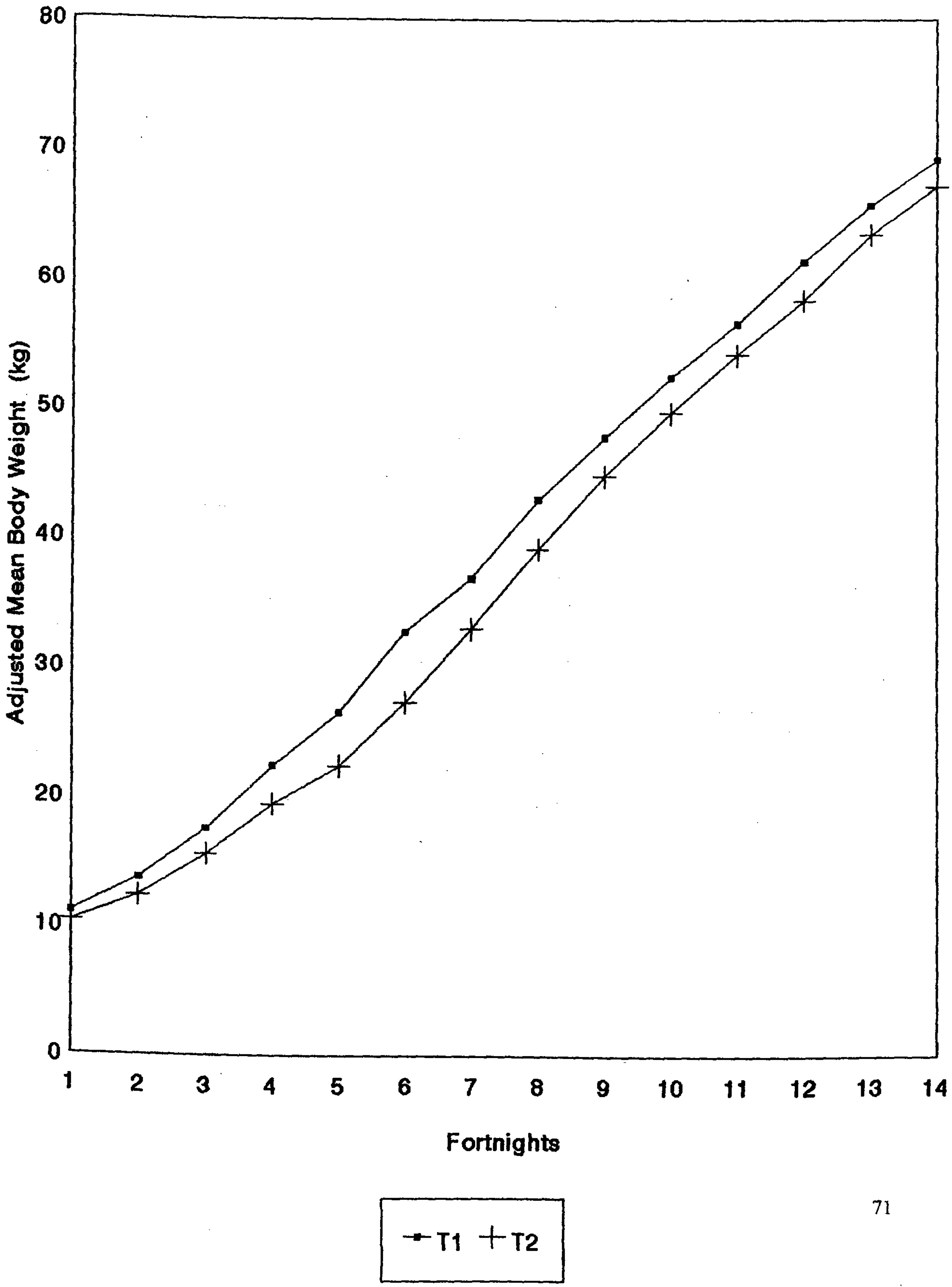

Table 4.2 Adjusted mean body length of three breeds of pigs fed with two different rations

Fortnights	Adjusted Mean Body Length (cm)							
	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
1	43.79^{a}	43.06^{a}	38.81^{b**}	41.89^{NS}	42.02^{a}	42.66^{a}	37.30^{b}	40.66
2	46.13^{a}	45.06^{a}	40.04^{b**}	43.74^{NS}	44.98^{a}	44.63^{a}	39.13^{b}	42.91
3	49.31^{a}	48.75^{a}	43.83^{b**}	47.30^{NS}	46.87^{a}	47.62^{a}	42.43^{b}	45.64
4	51.51^{a}	51.76^{a}	45.95^{b**}	49.74^{NS}	48.14^{a}	50.57^{a}	44.72^{b}	47.81
5	57.99^{a}	58.44^{a}	48.72^{b**}	55.05^{**}	54.79^{a}	56.80^{a}	47.56^{b}	53.05
6	63.79^{a}	62.58^{a}	51.05^{b**}	59.14^{**}	57.93^{a}	59.84^{a}	50.29^{b}	56.02
7	65.58^{a}	64.74^{a}	54.23^{b**}	61.52^{**}	60.41^{a}	61.85^{a}	52.99^{b}	58.41
8	69.40^{a}	67.98^{a}	58.16^{b**}	65.18^{**}	65.41^{a}	64.91^{a}	57.11^{b}	62.48
9	72.04^{a}	68.59^{a}	60.66^{b**}	67.10^{NS}	68.21^{a}	66.79^{a}	59.85^{b}	64.95
10	74.05^{a}	70.52^{a}	63.50^{b**}	69.36^{NS}	69.08^{a}	67.40^{a}	61.92^{b}	66.13
11	75.38^{a}	71.74^{a}	65.91^{b**}	71.01^{**}	70.60^{a}	69.32^{a}	63.87^{b}	67.93
12	78.87^{a}	72.42^{b}	67.09^{c**}	72.80^{NS}	74.31^{a}	71.58^{a}	66.53^{b}	70.80
13	84.20^{a}	78.58^{b}	72.03^{c**}	78.27^{NS}	81.84^{a}	74.12^{b}	69.20^{c}	75.05
14	86.64^{a}	81.34^{b}	74.21^{c**}	80.80^{NS}	83.22^{a}	77.56^{b}	73.14^{c}	77.97

Means having the same superscript in a row do not differ significantly

NS – Non significant

* – Significant at 5 per cent

** – Significant at 1 per cent

Fig 4.2a ADJUSTED MEAN BODY LENGTH OF PIGS FED WITH ICAR RATION

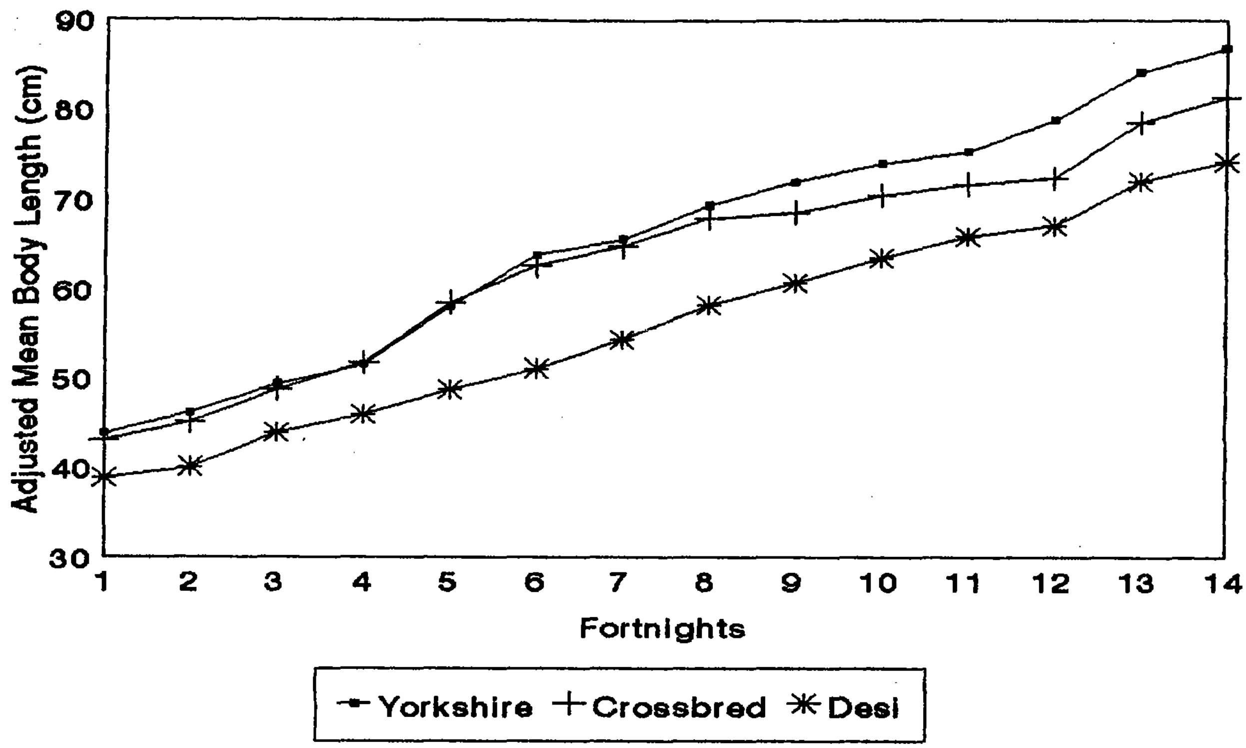

Fig 4.2b ADJUSTED MEAN BODY LENGTH OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

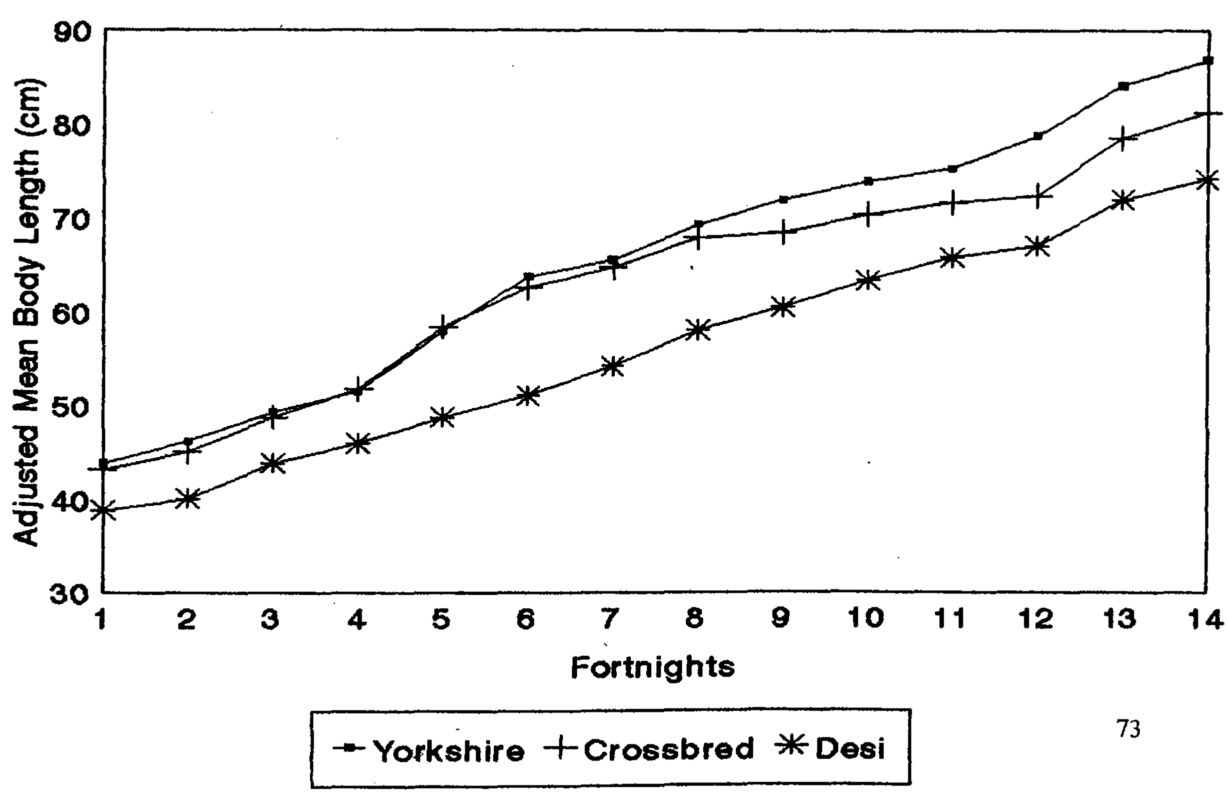

Fig 4.2c COMPARISON OF ADJUSTED MEAN BODY LENGTH OF PIGS FED WITH TWO DIFFERENT RATIONS

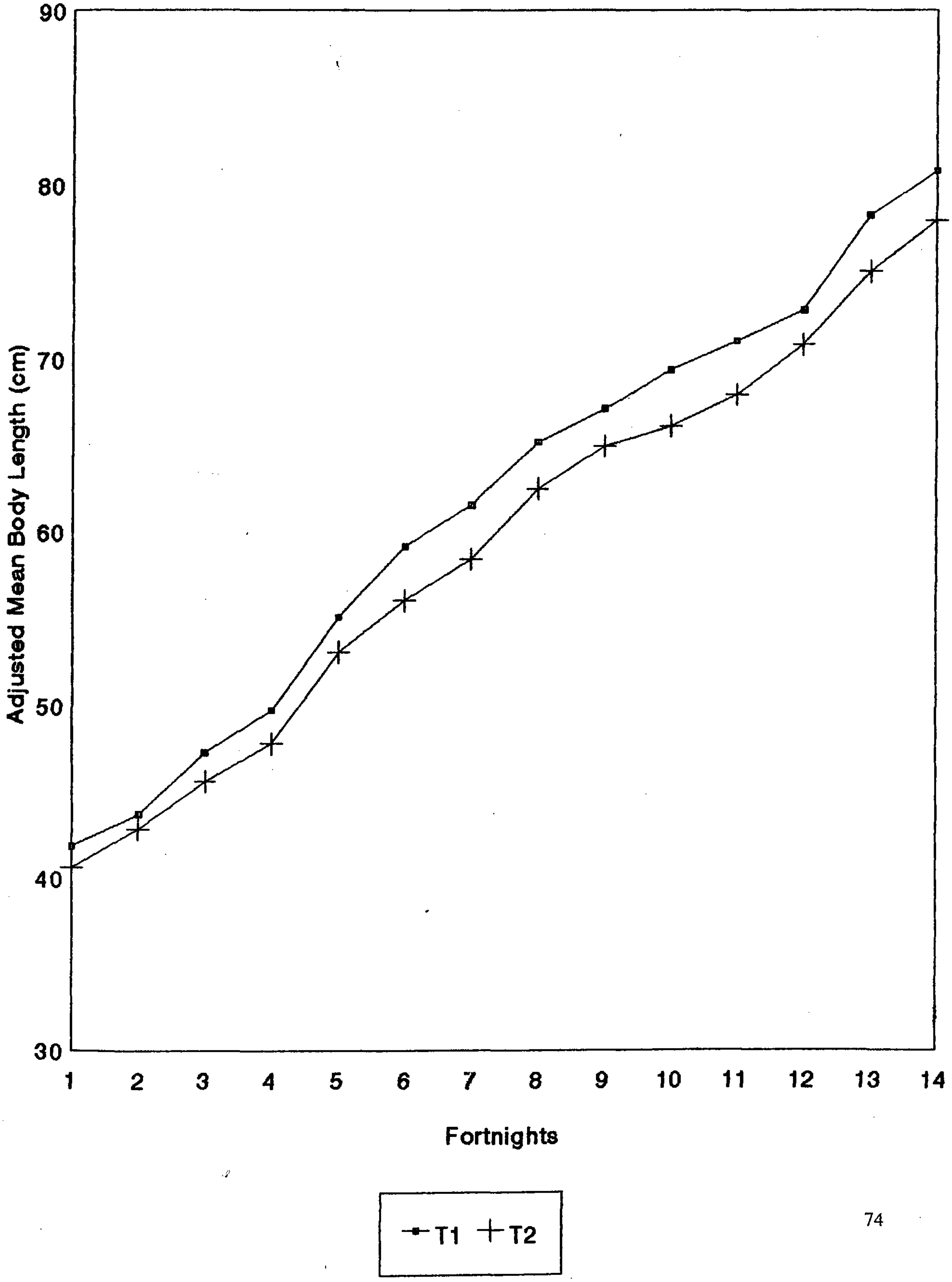

Table 4.3 Adjusted mean body girth of three breeds of pigs fed with two different rations

Fortnights	Adjusted Mean Body Girth (cm)							
	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
1	48.03 ^{a}	50.20 ^{a}	44.01 ^{b**}	47.41 **	46.70 ^{a}	46.53 ^{a}	42.02 ^{b}	45.08
2	51.98 ^{a}	53.17 ^{a}	46.91 ^{b**}	50.68 **	49.16 ^{a}	49.50 ^{a}	44.25 ^{b}	47.63
3	58.19 ^{a}	58.27 ^{a}	50.22 ^{b**}	55.56 **	53.16 ^{a}	54.20 ^{a}	48.26 ^{b}	51.87
4	60.22 ^{a}	60.96 ^{a}	54.68 ^{b**}	58.62 **	57.55 ^{a}	54.02 ^{b}	50.54 ^{c}	54.03
5	67.50 ^{a}	63.25 ^{b}	58.22 ^{c**}	62.99 **	66.06 ^{a}	55.67 ^{b}	51.94 ^{c}	57.89
6	74.47 ^{a}	71.99 ^{b}	64.75 ^{c**}	70.40 **	72.00 ^{a}	67.21 ^{b}	59.21 ^{c}	66.14
7	77.95 ^{a}	77.78 ^{a}	70.27 ^{b**}	75.33 **	74.67 ^{a}	72.77 ^{a}	65.70 ^{b}	71.04
8	81.02 ^{a}	81.44 ^{a}	66.40 ^{b**}	76.19 **	76.95 ^{a}	76.59 ^{a}	62.54 ^{b}	72.03
9	85.39 ^{a}	85.16 ^{a}	72.52 ^{b**}	81.02 **	80.81 ^{a}	81.28 ^{a}	65.48 ^{b}	75.86
10	87.00 ^{a}	87.34 ^{a}	75.22 ^{b**}	83.19 *	83.17 ^{a}	84.35 ^{a}	72.73 ^{b}	80.08
11	91.96 ^{a}	91.41 ^{a}	81.90 ^{b**}	88.42 *	88.90 ^{a}	86.11 ^{a}	75.36 ^{b}	83.46
12	94.76 ^{a}	93.85 ^{a}	84.43 ^{b**}	91.02 *	90.08 ^{a}	88.68 ^{a}	77.50 ^{b}	85.42
13	97.62 ^{a}	96.96 ^{a}	85.33 ^{b**}	93.30 *	93.00 ^{a}	92.35 ^{a}	80.85 ^{b}	88.73
14	101.34 ^{a}	100.92 ^{a}	88.25 ^{b**}	96.84 *	98.10 ^{a}	95.55 ^{a}	84.99 ^{b}	92.88

Means having the same superscript in a row do not differ significantly

NS – Non significant

* – Significant at 5 per cent

** – Significant at 1 per cent

Fig 4.3a ADJUSTED MEAN BODY GIRTH OF PIGS FED WITH ICAR RATION

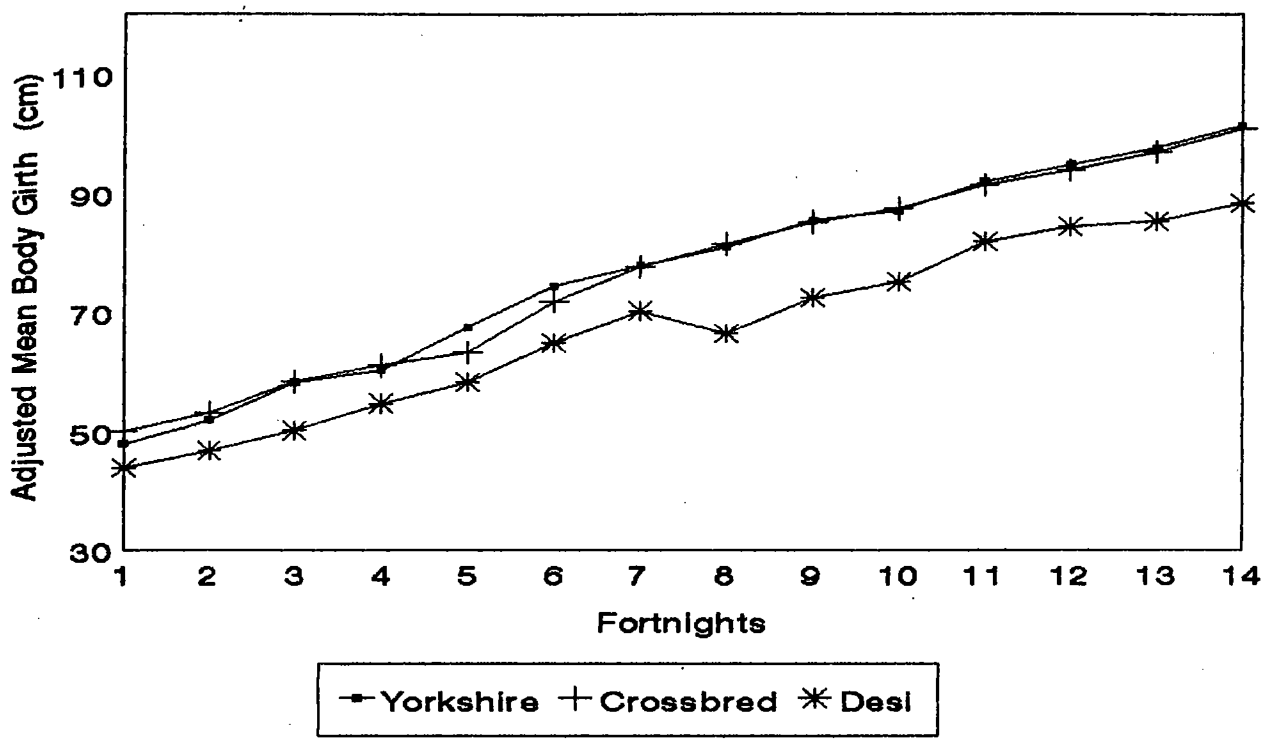

Fig 4.3b ADJUSTED MEAN BODY GIRTH OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

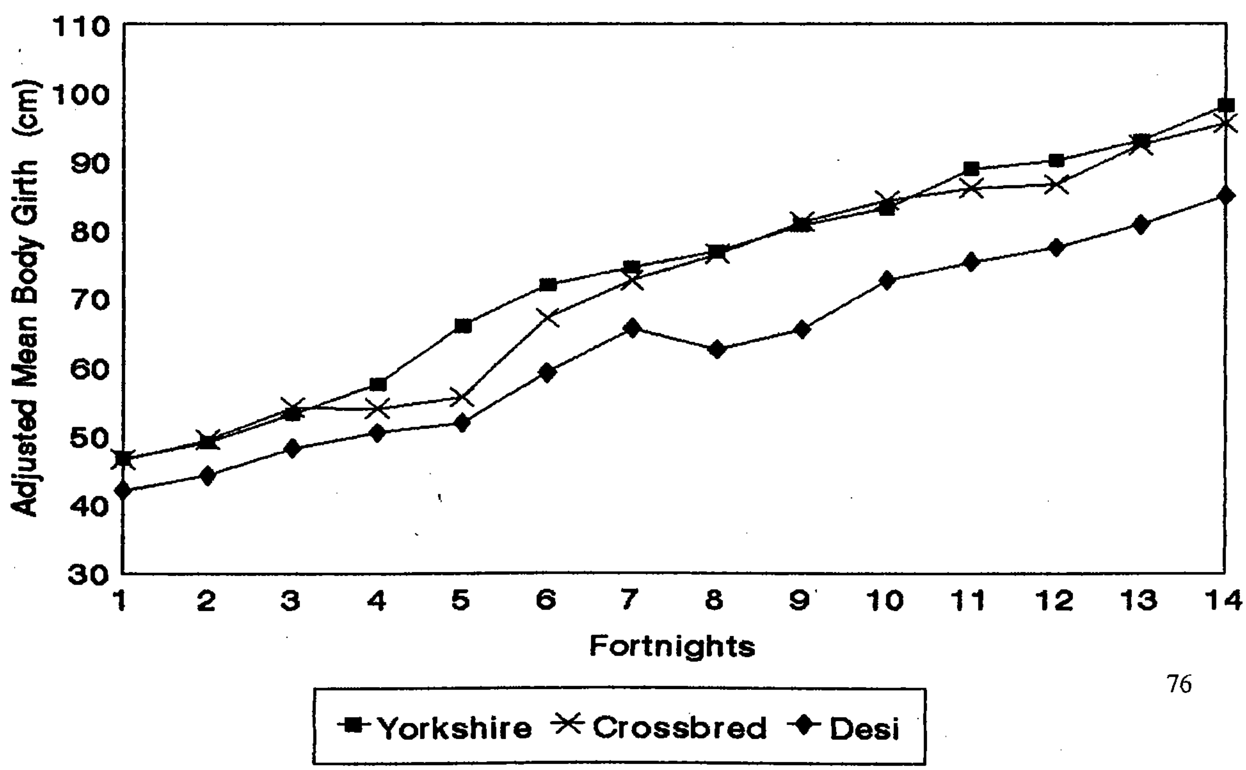

Fig 4.3c COMPARISON OF ADJUSTED MEAN BODY GIRTH OF PIGS FED WITH TWO DIFFERENT RATIONS

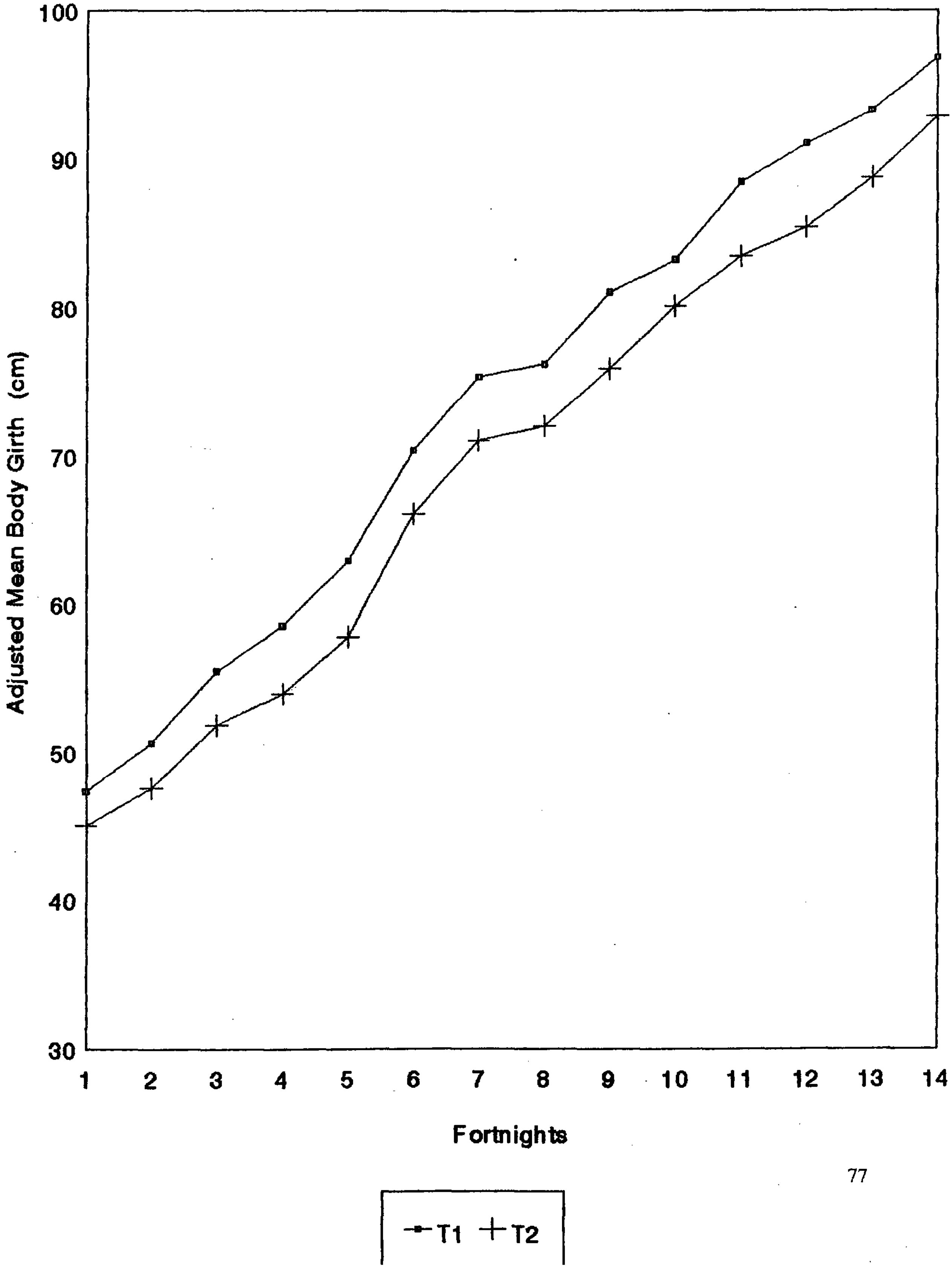

Table 4.4 Adjusted mean body height of three breeds of pigs fed with two different rations

Fortnights	Adjusted Mean Body Height (cm)							
	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
1	29.44^{a}	30.90^{a}	29.50^{a}	29.95^{NS}	29.63^{a}	29.09^{a}	28.58^{a}	29.10
2	32.05^{a}	32.97^{a}	30.69^{b*}	31.91^{**}	31.49^{a}	30.58^{a}	29.52^{b}	30.53
3	34.12^{a}	35.92^{b}	32.03^{c*}	34.02^{**}	32.35^{a}	31.82^{a}	30.40^{b}	31.52
4	36.19^{a}	38.00^{b}	33.74^{c*}	35.98^{**}	33.35^{a}	34.15^{a}	32.21^{ab}	33.24
5	40.31^{a}	42.26^{b}	34.40^{c**}	38.99^{**}	36.08^{a}	38.87^{b}	31.72^{c}	35.56
6	46.78^{a}	46.29^{a}	35.75^{b**}	42.94^{**}	40.88^{a}	43.05^{b}	34.22^{c}	39.39
7	48.89^{a}	47.50^{a}	36.82^{b**}	44.40^{NS}	46.03^{a}	45.14^{a}	35.42^{b}	42.20
8	50.84^{a}	48.64^{a}	37.79^{b**}	45.75^{*}	47.29^{a}	46.26^{a}	35.99^{b}	43.18
9	54.09^{a}	50.09^{b}	38.82^{c**}	47.77^{*}	50.96^{a}	47.60^{b}	36.61^{c}	45.06
10	57.19^{a}	51.44^{b}	40.06^{c**}	49.56^{*}	53.11^{a}	48.69^{b}	37.65^{c}	46.48
11	58.40^{a}	53.59^{b}	43.05^{c**}	51.68^{**}	54.98^{a}	50.17^{b}	38.78^{c}	47.98
12	60.02^{a}	55.13^{b}	45.86^{c**}	53.67^{**}	56.31^{a}	52.25^{b}	41.23^{c}	49.93
13	61.60^{a}	57.15^{b}	47.05^{c**}	55.27^{**}	58.91^{a}	54.46^{b}	42.48^{c}	51.95
14	62.97^{a}	59.52^{b}	48.01^{c**}	56.83^{**}	58.63^{a}	55.18^{b}	44.16^{c}	52.65

Means having the same superscript in a row do not differ significantly

NS – Non significant

* – Significant at 5 per cent

** – Significant at 1 per cent

Fig 4.4a ADJUSTED MEAN BODY HEIGHT OF PIGS FED WITH ICAR RATION

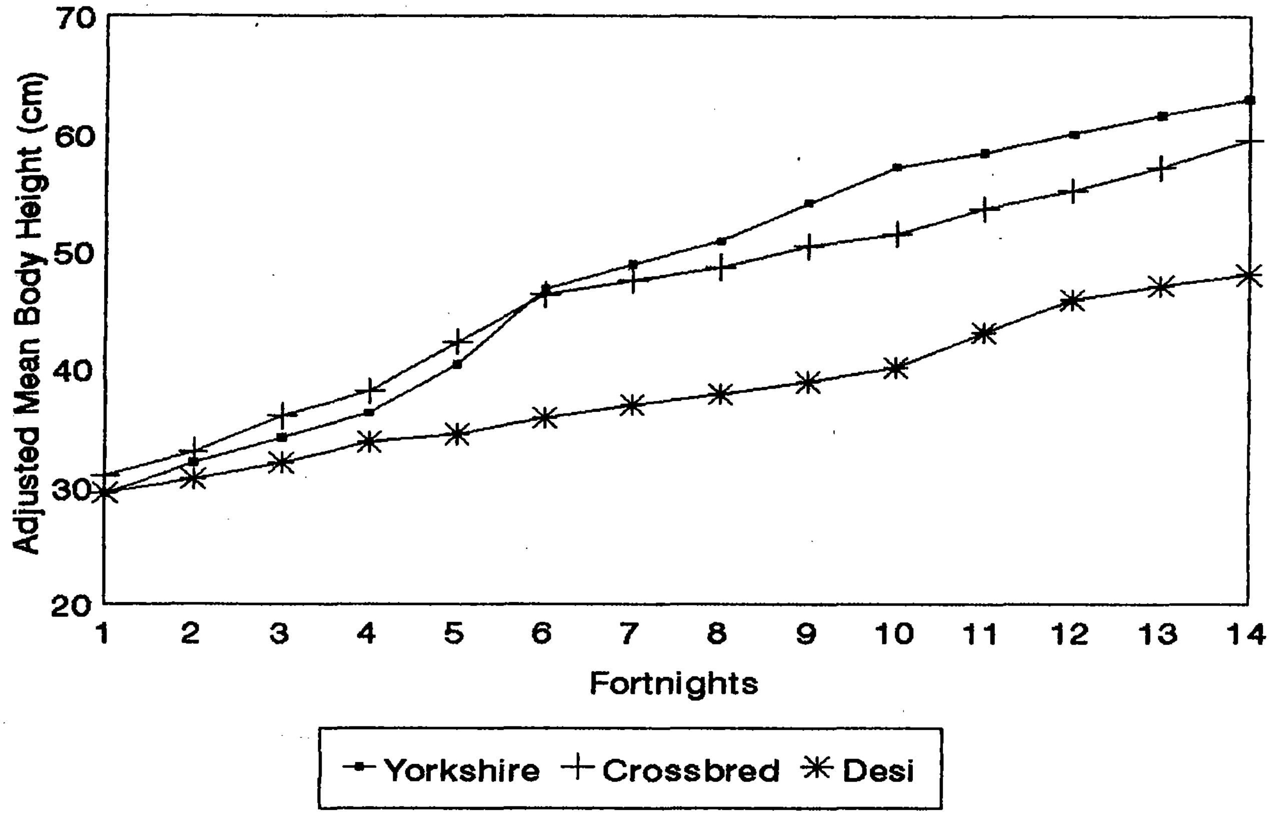

Fig 4.4b ADJUSTED MEAN BODY HEIGHT OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

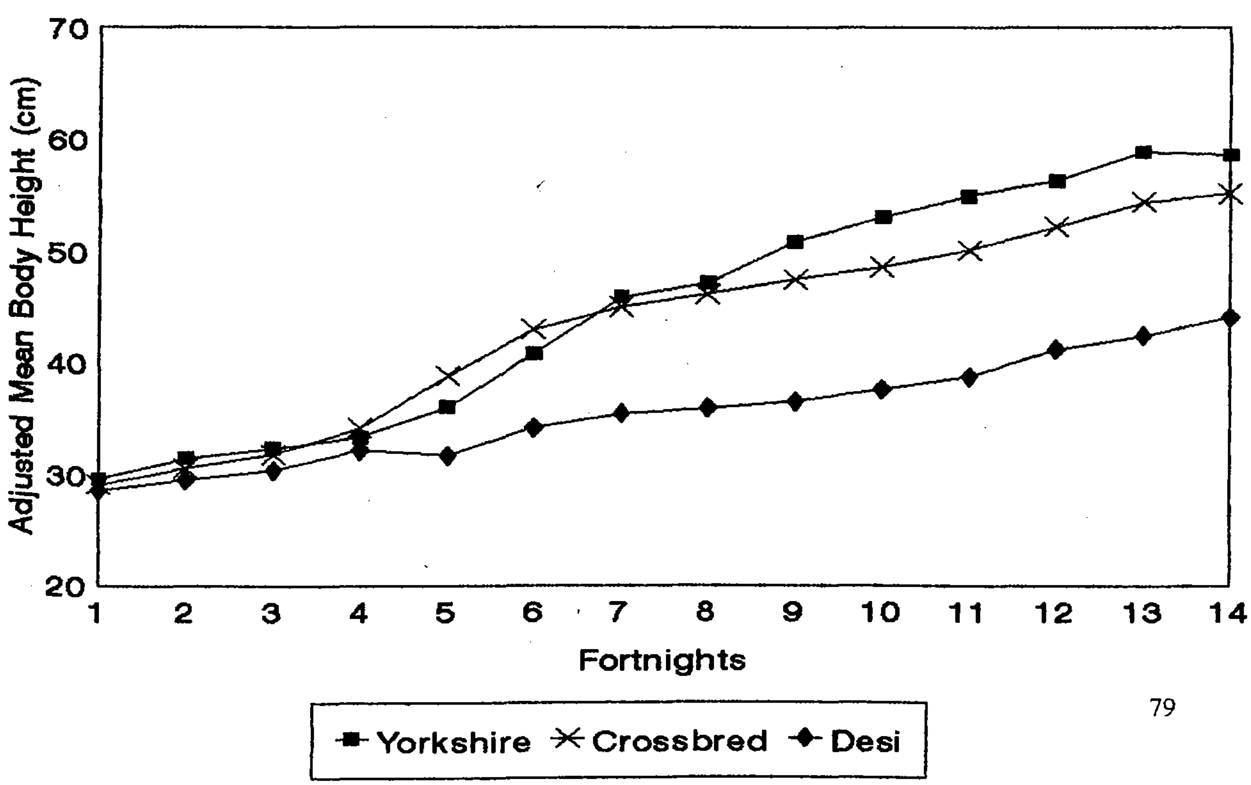

Fig 4.4C COMPARISON OF ADJUSTED MEAN BODY HEIGHT OF PIGS FED WITH TWO DIFFERENT RATIONS

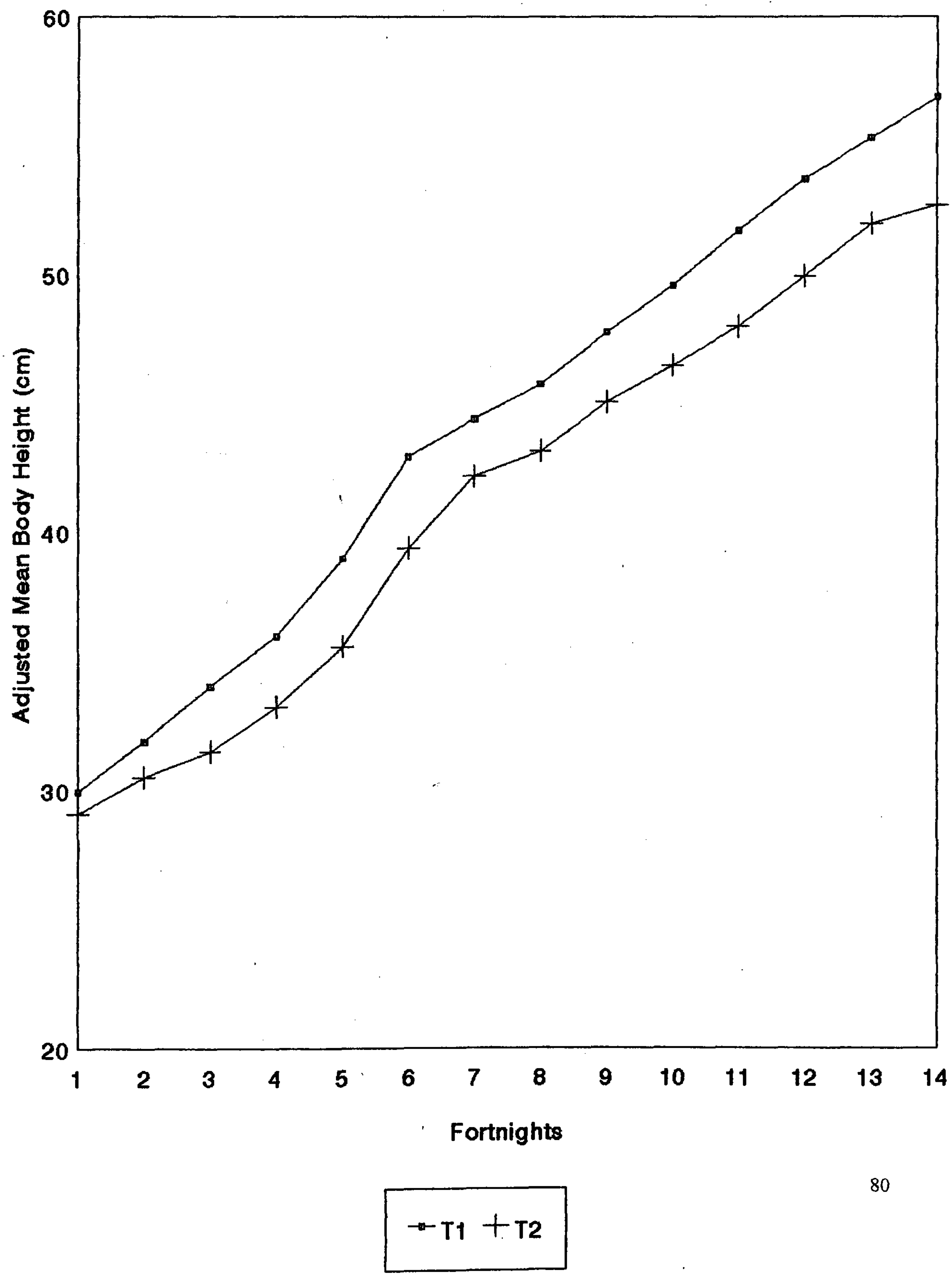

Table 4.5 Weekly rectal temperature (°F) of three breeds of pigs fed with two different rations

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13
Breeds	Treatment I (ICAR)												
Large White Yorkshire	102.9	103.0	103.1	103.1	103.1	102.7	102.5	102.6	102.7	102.1	102.1	102.1	102.0
Crossbred	102.8	102.5	102.5	102.5	102.5	102.3	102.1	102.7	102.6	102.5	102.5	102.3	102.3
Desi	102.7	102.6	102.5	102.5	102.6	102.5	102.4	102.3	102.4	102.4	102.3	102.3	102.1
Treatment Mean	102.8	102.7	102.7	102.7	102.6	102.5	102.3	102.5	102.4	102.3	102.3	102.2	102.1
	Treatment II (10 % less ICAR)												
Large White Yorkshire	102.9	102.8	102.6	102.6	102.3	102.2	102.3	102.3	102.0	102.1	102.1	10.21	101.9
Crossbred	102.6	102.5	102.6	102.7	102.5	102.5	102.5	102.5	102.4	102.5	102.4	102.3	102.1
Desi	102.5	102.5	102.5	102.5	102.4	102.4	102.3	102.3	102.2	102.1	102.1	102.0	102.0
Treatment Mean	102.7	102.6	102.6	102.6	102.4	102.4	102.4	102.3	102.2	102.2	102.2	102.1	102.0

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Breed Mean
Treatment I (ICAR)															
101.9	101.7	101.7	102.3	102.2	101.8	101.7	101.9	102.0	102.1	102.1	102.2	102.1	102.1	102.0	102.2^{a}
102.3	102.1	101.9	101.8	101.9	101.9	101.9	101.7	101.7	101.6	101.5	101.4	101.4	101.2	101.1	102.2^{a}
102.1	102.1	102.1	102.0	102.0	101.8	101.8	102.1	101.9	101.8	101.8	101.7	101.9	101.9	101.8	102.2^{a}
102.1	101.9	101.9	102.0	102.0	101.8	101.8	101.9	101.8	101.9	101.8	101.8	101.8	101.7	101.6	102.2^{NS}
Treatment II (10 % less ICAR)															
101.8	101.8	101.9	102.1	102.1	102.1	102.1	102.0	102.0	102.1	102.1	102.1	102.1	102.1	102.0	102.1^{a}
102.1	102.3	102.3	102.0	102.0	101.8	101.8	101.7	101.6	101.5	101.5	101.5	101.4	101.4	101.4	102.1^{a}
102.2	101.9	101.8	102.0	101.9	102.0	101.9	101.8	101.8	101.7	101.8	101.7	101.6	101.8	101.8	102.1^{a}
102.0	102.0	102.0	102.0	102.0	102.0	101.9	101.8	101.8	101.8	101.8	101.8	101.7	101.8	101.7	102.1^{NS}

Figures having the same superscript in a row do not differ significantly

NS - Non significant

Fig 4.5a WEEKLY RECTAL TEMPERATURE (°F) OF PIGS FED WITH ICAR RATION

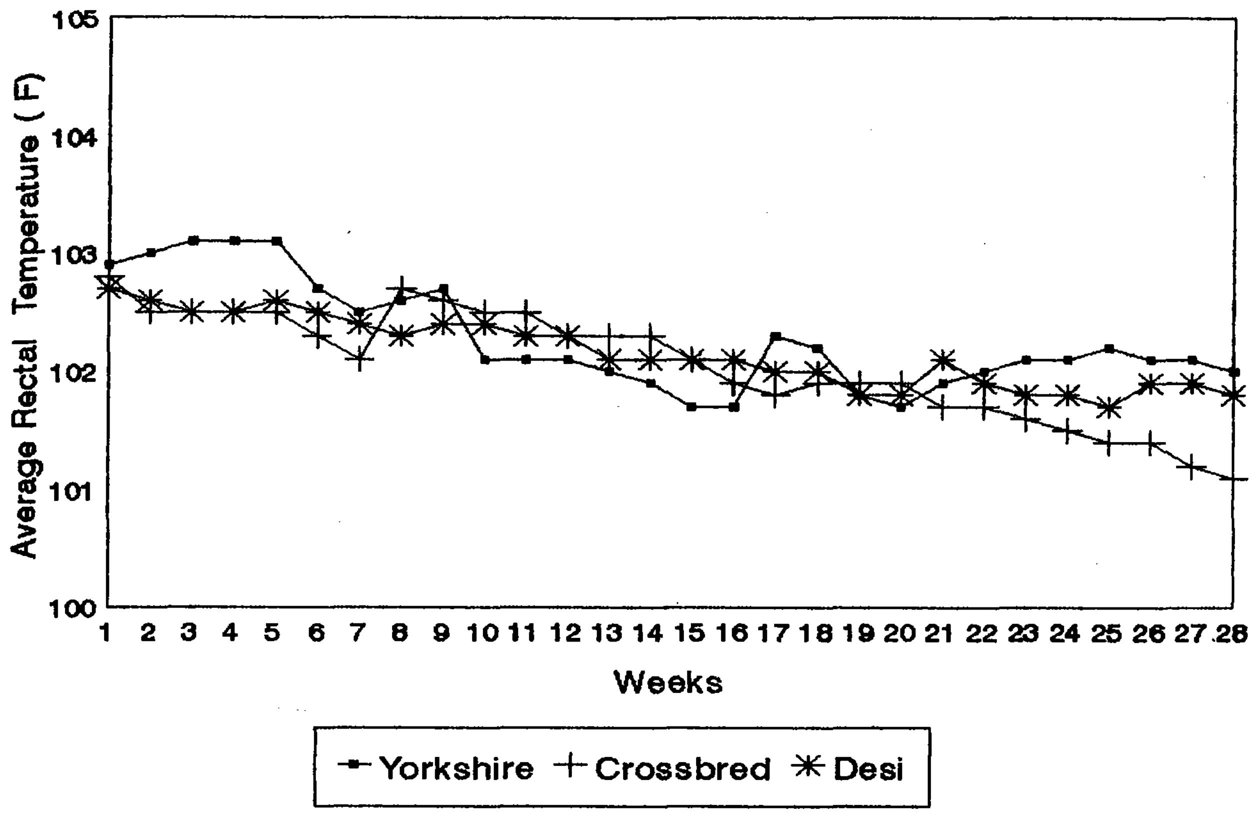

Fig 4.5b WEEKLY RECTAL TEMPERATURE OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

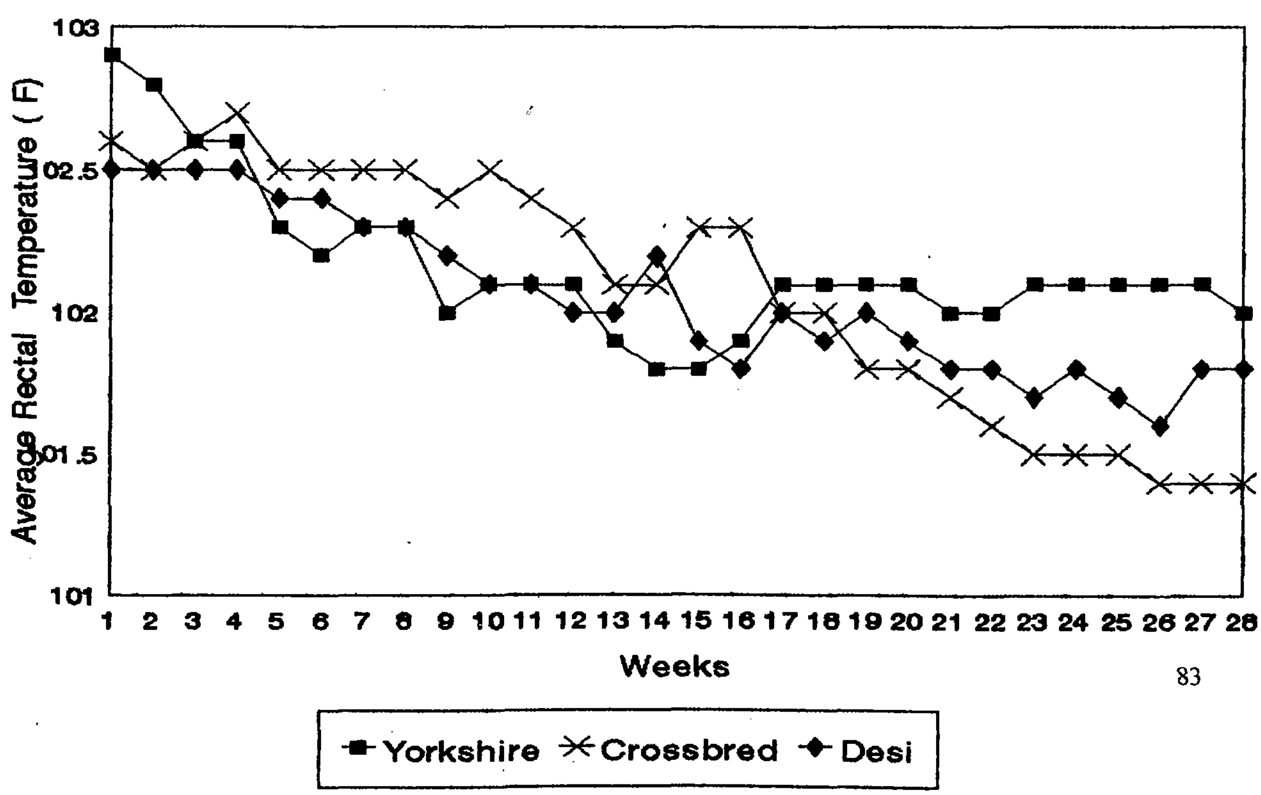

Fig 4.5c COMPARISON OF RECTAL TEMPERATURE (°F) OF PIGS FED WITH TWO DIFFERENT RATIONS

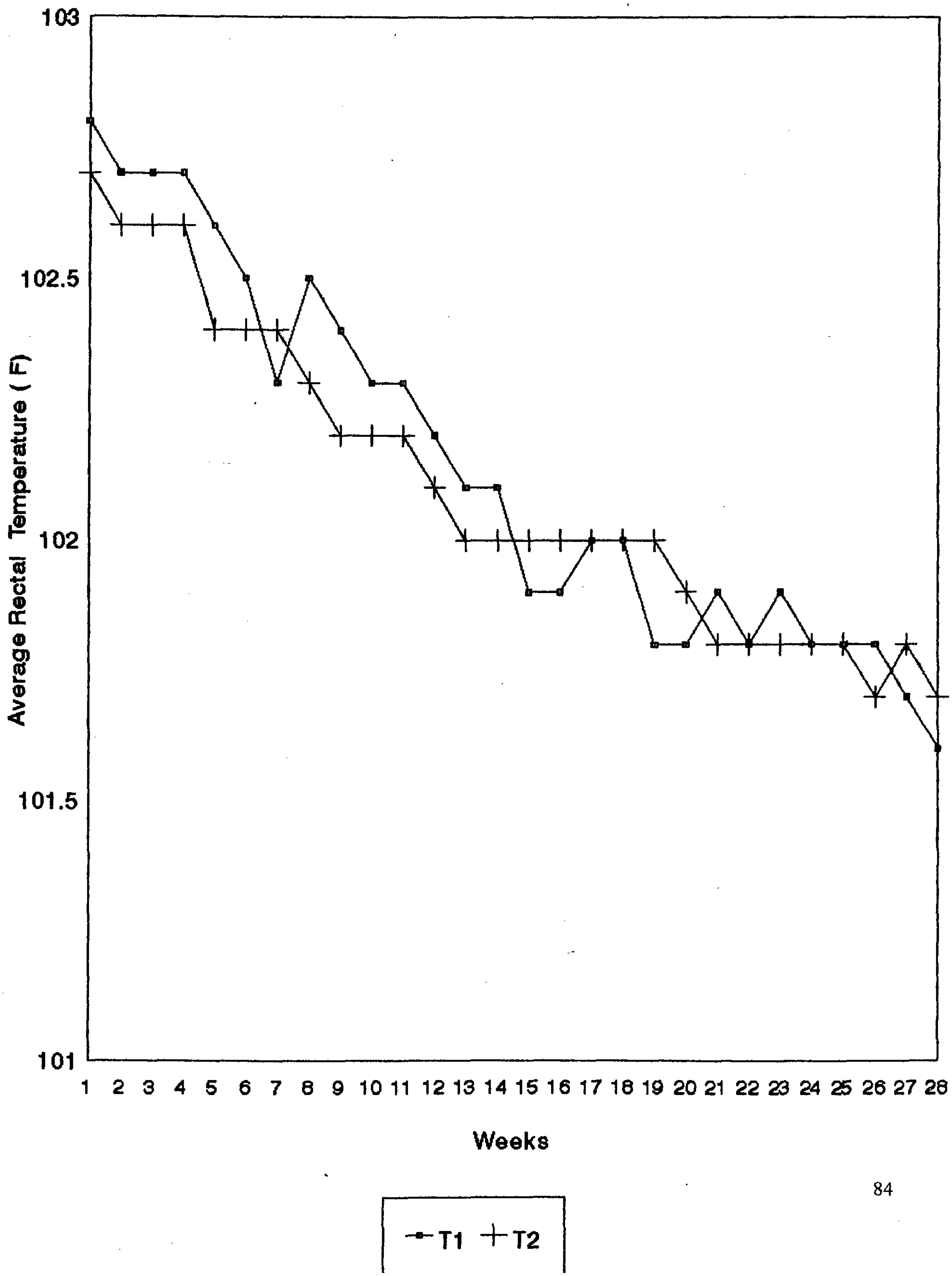

Table 4.6 Weekly pulse rate of three breeds of pigs fed with two different rations

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13
Breeds	Treatment I (ICAR)												
Large White Yorkshire	89	85	86	83	82	82	72	72	75	76	73	69	69
Crossbred	90	90	89	85	84	85	72	74	77	76	74	70	70
Desi	92	90	88	85	82	84	74	74	78	77	73	70	70
Treatment Mean	90	88	87	84	82	83	72	73	76	76	73	69	69
Treatment II (10 % less ICAR)													
Large White Yorkshire	87	84	85	83	82	83	72	73	75	75	73	70	69
Crossbred	90	90	87	83	82	83	71	73	75	75	72	70	71
Desi	91	91	87	83	81	84	72	72	76	74	72	72	70
Treatment Mean	89	88	86	83	81	83	71	72	75	74	72	70	70

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Breed Mean
Treatment I (ICAR)															
69	70	70	69	67	66	67	67	65	67	63	64	62	63	61	71[a]
71	70	70	69	66	66	68	68	65	65	63	63	62	61	61	72[a]
72	71	72	69	67	66	69	68	66	65	64	63	62	61	62	72[a]
70	70	70	69	66	66	68	67	65	65	63	63	62	61	61	72[NS]
Treatment II (10 % less ICAR)															
70	69	69	68	65	65	66	66	64	65	62	63	64	62	61	71[a]
70	69	69	68	65	65	66	66	64	65	62	62	62	61	60	71[a]
71	69	69	68	66	65	66	67	67	64	63	62	62	62	61	71[a]
70	69	69	68	65	65	66	66	65	64	62	62	62	61	60	71[NS]

Figures having the same superscript in a row do not differ significantly

NS – Non significant

Fig 4.6a WEEKLY PULSE RATE OF PIGS FED WITH ICAR RATION

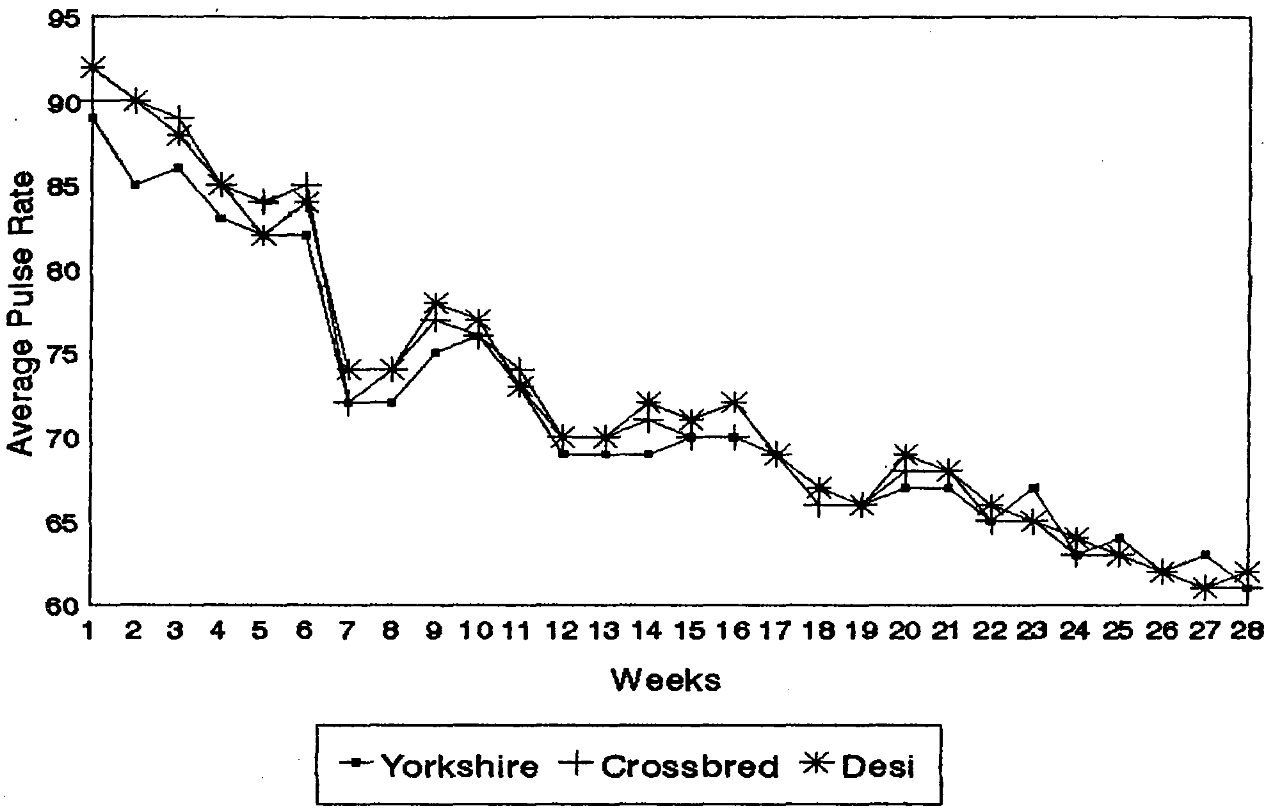

Fig 4.6b WEEKLY PULSE RATE OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

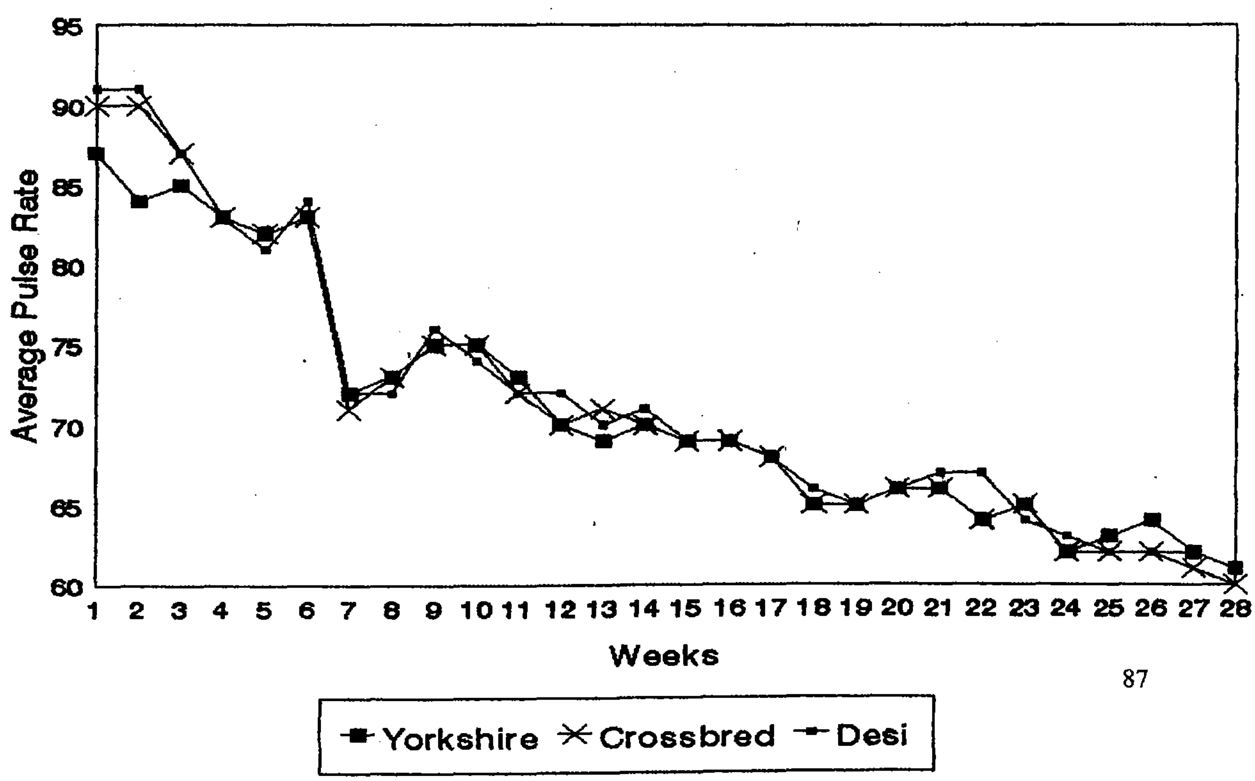

Fig 4.6c COMPARISON OF PULSE RATE OF PIGS FED WITH TWO DIFFERENT RATIONS

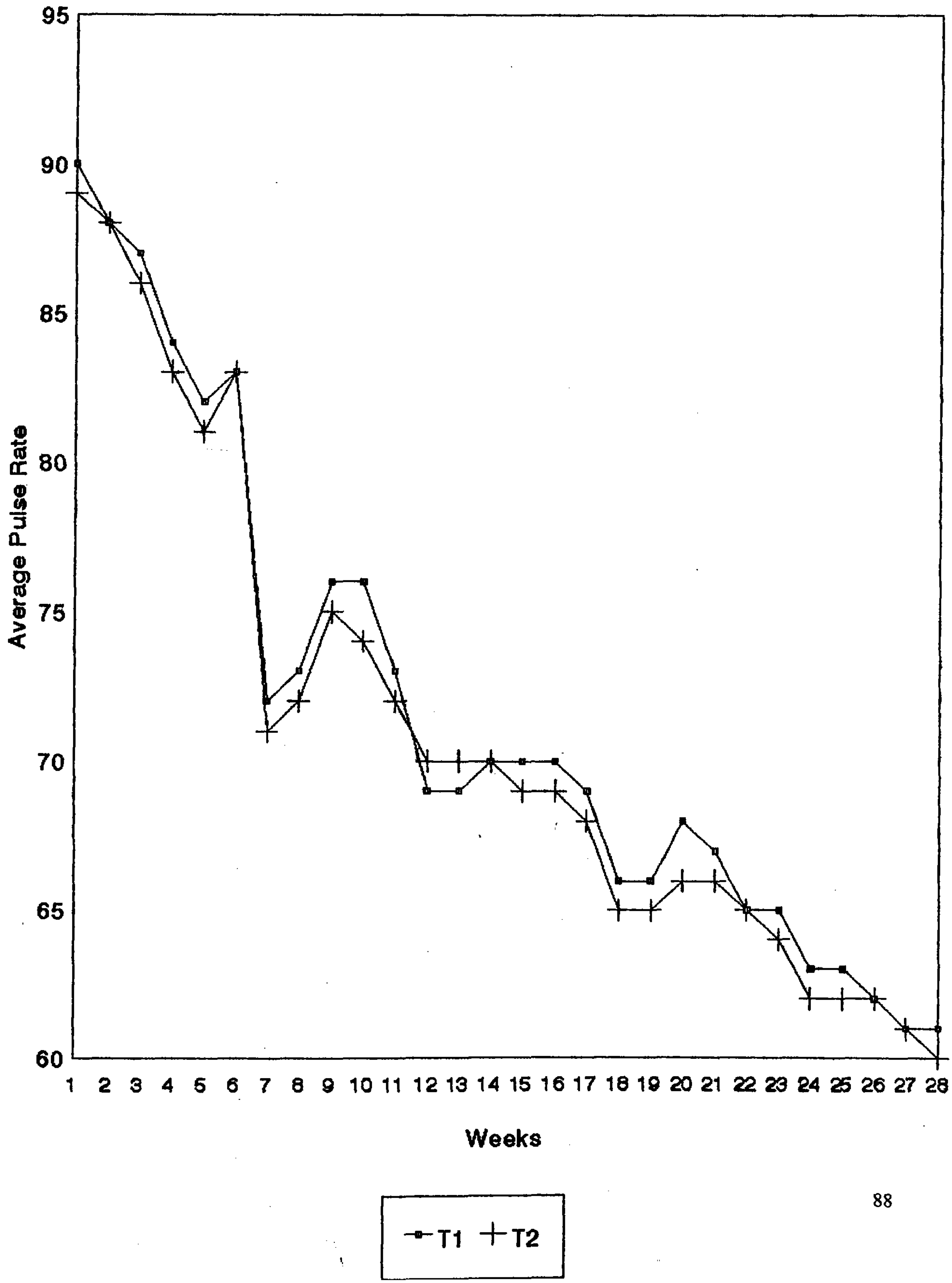

Table 4.7 Weekly respiratory rate of three breeds of pigs fed with two different rations

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13
Breeds	Treatment I (ICAR)												
Large White Yorkshire	39	38	36	37	42	42	40	42	27	28	23	24	25
Crossbred	38	37	36	36	41	42	41	41	27	28	23	24	25
Desi	37	36	35	36	41	40	41	40	27	27	23	25	25
Treatment Mean	38	37	35	36	41	41	40	41	27	27	23	24	25
Treatment II (10 % less ICAR)													
Large White Yorkshire	37	38	37	35	45	42	43	41	26	28	24	25	24
Crossbred	36	37	35	45	42	43	40	41	26	28	24	24	23
Desi	36	36	35	35	40	40	41	39	27	26	22	25	26
Treatment Mean	36	37	35	38	42	41	41	40	26	27	23	24	24

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Breed Mean
Treatment I (ICAR)															
24	27	27	28	28	26	26	27	28	23	24	25	26	25	24	29[a]
24	27	27	28	26	25	26	26	28	22	24	24	26	24	24	29[a]
24	27	26	28	26	25	25	25	28	23	24	23	25	23	23	29[a]
24	27	26	28	26	25	25	26	28	22	24	24	25	24	23	29[NS]
Treatment II (10 % less ICAR)															
23	24	25	26	26	25	25	26	24	22	23	24	22	23	21	28[a]
21	24	25	26	25	23	24	26	23	22	22	23	22	18	19	28[a]
24	26	25	27	25	25	24	24	27	23	23	21	24	22	19	28[a]
22	24	25	26	25	24	24	25	24	22	22	22	22	21	19	28[NS]

Figures having the same superscript in a row do not differ significantly

NS – Non significant

Fig 4.7a WEEKLY RESPIRATORY RATE OF PIGS FED WITH ICAR RATION

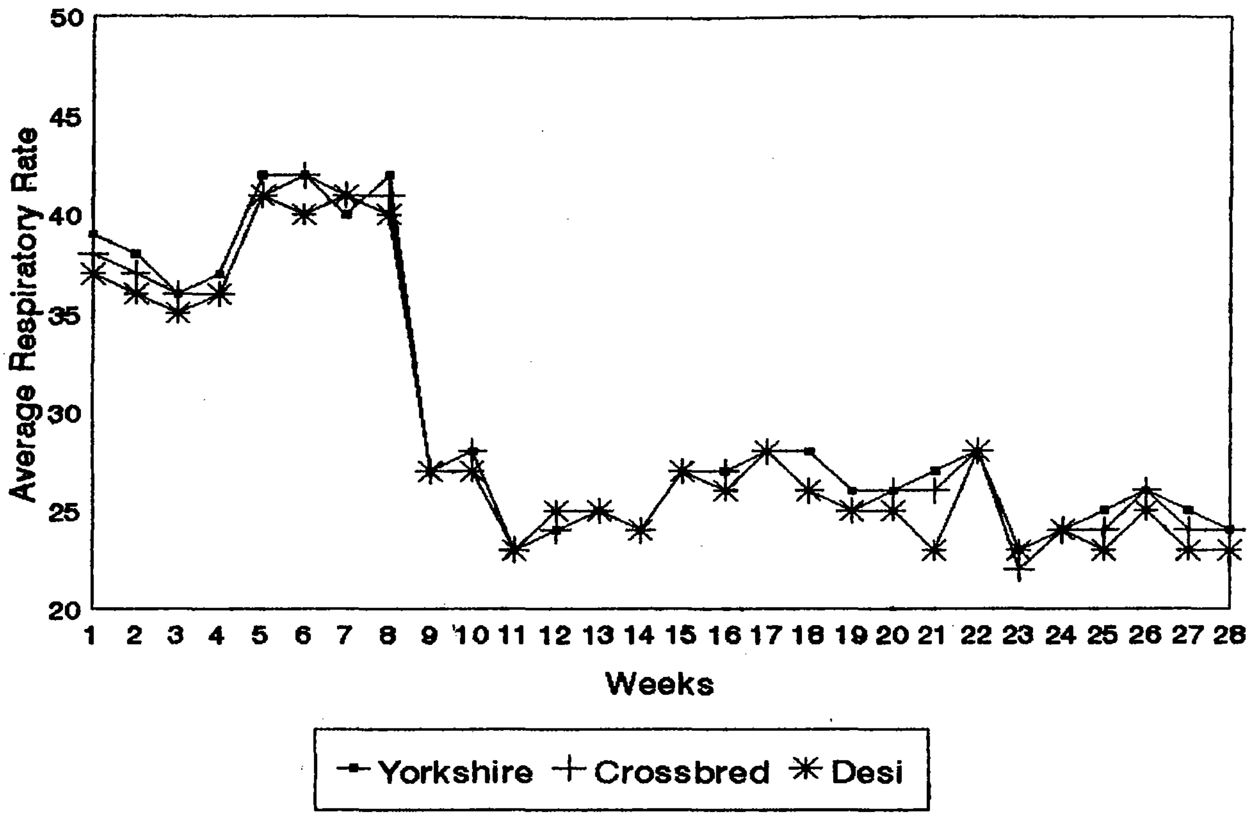

Fig 4.7b WEEKLY RESPIRATORY RATE OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

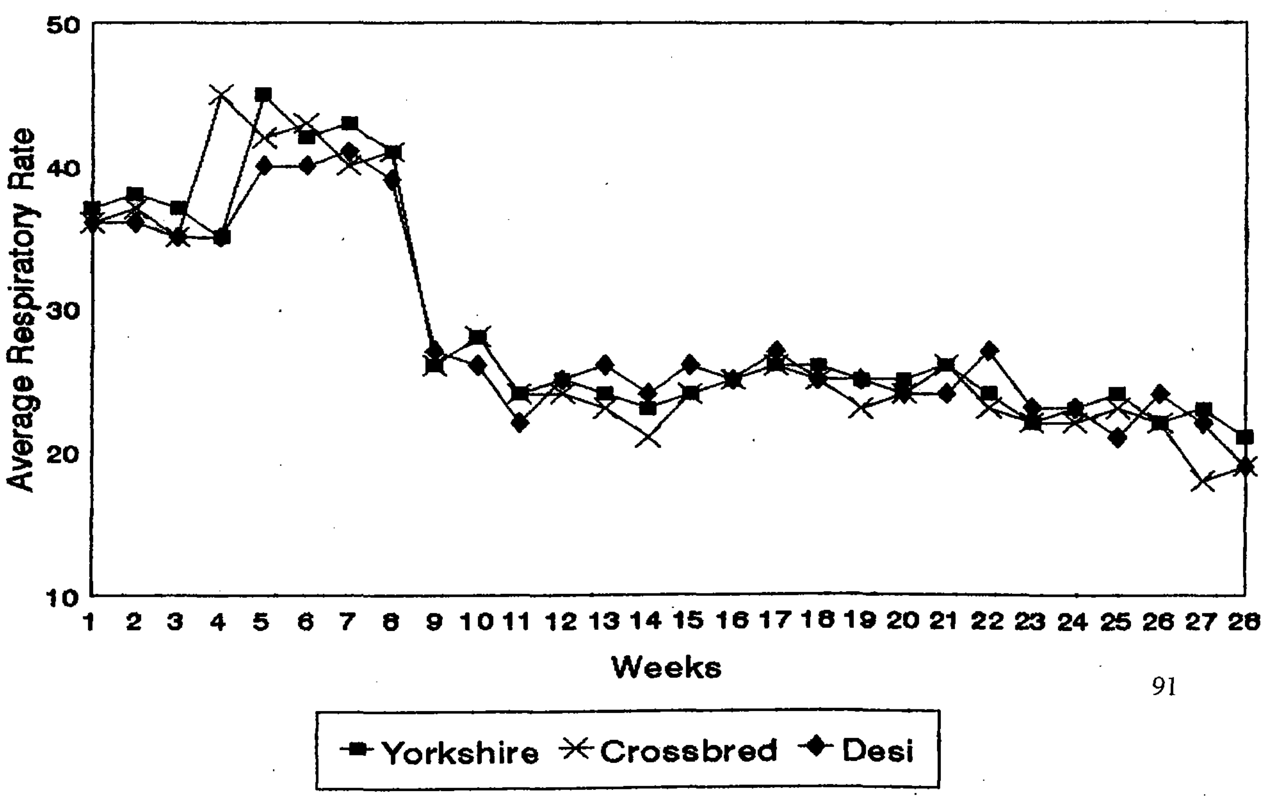

Fig 4.7c COMPARISON OF RESPIRATORY RATE OF PIGS FED WITH TWO DIFFERENT RATIONS

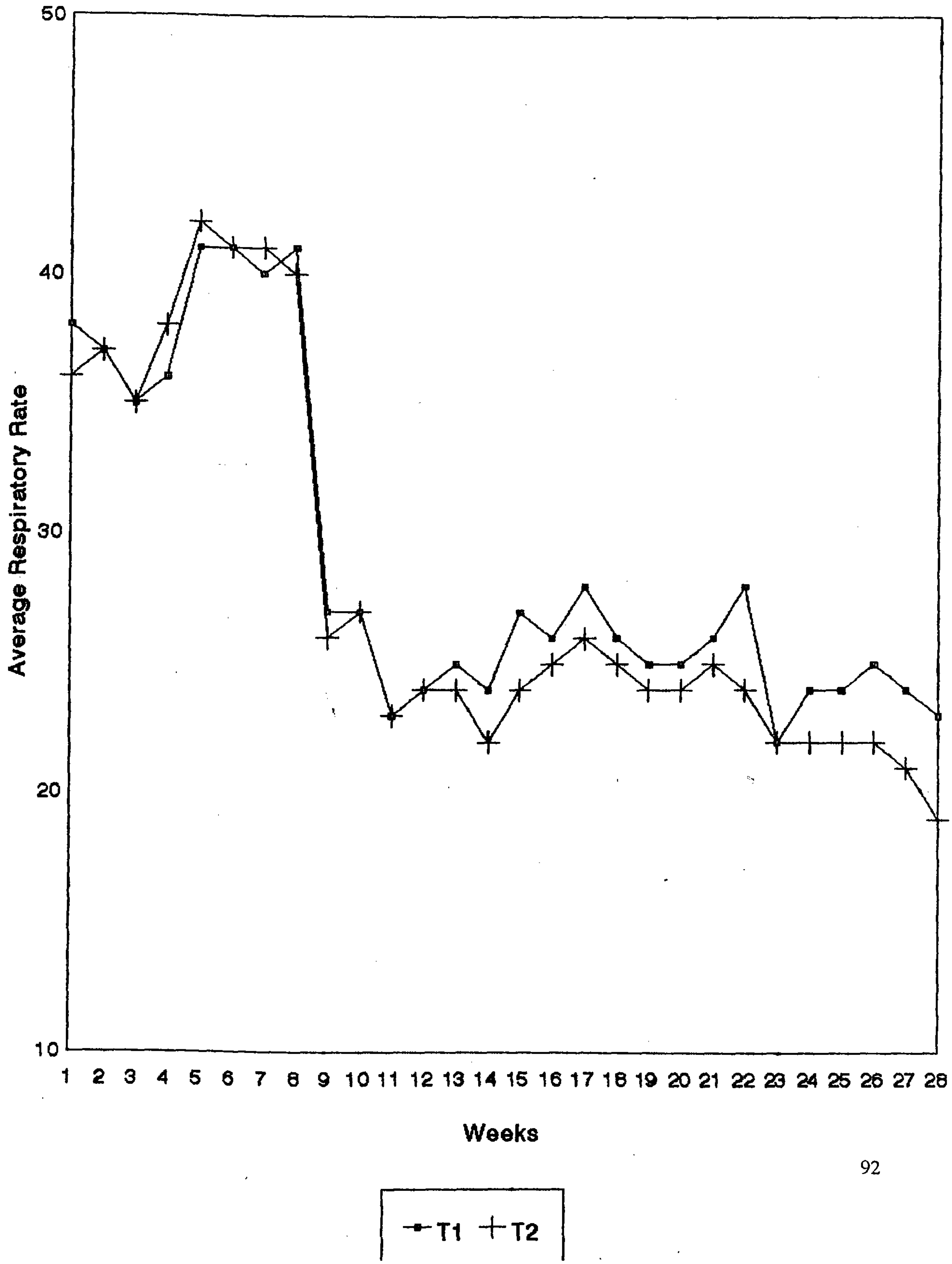

Table 4.8 Average daily feed intake of pigs fed with two different rations

Fortnights	Treatment I (ICAR)			Treatment II (10 % less ICAR)		
	Large White Yorkshire	Crossbred	Desi	Large White Yorkshire	Crossbred	Desi
1	0.492	0.580	0.445	0.480	0.545	0.430
2	0.584	0.634	0.464	0.562	0.602	0.452
3	0.802	0.902	0.646	0.784	0.862	0.636
4	0.910	0.990	0.760	0.882	0.916	0.740
5	1.122	1.252	0.932	1.023	1.020	0.890
6	1.195	1.290	1.150	1.172	1.140	1.040
7	1.450	1.405	1.292	1.370	1.302	1.150
8	1.520	1.604	1.320	1.486	1.340	1.210
9	1.880	1.890	1.450	1.854	1.782	1.290
10	1.992	2.050	1.472	1.960	1.920	1.360
11	2.050	2.152	1.580	2.012	2.014	1.440
12	2.100	2.196	1.628	2.030	2.080	1.524
13	2.152	2.200	1.650	2.082	2.140	1.602
14	2.250	2.340	1.680	2.140	2.220	1.615
Daily Mean ± SE	1.464 ± 0.165[a]	1.535 ± 0.164[a]	1.176 ± 0.119[a]	1.417 ± 0.161[a]	1.420 ± 0.159[a]	1.099 ± 0.110[a]
Fortnightly mean	20.490[a]	21.480[a]	16.460[a]	19.830[a]	19.880[a]	15.370[a]
Overall treatment mean	1.392[NS]			1.312[NS]		

NS – Non significant

Fig 4.8a AVERAGE DAILY FEED INTAKE OF PIGS FED WITH ICAR RATION

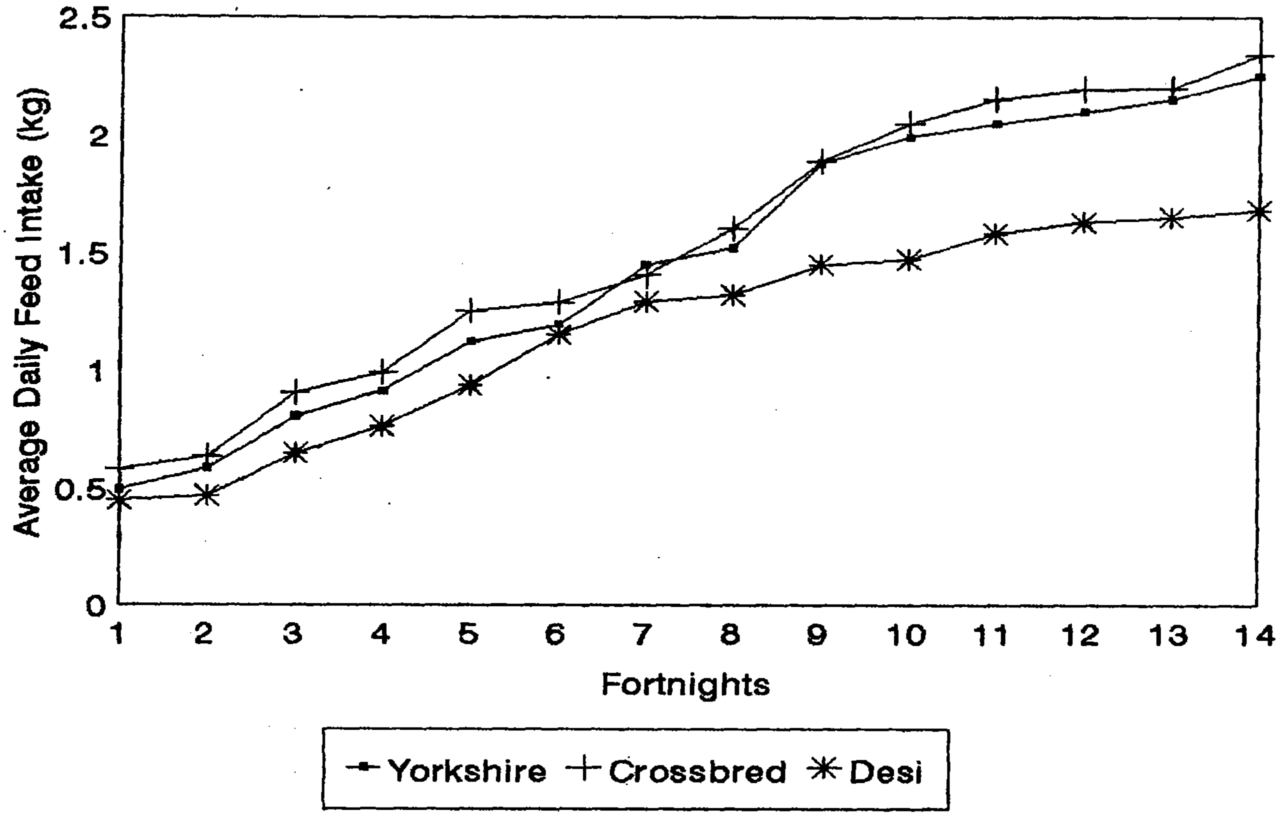

Fig 4.8b AVERAGE DAILY FEED INTAKE OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

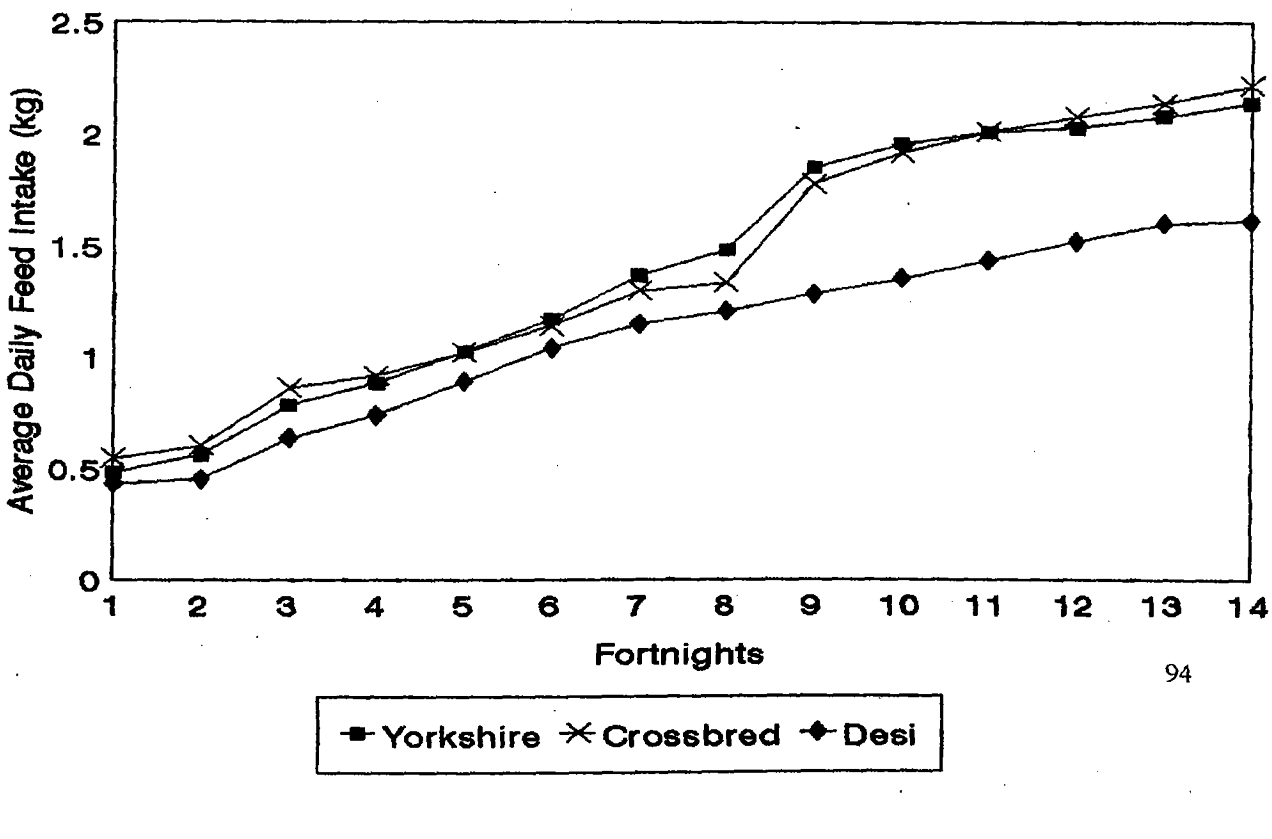

Table 4.9 Mean and standard error of average daily body weight gain of pigs fed with two different rations

Fortnights	Average Daily Body Weight Gain (g)							
	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
1	179±36	208±32	238±71	375^{NS}	185±42	220. ±25	117±34	312
2	232±44	149±28	190±18	342^{NS}	149±43	161±42	113±14	253
3	333±47	155±22	327±19	489^{NS}	226±29	179±16	298±26	421
4	381±51	530±65	137±53	628^{NS}	161±48	482±80	196±33	503
5	315±52	286±40	292±62	535^{**}	173±21	185±46	262±45	371
6	792±101	363±50	250±71	842^{**}	536±109	244±45	208±41	592
7	357±103	304±53	214±29	525^{**}	530±42	482±60	202±35	728
8	679±118	435±93	256±42	821^{NS}	661±47	321±73	262±35	746
9	387±70	476±119	262±30	675^{NS}	405±51	488±83	214±26	664
10	423±82	339±71	304±61	639^{NS}	452±70	226±43	292±51	582
11	411±51	286±80	244±37	564^{NS}	375±44	298±47	256±37	557
12	363±31	381±31	298±47	625^{NS}	381±34	315±42	179±26	525
13	506±58	304±48	185±23	596^{NS}	482±53	435±71	113±25	617
14	399±30	226±40	161±29	471^{NS}	452±54	179±60	113±21	446
Mean ± SE	$411.21±62^{a}$	$317±55^{ab}$	$239±42^{b**}$		$369±49^{a}$	$301±52^{ab}$	$201±32^{b**}$	

Figures having the same superscript in a row do not differ significantly

NS – Non significant

* – Significant at 5 per cent

** – Significant at 1 per cent

Fig 4.9a AVERAGE DAILY BODY WEIGHT GAIN OF PIGS FED WITH ICAR RATION

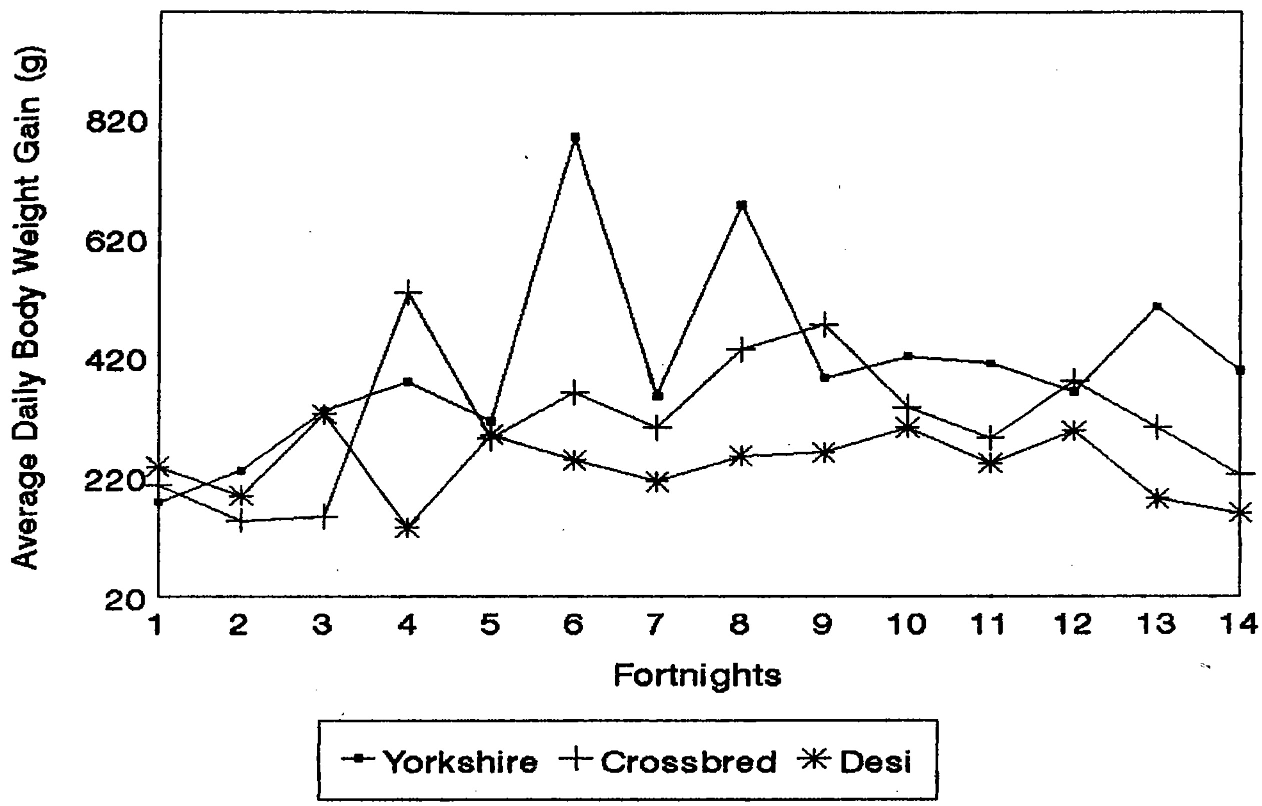

Fig 4.9b AVERAGE DAILY BODY WEIGHT GAIN OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

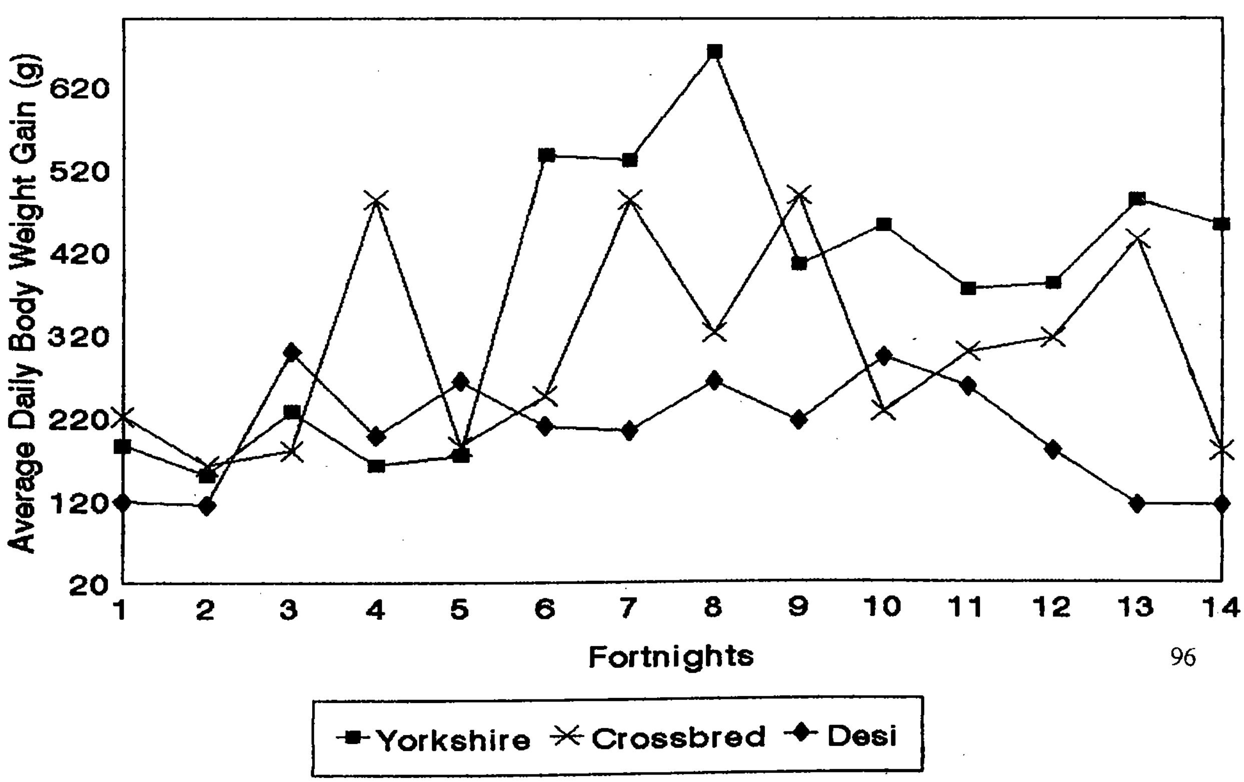

Table 4.10 Feed conversion efficiency of pigs fed with two different rations

Treatment I (ICAR)				Treatment II (10 % less ICAR)			
Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Cross-bred	Desi	Treatment Mean
3.815^{a**}	5.184^{b}	5.256^{b}	4.750^{NS}	4.113^{a}	5.055^{b}	5.832^{b}	5.000^{NS}

Figures having the same superscript in a row do not differ significantly

NS - Non significant

** - Significant at 1 per cent

Fig. 4.10 COMPARISON OF FEED CONVERSION EFFICIENCY OF PIGS FED WITH TWO DIFFERENT RATIONS

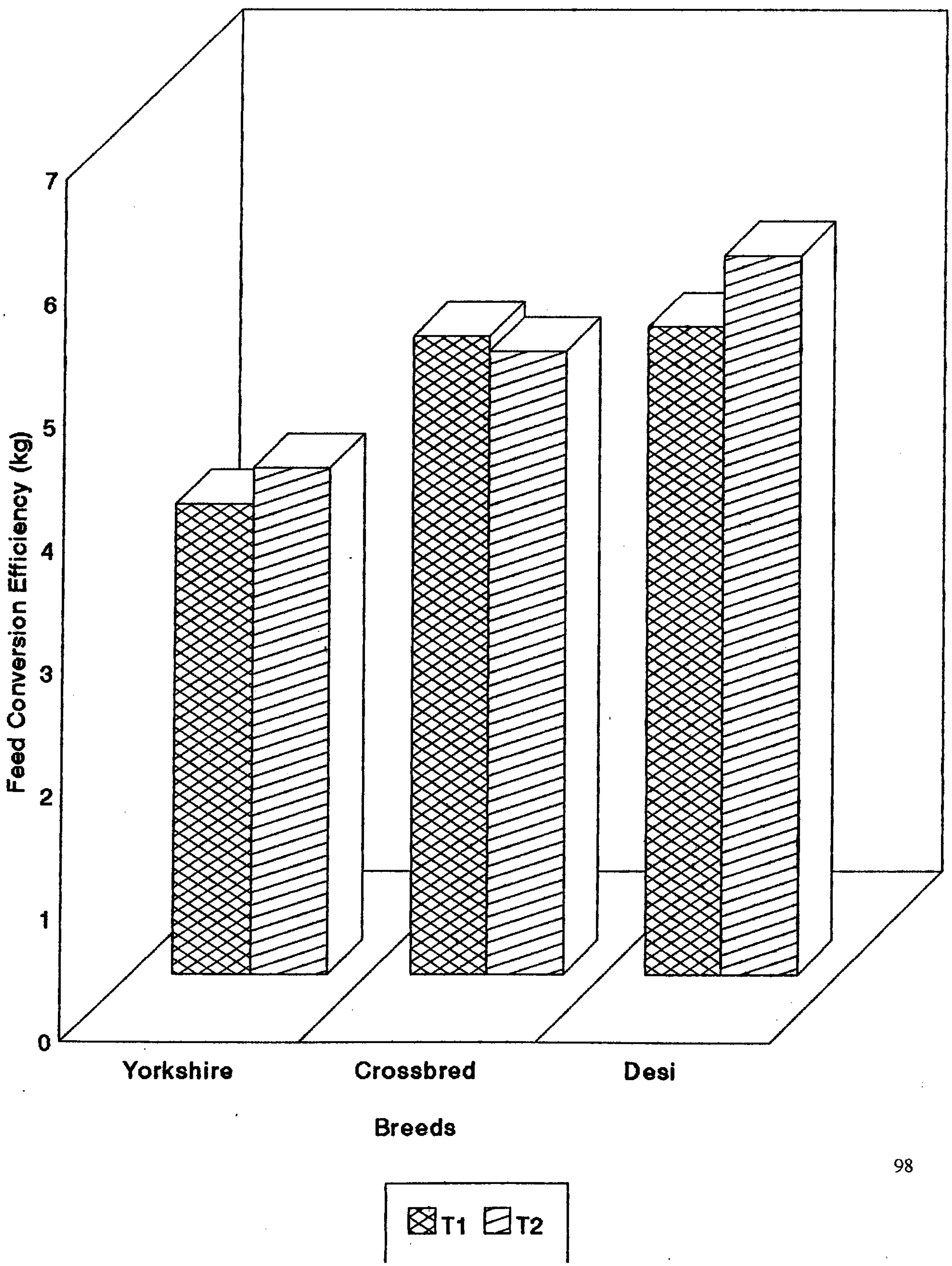

Table 4.11 Average digestibility coefficient of nutrients of pigs fed with two different experimental diets

Digestibility coefficient of nutrients	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
Dry Matter	70.832^{a}	68.570^{b}	67.376^{c**}	68.926**	67.334^{a}	66.980^{a}	65.550^{b}	66.621
Crude Protein	65.982^{a}	63.910^{b}	60.656^{c**}	63.516^{NS}	63.570^{a}	62.630^{a}	61.430^{b}	62.543
Ether Extract	56.126^{a}	52.781^{b}	53.057^{c**}	53.988^{NS}	55.240^{a}	53.840^{b}	52.580^{c}	53.887
Crude Fibre	25.146^{a}	20.583^{b}	19.397^{c**}	21.709^{NS}	23.310^{a}	22.260^{b}	20.160^{c}	21.910
Nitrogen Free Extract (NFE)	70.106^{a}	70.330^{a}	68.971^{a}	69.802**	68.160^{a}	67.000^{a}	67.220^{a}	67.460

Means having the same superscript in a row do not differ significantly

NS – Non significant
** - Significant at 1 per cent

Fig. 4.11a AVERAGE DIGESTIBILITY COEFFICIENT OF NUTRIENTS OF PIGS FED WITH ICAR RATION

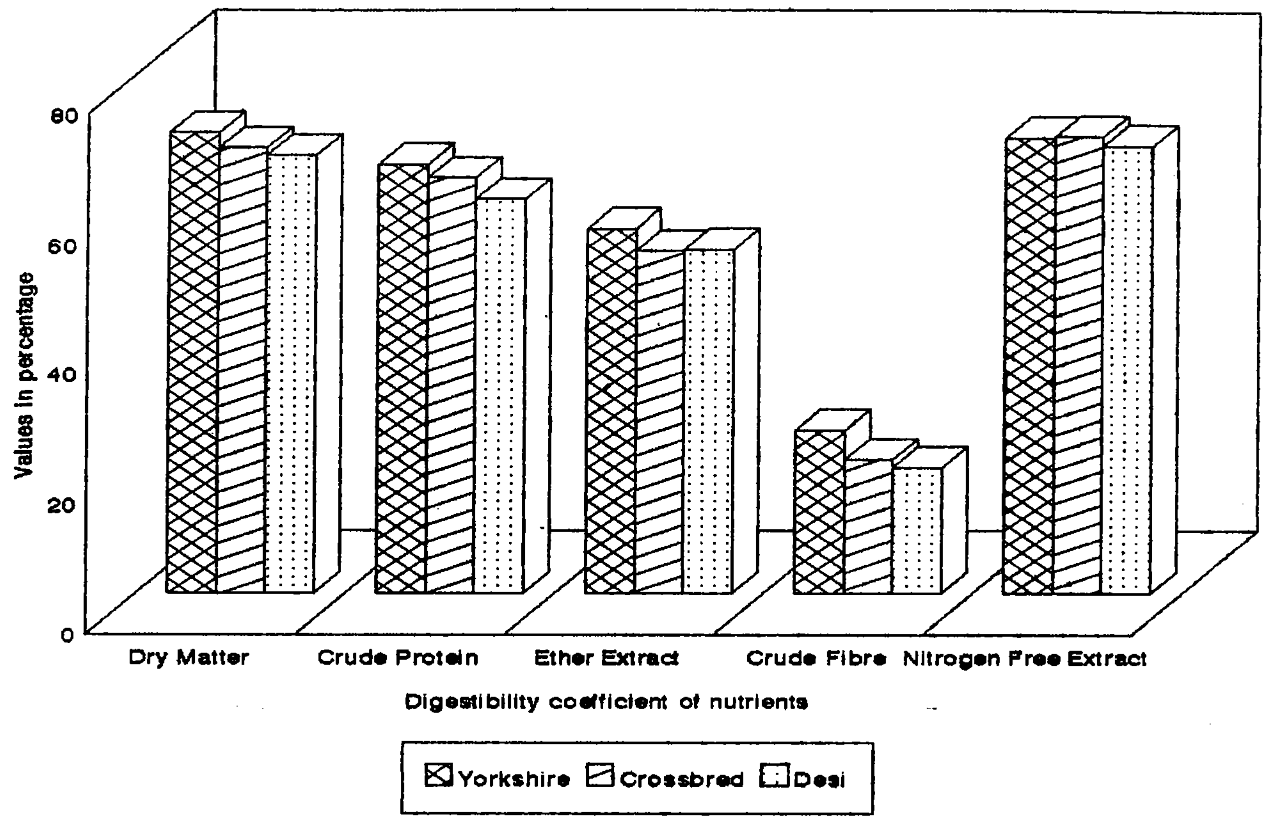

Fig. 4.11b AVERAGE DIGESTIBILITY COEFFICIENT OF NUTRIENTS OF PIGS OF PIGS FED WITH TEN PERCENT LESS CRUDE PROTEIN

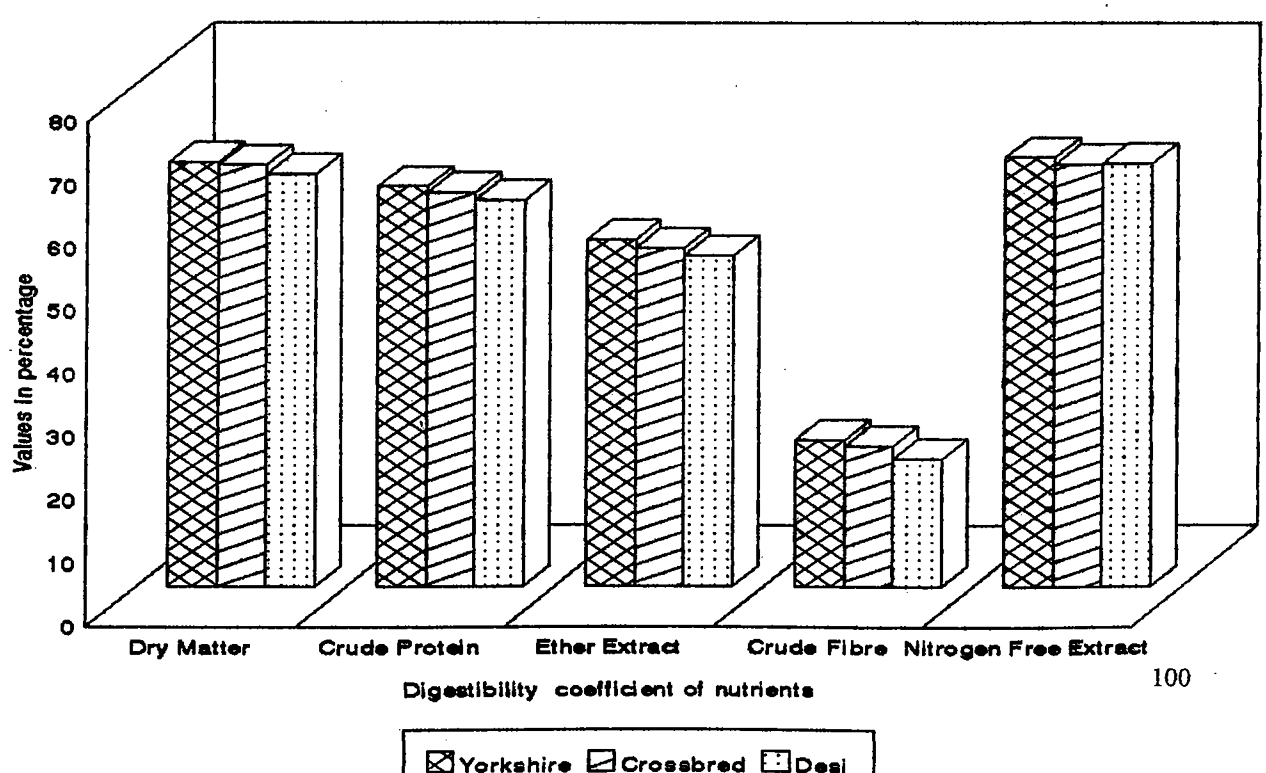

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Fig. 4.11c COMPARISON OF DIGESTIBILITY COEFFICIENT OF NUTRIENTS OF PIGS FED WITH TWO DIFFERENT RATIONS

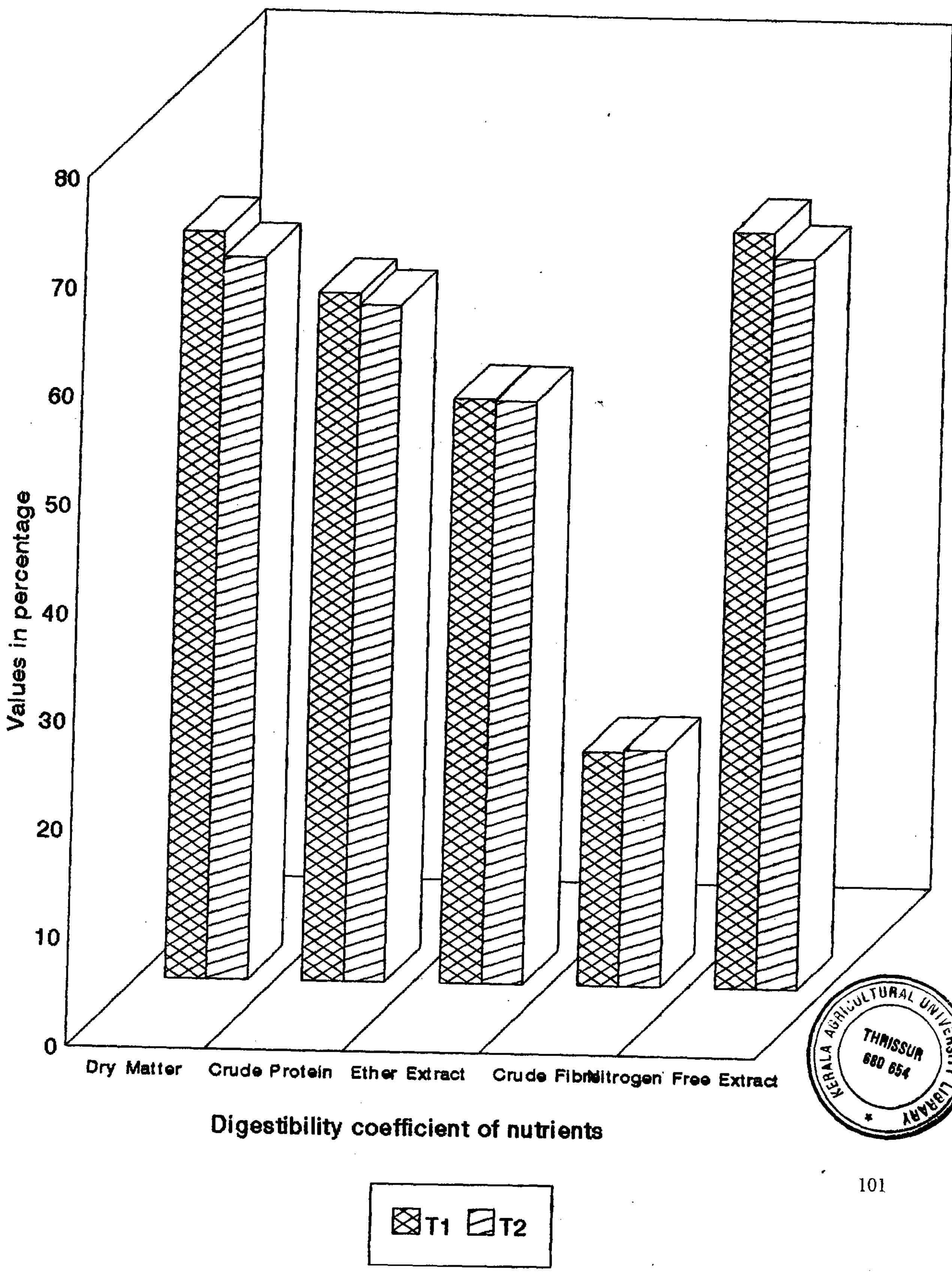


Table 4.12 Carcass characteristics of pigs at seven months of age fed with two different rations

Carcass characteristics	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
Live Weight at slaughter (kg)	96.66^{a} ± 3.28	76.33^{b} ± 4.17	46.00^{c**} ± 4.51	73.00^{NS}	93.16^{a} ± 5.05	66.33^{b} ± 6.23	40.00^{c} ± 1.15	66.50
Weight of Head (kg)	5.93^{a} ± 0.32	4.41^{b} ± 0.16	3.07^{c**} ± 0.20	4.47^{NS}	5.70^{a} ± 0.38	4.26^{b} ± 0.28	2.81^{c} ± 0.11	4.26
Carcass weight (kg)	72.66^{a} ± 4.18	55.33^{b} ± 3.71	33.33^{c**} ± 3.33	53.77^{NS}	66.66^{a} ± 3.71	47.33^{b} ± 3.71	28.66^{c} ± 1.45	47.55
Dressing percentage with head	81.21^{a} ± 2.23	78.19^{b} ± 1.32	79.16^{b*} ± 0.59	79.52^{NS}	77.68^{a} ± 1.51	77.93^{a} ± 2.50	78.68^{a} ± 3.06	78.09
Dressing percentage without head	75.07^{a} ± 2.04	72.39^{b} ± 1.34	72.43^{b*} ± 0.52	73.30^{NS}	71.57^{a} ± 1.40	71.62^{a} ± 2.04	71.65^{a} ± 2.93	71.61
Carcass length (cm)	83.33^{a} ± 0.88	71.83^{a} ± 3.06	48.33^{c**} ± 0.67	67.83^{NS}	82.66^{a} ± 1.67	68.66^{b} ± 2.96	46.5^{a} ± 0.58	65.94
Back fat thickness (cm)	3.91^{a} ± 0.51	3.22^{b} ± 0.06	2.78^{c**} ± 0.06	03.30^{NS}	3.61^{a} ± 0.01	3.12^{b} ± 0.06	2.60^{c} ± 0.12	3.11
Loin eye area (cm^2)	33.00^{a} ± 0.58	22.00^{b} ± 1.53	15.66^{c**} ± 1.20	23.55^{NS}	32.00^{a} ± 1.15	19.00^{b} ± 1.53	15.33^{c} ± 0.88	22.11

Means having the same superscript in a row do not differ significantly

NS – Non significant

* – Significant at 5 per cent

** – Significant at 1 per cent

Table 4.13 Characteristics of fat of pigs fed with two different rations

Characteristics	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
Melting point of lard (^0C)	48.00^a ± 0.000	48.67^a ± 0.33	48.00^a ± 0.000	48.22^{NS}	48.00^a ± 0.00	47.33^a ± 0.33	48.00^a ± 0.000	47.77
Saponification value of fat	193.67^a ± 1.20	194.00^a ± 2.31	193.33^a ± 0.67	193.66^{NS}	193.33^a ± 0.88	190.67^a ± 1.45	191.00^a ± 0.58	191.66
Iodine value of fat	69.00^a ± 0.58	71.00^a ± 0.58	71.00^a ± 0.58	70.33^{NS}	70.00^a ± 0.58	69.33^a ± 0.33	69.00^a ± 0.58	69.44

Means having the same superscript in a row do not differ significantly
NS – Non significant

Table 4.14 Feeding behaviour of pigs fed with two different rations

Score	Treatment I (ICAR) (in percentage)			Treatment II (10 % less ICAR) (in percentage)		
	Large White Yorkshire	Crossbred	Desi	Large White Yorkshire	Crossbred	Desi
3	71.43^{a**}	9.52^{b}	2.38^{a**}	42.85^{b}	4.76^{b}	0.00^{b}
2	28.57^{a**}	57.14^{b**}	16.67^{NS}	57.15^{b}	66.67^{c}	14.29^{b}
1	0.00	33.34^{NS}	80.95^{NS}	0.00	28.57^{NS}	85.71^{NS}

Means having the same superscript in a row do not differ significantly

Percentage tested by proportion test (two factor)

NS – Non significant

** – Significant at 1 per cent

Table 4.15 Agonistic behaviour of pigs fed with two different experimental rations

Behaviour	Treatment I (ICAR)				Treatment II (10 % less ICAR)			
	Large White Yorkshire	Crossbred	Desi	Treatment Mean	Large White Yorkshire	Crossbred	Desi	Treatment Mean
Number of threats/day	$10.214^{a} \pm 0.528$	$9.179^{b} \pm 0.405$	$5.143^{c**} \pm 0.190$	2.901^{**}	$11.107^{a} \pm 0.369$	$10.607^{b} \pm 0.396$	$5429^{c} \pm 0.215$	3.045
Number of ear biting/day	$2.464^{a} \pm 0.141$	$1.500^{b} \pm 0.096$	$0.643^{c**} \pm 0.092$	1.383^{NS}	$2.571^{a} \pm 0.195$	$1.571^{b} \pm 0.130$	$0.714^{c} \pm 0.087$	1.408

Figures having the same superscript in a row do not differ significantly

NS – Non significant

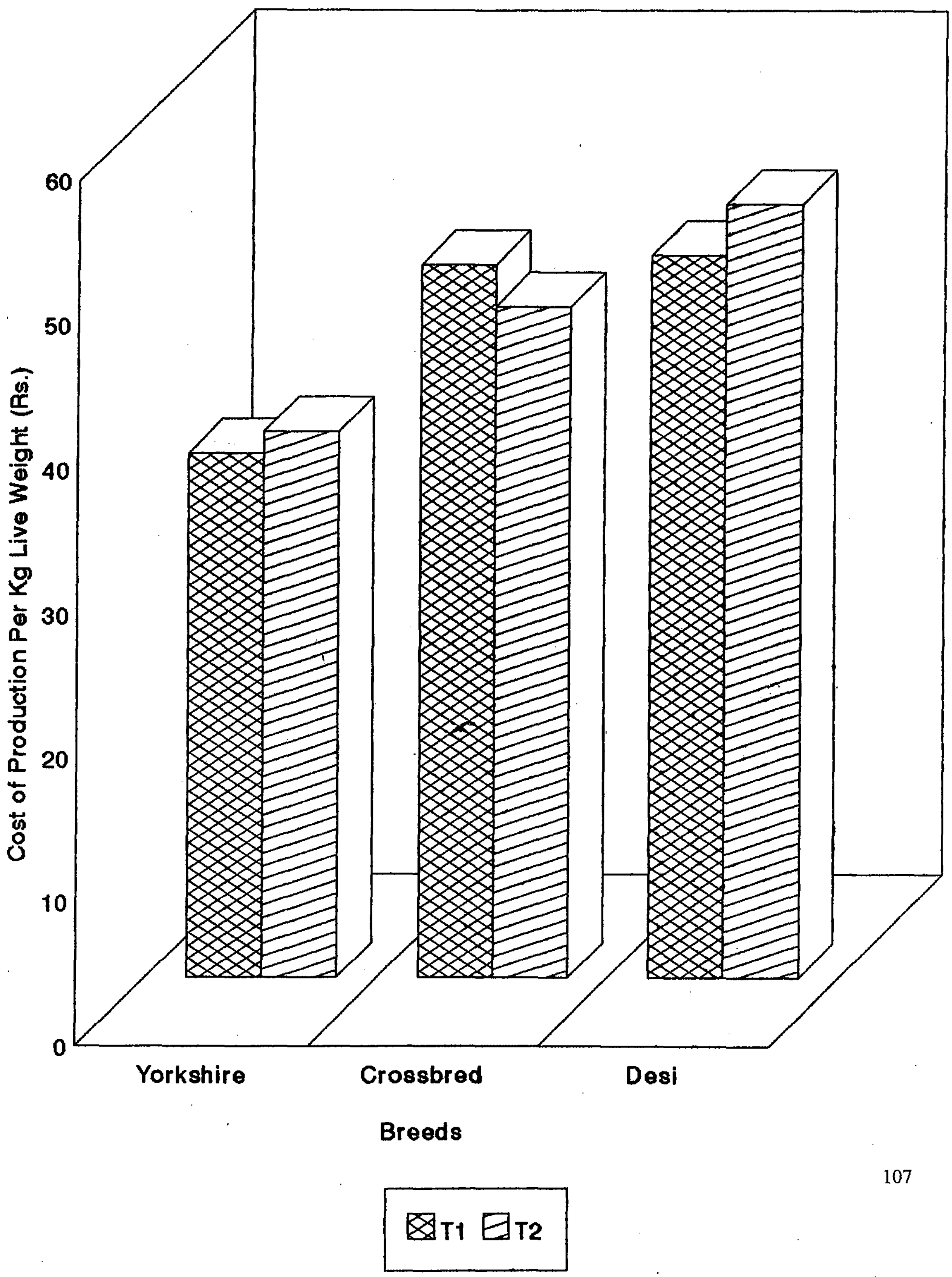
** – Significant at 1 per cent

Table 4.16 Cost of production per kg live weight of three breeds of pigs fed with two different rations

Observation	Treatment I (ICAR)			Treatment II (10 % less ICAR)		
	Large White Yorkshire	Crossbred	Desi	Large White Yorkshire	Crossbred	Desi
Number of animals	6	6	6	6	6	6
Total initial body weight (kg)	53.5	49	39	53	48	38.7
Total final body weight (kg)	483.5	373	282	434	354	237.3
Total body weight gain (kg)	430	324	243	381	306	198.6
Total feed intake (kg)	1844.91	1933.65	1482.21	1785.33	1789.47	1384.11
Total feed cost (Rs)	13218.45	13859.17	10624.55	12344.23	12376.59	9579.15
Cost of feed per kg (Total feed cost/ total feed intake)	7.16	7.16	7.16	6.91	6.91	6.91
Feed conversion efficiency	3.81	5.18	5.25	4.11	5.05	5.83
Cost of production on feed basis (Rs.) (FCR x Cost of feed/kg)	27.27	37.08	37.59	28.40	34.89	40.28
Cost of production/kg live body weight (Rs.)*	36.36	49.44	50.12	37.86	46.52	53.70
Overall treatment Mean (Rs)	45.30			46.02		

* - Under the assumption that cost of feed accounts for about 75 per cent of total cost of production in pigs (Joseph, 1997)

Fig. 4.12 COST OF PRODUCTION PER KG LIVE WEIGHT OF PIGS FED WITH TWO DIFFERENT RATIONS



Discussion

5. DISCUSSION

The results of the experiment are discussed hereunder.

5.1 Growth

In Livestock production growth is very important since it is the basis for meat, milk etc. Growth represented by an increase in size and weight with age and development, is thus of great economic significance.

From Table 4.1 it can be seen that adjusted mean body weight of Large White Yorkshire and crossbreds were different at different stages of growth maintained on the two dietary regimes for a period of seven months. The animals used in this study showed a progressively increasing weight from weaning to 14^{th} fortnight. This nature of growth is in agreement with the pattern of growth reported by Brody (1945) and Maynard *et al.*, (1979). They have reported an increase in body weight from birth in a way characteristic to the species. Plane of feeding was found to affect the performance of different breeds.

Highly significant difference ($P<0.01$) was noticed during the growing phase between the high protein ration (13.69 to 32.80 kg) and low protein ration (12.33 to 27.33 kg). Eventhough numerical difference was noticed between these treatment groups during the finishing period it was not significant statistically.

The results obtained during the course of this study are in agreement with the results reported by Woodman *et al.* (1939), Braude and Rowell (1968) and Meade *et al.* (1969) who found improvement in live body weight gain in pigs fed on higher levels of protein in the initial growth period. Similarly, Davey (1976) and Christian *et al.* (1980) observed reduction in growth rate of Duroc and Yorkshire pigs when fed with low protein diet. The trend continued during the finishing phase also eventhough the differences were not significant. Das (1997) noticed higher body weight during the finishing phase in crossbred female pigs fed with diet containing high protein.

Body weight at different stages of growth of Desi pigs were significantly lower ($P<0.01$) than Large White Yorkshire and crossbred pigs. Similar results were reported by Saseendran and Rajagopalan (1982), AICRP (1996), Sharma *et al.* (1992) and Suraj (2000).

The growth studies indicated higher body weight in Large White Yorkshire followed by crossbred and Desi pigs in all fortnights. Similar finding has been observed by Chatterjee *et al.* (1988) and Gaur *et al.* (1996).

5.2 Body measurements

The average body length, body girth and body height of three breeds of pigs fed with two different dietary regimes are given in Table 4.2, 4.3 and 4.4 respectively. When the data were subjected to statistical analysis, the differences were found to be highly significant ($P<0.01$) between the treatment groups except body length which was not significant. Body length, Body girth and Body height of Desi pigs were significantly lower ($P<0.01$) than the other groups at seven months of age.

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). Literature on the influence of dietary protein level on the gain in measurements in pigs are rather scanty. In both the treatment groups the length showed a progressive increase from the initial to the final stage.

The linear relationship between live weight gain and body measurement was also reported by several other authors (Mickwitz and Bobeth, 1972; Deo and Raina, 1983 and Sahaayaruban *et al.,* 1984; Sinthiya, 1998 and Ramamoorthi, 1999). Height of Desi pigs were significantly lower than both Large White Yorkshire and crossbred pigs at all stages of growth except at first fortnight. The above observations are in accordance with the finding of Saseendran, (1979), Devi (1981), Joseph (1997) and Suraj (2000).

5.3 Rectal temperature, pulse rate and respiratory rate

From Table 4.5, 4.6 and 4.7 it can be seen that the average rectal temperature, pulse rate and respiratory rate of Large White Yorkshire, crossbred and Desi pigs fed with ICAR ration were 102.28, 102.22 and 102.24°F; 71.53, 72.28 and 72.44; 29.67, 29.28 and 29.15 respectively with an overall average rectal temperature, pulse rate and respiratory rate of 102.19°F, 72.16 and 29.28 respectively.

The average rectal temperature, pulse rate and respiratory rate of the same breeds in 10 per cent less crude protein than ICAR ration were found to be 102.16, 102.12 and 102.14°F, 71.07, 71.28 and 71.67; 28.71, 28.10 and 28.10 respectively with overall average rectal temperature, pulse rate and respiratory rate of 102.14^{0}F, 71.35 and 28.10. There was no significant (P>0.05) difference between the breeds and between the dietary regimes. This is in agreement with the observation of west (1985); Mathur (1990); Sebastian, (1992) and Dinesh (2000).

5.4 Feed intake

The average daily feed intake of the three breeds of pigs increased progressively with advance in age. From Table 4.8 it can be seen that the average daily feed intake of Large White Yorkshire, crossbred and Desi pigs fed with ICAR ration was 1.464 ± 0.165, 1.535 ± 0.164 and 1.76 ± 0.119 kg respectively with an overall average of 1.39 kg. The daily feed intake of the same breeds in 10 per cent less crude protein than ICAR ration was found to be 1.417 ± 0.161, 1.420 ± 0.159 and 1.099 ± 0.110 kg respectively with an overall average of 1.312 kg. The difference noted in daily feed intake between the treatment groups and between the breeds were 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. Feed intake of Desi pigs was lower than Large White Yorkshire and crossbred pigs throughout the experimental period. This was in accordance with the findings of Saseendran (1979), Joseph (1997) and Suraj (2000).

5.5 Average daily body weight gain and feed conversion efficiency

The mean average daily body weight gain of Large White Yorkshire, Crossbred and Desi pigs fed with ICAR ration was found to be 411.21 ± 62.00, 317 ± 55.00 and 239.00 ± 42.00g respectively. There was a significant difference ($P<0.01$) between Large White Yorkshire and Desi, but the difference between Large White Yorkshire and Crossbred and between Crossbreds and Desi were non-significant. The treatment had no effect on the daily body weight gain.

The above results obtained during the study period are in agreement with the reports of Aunan *et al.* (1961), Clawson *et al.* (1962), Washington and Cripp, (1980), Feng *et al.* (1985), and Kuhn and Burgstaller, (1995) who had observed no significant difference on the average daily body weight gain in pigs fed with high or low protein diets. But Das (1997) reported a higher average daily gain during the finishing period in crossbred female pigs fed with diet containing higher protein.

The feed conversion efficiency of Large White Yorkshire, Crossbred and Desi pigs fed ICAR ration was found to be 3.815, 5.184 and 4.75 respectively. The feed conversion efficiency of the same breeds in 10 per cent less crude protein than ICAR ration was found to be 4.113, 5.055 and 5.832 respectively. The overall feed efficiency of the three breeds of pigs in treatment groups I and II was 4.75 and 5.00 respectively and no significant difference was noticed (P>0.05). This is in agreement with the findings of Aunan *et al.* (1961), Clawson *et al.* (1962), Washington and Cripp, (1980), Feng *et al.* (1985) and Kuhn and Burgstaller (1995) who had reported no significant difference on the feed efficiency in pigs fed with high or low protein diets, but contradicts the result obtained by Cromwell *et al.* (1978) who reported that pigs on high protein diet showed higher feed efficiency than low protein diet.

The feed conversion efficiency of Large White Yorkshire was significantly higher (P<0.01) than both the crossbreds and Desi pigs, but the difference between crossbreds and Desi was non significant. The present study revealed that Large White Yorkshire pigs were having better feed efficiency when compared to crossbreds and Desi pigs. Feed contributes about 70-75 per cent of the total cost of production in swine (Krider and Carrol, 1971). So a higher average daily body weight gain and feed conversion efficiency is important in selecting a genetic group in a short term farming operation for better profit.

5.6 Digestibility coefficient of nutrients

The digestibility coefficient of dry matter, crude protein, ether extract, crude fibre and nitrogen free extract of three breeds of pigs fed with two different rations are presented in Table 4.11. Statistical analysis of the data revealed that the digestibility of dry matter and nitrogen free extract were found to be highly significant ($P<0.05$) between the treatment groups. Digestibility coefficients of crude protein, ether extract and crude fibre were found to be non significant ($P>0.05$).

Digestibility coefficient of dry matter, crude protein, ether extract and crude fibre were found to be highly significant ($P<0.01$) between the breeds except nitrogen free extract on which breed had no effect. However, the results indicate that there is an increase in digestibility of crude protein with an increase in dietary protein level. This finding is in agreement with Sikka *et al.* (1987) who also observed higher digestibility of protein with increase in dietary protein level. In this study, Large White Yorkshire pigs had better digestibility than crossbreds and Desi pigs. Similar results were reported by Mohan, (1991) and Ramamoorthi (1999).

5.7 Carcass traits

Table 4.13 gives the comparative carcass traits of the three breeds of pigs fed with two different rations.

The statistical analysis of the data indicated that dressing percentage, carcass weight, carcass length, back fat thickness and loin eye area did not show any significant difference (P>0.05) between the treatment groups. This may be due to the small differences in protein levels used in the experimental rations. Similar results are reported by Aunan *et al.* (1961) in their studies with pigs using rations with protein levels of 18, 16 and 14 per cent. These results are also supported by Clawson *et al.* (1962) and Ramachandran (1977) who could not detect any significant difference in carcass characteristics of pigs maintained on different dietary protein levels. Shields and Mahan (1980) found that temporary moderate protein restrictions in diets did not affect carcass traits. Similarly, Kuhn and Burgstaller (1995) revealed no significant difference in carcass traits in pigs fed with low protein diet. Several workers on the other hand, had obtained increased lean growth (Cunningham *et al.*, 1973;

Baird *et al.*, 1975 and Irwin *et al.* 1975) and decreased back fat thickness (Irwin *et al.*, 1975) on higher dietary protein levels.

A clear breed difference was noticed with respect to carcass traits such as carcass weight, carcass length, back fat thickness and loin eye area except dressing percentage in both the treatment groups. Dressing percentage of Large White Yorkshire was significantly (P<0.05) higher than Crossbreds and Desi pigs in treatment group I but it was non significant statistically in treatment group II. These findings are in accordance with that of Saseendran (1979), Joseph, (1997) and Gopi (2001). The Large White Yorkshire excelled Crossbred and Desi pigs in all carcass traits. This is in agreement with the observations made by Deo *et al.* (1992).

5.8 Fat constants

Summarised data on fat constants (Table 4.13) and their statistical analysis indicate that there was no significant difference (P>0.05) in melting point, saponification value and iodine value of body fat of animals maintained under the two dietary treatment groups. This may be due to the fact that the experimental rations used in the study were essentially similar in all except for the little difference in the percentage of crude protein, to exert any marked influence on any of the fat characteristics studied.

The values obtained in the present study is in agreement with the results of Woodman, (1941); Carton, (1965); Maynard *et al.* (1979); Sebastian, (1972); Ramachandran, (1977) and Sebastian (1992) who also observed similar range of melting point, saponification value and iodine value. But lower iodine value (range 53-63) was reported by Yatsenko (1987) in Large White Yorkshire pigs

5.9 Behaviour of pigs

5.9.1 Feeding behaviour

The feeding behaviour score of pigs which is a measure of manifestation of appetite in feeding is shown in Table 4.14.

Statistically significant difference was observed between the feeding behaviour of the Large White Yorkshire fed with two different rations. In ICAR ration the score three was 71.43 per cent observed and the score two 28.57 per cent whereas in 10 per cent less crude protein than ICAR ration it was 42.85 and 57.15 per cent respectively. The crossbred pigs fed with ICAR ration showed score two for 57.14 per cent whereas in 10 per cent less crude protein than ICAR ration 66.67 per cent. The difference in the behaviour was statistically significant (P<0.01). In both the treatment groups, Desi pigs showed the behavioural score one and the difference noted was not statistically significant.

This is in agreement with the observation of Joseph, (1992) and Labroue *et al.* (1995) who had reported difference in feeding behaviour in Large White Yorkshire pigs.

5.9.2 Agonistic behaviour

In the present study, the agonistic behaviour was measured by counting the number of threats and ear biting incidence during the feeding time (Table 4.15). Statistically the results showed highly significant difference (P<0.01) in number of threats between the treatment groups (Table 4.15) and between the breeds.

Number of ear biting during the feeding time revealed no significant difference (P>0.05) between the treatment groups and highly significant (P<0.01) between the breeds. During feeding time, the animals tried to displace the other animals from the manger. This activity was noticed from second month onwards. Before feeding they huddled together for sleeping. Immediately after feeding the animal from ICAR fed ration group used to go for sleeping and in the other group some animals tried to "Chase" mount and attack the other animals. All the pigs marked a definite area either near waterer near the wallowing tank for defecation and urination. Large White Yorkshire pigs were the most aggressive or excited followed by Crossbred and Desi pigs. The result obtained in the study is in agreement with Dinesh (2000).

5.10 Economics

Calculation of cost of production per kg of live body weight depends upon several factors like total feed intake, feed cost and feed conversion efficiency and total body weight gain from weaning to seven months of age. The cost of production per kg of live weight of pigs fed with treatment ration I and II are presented in Table 4.16. It can be seen from Table 4.16 that the cost of production per kg of live body weight in Large White Yorkshire, Crossbreds and Desi pigs were Rs. 36.36, Rs. 49.44 and Rs. 50.12 respectively in treatment group I. In treatment group II, the cost of production per kg of live body weight of the same breeds were Rs. 37.86, Rs. 46.52 and Rs. 53.70 respectively. The cost of production per kg of live body weight is lower for Large White Yorkshire followed by Crossbred and Desi pigs respectively. Large White Yorkshire pigs performed better in growth rate, feed conversion efficiency and carcass traits and may be recommended for large and modern commercial piggery units. But the cost of production per kg of live body weight is lower for crossbred pigs maintained on 10 per cent less crude protein than ICAR ration. So for the farmer with limited resources, rearing of crossbred pigs are affordable.

Optimum feeding and managemental conditions are needed for full exploitation of the growth potential of Large White Yorkshire. The study shows that in all aspects of growth the Large White Yorkshire out perform the Desi and the Crossbreds between Large White Yorkshire and Desi. Feed conversion ratio was also better in Large White Yorkshire followed by Crossbred and Desi in that order. Considering these, in any commercial operation one should prefer the Large White Yorkshire or similar breeds. Crossbred pigs have their relevance only in extensive pig farming of the type seen in Indian villages where there is very adverse environmental conditions and inferior feeding conditions. In such environments pure exotic breeds are unlikely to perform well. Desi have proven their ability to perform under such conditions. If the superiority of the Crossbred over Desi observed under experimental conditions can be replicated under the harsh village conditions, this may enhance pig production through the extensive village system.

Summary

6. SUMMARY

An experiment was conducted to compare the merits and demerits of crossbred pigs over indigenous and exotic pigs with respect to growth and carcass characteristics and to study the economic feasibility of rearing crossbred pigs.

Three groups of twelve weaned female piglings each belonging to indigenous (Desi), Large White Yorkshire (LWY) and crossbred (CB) (LWY x Desi) of Centre for Pig Production and Research, Mannuthy were selected as uniform as possible with regard to age and body weight. Animals in each breed group were randomly divided into two equal dietary treatment groups of six viz., (T_1 – ICAR recommended level of crude protein, T_2 – A low plane (LP) of 10 per cent less of crude protein with reference to ICAR level).

All the pigs were fed isocaloric ration as per ICAR recommendation. The experiment was conducted for seven months. The piglings were fed twice daily and maintained under identical managemental conditions.

The body weight and body measurements were recorded at fortnightly intervals and average daily body weight gain and feed conversion efficiency were estimated in each breed. The rectal temperature, pulse rate and respiratory rate were recorded at weekly intervals. A digestibility trial using chromic oxide as external indicator was carried out to determine the digestibility coefficient of nutrients in the two experimental diets, when the pigs attained seven months of age. Three animals from each treatment group were randomly selected and slaughtered at the end of the experiment to obtain the data on carcass characteristics. Melting point of lard, saponification value and iodine value of fat were also estimated. Animals were also observed for feeding and agonistic behaviour before, during and after feeding hours to study the adaptive behavioural manifestations. The data were statistically analysed.

The adjusted mean body weight of Large White Yorkshire and crossbred pigs were different at different stages of growth maintained on the two dietary regimes for a period of seven months. The animals showed a progressively increasing weight from weaning to 14^{th} fortnight. Highly significant difference ($P<0.01$) in weight gain was noticed during the growing phase between the high protein ration and low protein ration and non significant difference between these dietary regimes during the finishing period. Body weight at different stages of growth of Desi pigs were significantly lower than Large White Yorkshire and Crossbred pigs.

Body measurements were significantly ($P<0.01$) different between the treatment groups except body length which was non significant. Body measurements of Desi pigs were significantly lower ($P<0.01$) than the other groups at 14th fortnight.

Physiological variables like rectal temperature, pulse rate and respiratory rate of pigs did not vary due to dietary regimes or genetic groups.

The average daily feed intake of the three breeds of pigs increased progressively with advance in age. The difference noted in daily feed intake between the treatment groups and between the breeds were found to be non significant. Feed intake of Desi pigs was lower than Large White Yorkshire and Crossbred pigs throughout the experimental period.

The treatment had no effect on the daily body weight gain and feed conversion efficiency. There was a significant difference ($P<0.01$) between Large White Yorkshire and Desi, but the difference between Large White Yorkshire and Crossbreds and between Crossbreds and Desi were non significant. The feed conversion efficiency of Large White Yorkshire was significantly higher than both the Crossbreds and Desi pigs, but the difference between Crossbreds and Desi was non significant.

The digestibility coefficient of dry matter and nitrogen free extract varied significantly ($P<0.01$) between the treatment groups. Digestibility coefficient of crude protein, ether extract and crude fibre were found to be non significant ($P>0.05$). Digestibility coefficient of dry matter, crude protein and ether extract and crude fibre varied significantly ($P<0.01$) between the breeds except nitrogen free extract in which breed had no effect.

Protein levels used in the ration do not seem to exert any significant influence on the various carcass characteristics studied. In carcass traits like dressing percentage, carcass weight, carcass length, back fat thickness and loin eye area the two levels of protein in the ration did not cause any significant difference ($P>0.05$) between them. A clear breed difference was noticed with respect to carcass traits such as carcass weight, carcass length, back fat thickness and loin eye area except dressing percentage in both the treatment groups. Dressing percentage of Large White Yorkshire was significantly (P<0.05) higher than Crossbreds and Desi pigs in treatment group I but it was non significant in treatment group II. The Large White Yorkshire excelled Crossbred and Desi pigs in all carcass traits.

Fat constants like melting point, saponification value and iodine value were not influenced either by protein levels or by body weights. Statistically significant difference was observed between the feeding behaviour of Large White Yorkshire and Crossbred pigs. The agonistic behaviour of pigs showed highly significant difference (P<0.01) in number of threats between the treatment groups and between the breeds. The number of ear biting during the feeding time revealed no significant difference (P>0.05) between the treatment groups but there was a highly significant difference (P<0.01) between the breeds. Large White Yorkshire pigs were the most aggressive or excited followed by Crossbreds and Desi pigs in that order.

The cost of production per kg live weight was lower for Large White Yorkshire followed by Crossbreds and Desi pigs respectively. Large White Yorkshire pigs had higher growth rate, better feed conversion efficiency and average daily weight gain and carcass traits when compared to Crossbreds and Desi pigs.

The cost of production was lowest in Large White Yorkshire followed by Crossbreds and Desi pigs. Thus under organised farm conditions Large White Yorkshire or similar exotic breeds appear superior. However for vast majority of pigs reared under extensive scavenging systems involving low plane of feeding and adverse environmental conditions, introduction of Crossbreds may be advantageous. The cost of production of Crossbred pigs maintained on 10 per cent less crude protein was lower than full ICAR ration.

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COMPARATIVE STUDY OF GROWTH, CARCASS CHARACTERISTICS AND ECONOMICS OF CROSSBRED, INDIGENOUS AND EXOTIC PIGS

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ABSTRACT OF A THESIS

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ABSTRACT

A detailed investigation was carried out to compare the merits and demerits of crossbred pigs over indigenous and exotic pigs with respect to growth and carcass characteristics and to study the economic feasibility of rearing crossbred pigs.

Three groups of twelve weaned female piglings each belonging to indigenous (Desi), Large White Yorkshire (LWY) and crossbred (CB) (LWY x Desi) of Centre for Pig Production and Research, Mannuthy were selected as uniform as possible with regard to age and body weight. Animals in each breed group were randomly divided into two equal dietary treatment groups of six. Treatment group one was fed with a ration specified by ICAR and treatment group two with a ration containing 10 per cent less crude protein than ICAR ration. All the pigs were fed isocaloric ration as per ICAR recommendation.

The protein level in the ration had a moderate influence on the performance of grower pigs. There was a trend in favour of full ICAR ration with respect to the parameters like growth rate, feed conversion efficiency, average daily weight gain and carcass characteristics.

Eventhough, there was no significant difference (P>0.05) between the two dietary regimes there was highly significant difference (P<0.01) between the breeds. A clear breed difference was noticed between Large White Yorkshire and Desi pigs with respect to traits such as feed intake, body weight, body measurements, average daily body weight gain and feed conversion efficiency. But there was no significant difference (P > 0.05) between crossbreds and Desi Pigs in average daily body weight gain and feed conversion efficiency. Large White Yorkshire pigs had better digestibility than crossbred and Desi pigs. The cost of production per kg live body weight was found to be less (Rs. 45.30) in ICAR ration than 10 per cent less crude protein ration (Rs. 46.02) due to higher feed efficiency and better growth rate.

The overall results obtained during the course of present study is that the unit cost of production is less for animals maintained on ICAR ration. The present study also revealed that Large White Yorkshire had higher growth rate, better feed conversion efficiency, average daily weight gain and higher values for carcass traits when compared to crossbred and Desi pigs. So the cost of production per kg of live body weight was calculated, Large White Yorkshire had lowest cost of production when compared to crossbred and Desi pigs. But the cost of production per kg live body weight is lower for crossbred pigs maintained on 10 per cent less crude protein than ICAR ration. On the whole, Large White Yorkshire breed is most suited for large scale commercial piggery units. However, for the vast majority of extensive scavenging pig rearing systems under harsh environment, poor hygienic condition and low plane of nutrition the Desi pig has adapted albeit extremely low level of productivity. The Large White Yorkshire and similar exotic breeds with their highly sophisticated requirements are not likely to perform well in these sub-standard production systems. The Crossbreds which showed production traits in between the two, i.e., higher than Desi but lower than Large White Yorkshire may fit in by adapting to the conditions and improving the productivity of the system. The fact that on low protein diet cost of production was lower than on full protein diet, points to that.