ADAPTABILITY OF CROSSBRED PIGS UNDER DIFFERENT HOUSING AND FEEDING SYSTEMS

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Thesis submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University, Thrissur

2005

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DECLARATION

I hereby declare that the thesis, entitled **"ADAPTABILITY OF CROSSBRED PIGS UNDER DIFFERENT HOUSING AND FEEDING SYSTEMS"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENTS

With great respect, I place on record my most sincere and heartfelt gratitude to the Chairman of the Advisory Committee, **Dr. Joseph Mathew,** *Assistant Professor, Department of Livestock Production Management, for his meticulous guidance, unstinted support, persuasion and help rendered in all possible ways, which was the major factor that led me to accomplish this task. I am eternally grateful for the patience he endorsed in tackling my case.*

I humbly place my gratitude to **Dr. P. C. Saseendran,** *Professor and Head, Department of Livestock Production Management and member of Advisory Committee for his care and concern and inspiring professional guidance during my course of study.*

I am indebted to **Dr. M. R. Rajan,** *Associate Professor and Head, Centre for Pig Production and Research (CPPR) as a member of the Advisory Committee and wish to put on record my sincere thanks to him for the provision of all facilities, valuable suggestions, constructive criticism, fruitful discussions and critical supervision of the work from time to time which he did, despite his busy schedule.*

I am privileged to have, **Dr. George T. Oommen,** *Associate Professor, Department of Livestock Products Technology, as a member of Advisory Committee. I thank him for constant encouragement, genuine support and timely help rendered to me for the completion of my work.*

I remember with gratitude the help extended to me by **Dr. Francis Xavier,** *Associate Professor and* **Dr. K. S. Anil,** *Assistant Professor Department of Livestock Production Management during the course of study.*

I am extremely thankful to **Dr. Kannan,** *Assistant Professor Department of Livestock Production Management, for his valuable help, expert advice, suggestions and keen interest shown at every stage of this research work.*

I sincerely thank **Dr. K. S. Sebastian,** *Professor (Research Co-ordination) for his kind help during the research programme.*

My sincere thanks to **Dr. Viswanathan,** *Professor and Head, and Department of Animal Nutrition, for granting permission to use the laboratory.*

I sincerely thank **Mrs. K. S. Sujatha** *Associate Professor and Head, Department of Statistics for her help in the analysis of the data.*

I wish to thank **Dr. Suresh Kumar,** *Assistant Professor, Radiotracer Laboratory, Vellanikkara for his help in cortisol analysis.*

I am highly indebted to my senior Ph. D scholars ***Dr. Murugan, Dr. Rajaganapathy*** *and* ***Dr. Sabin*** *Department of Livestock Production Management for their timely help, support and keen interest shown on my research work.*

Words fall short in expressing my deep sense of obligation to my colleagues ***Dr. Subash, Dr. Deepak, Dr. Roshin, Dr. Sheena, Dr. Smitha, Dr. Jeeba*** *and* ***Dr. Shymaja*** *for their moral support and help.*

I sincerely thank my senior colleagues ***Dr. Cijo, Dr. Sada, Dr. Anup, Dr. Shibi, Dr. Uma*** *and* ***Dr. Devi.*** *I also extend my heartfelt thanks to my junior colleagues,* ***Dr. Acty, Dr. Vijay, Dr. Biya, Dr. Geetha Dr. Kavi and dear most Winny, Cyrus, Jinu and Praveen*** *for their timely help and support rendered to me.*

Mere words are insufficient to express the sentiments I feel for my dearest friends ***Dr. Arul, Dr. Senthil, Dr. Raja, Dr. Ragu Dr. Sumi, Dr. Meena, Dr. Anbu, Dr. Jothi, Dr. Jeba, Dr. Selvi, Dr. Jeni*** *and* ***Dr. Kavitha*** *for their constant motivation which instilled in me the confidence to tackle many a hurdles during the study.*

I am deeply indebted to ***Mr. Gopi, Mr. Sajeev*** *and* ***Mrs. Sarada*** *of the Department of Livestock Production Management for their cooperation and support.*

I am grateful to the staff and labourers of Centre for Pig Production and Research for their sincere help and co-operation.

I thank the ***Dean,*** *Faculty of Veterinary and Animal Sciences for providing the facilities for the study. I am indebted to* ***Kerala Agricultural University*** *for awarding me the fellowship for the postgraduate study.*

I greatly cherish my family members ***Amma, Appa, Annan, Auxi, Atthan, Ajay & Adlin*** *to whom I am most indebted, since without their love and support this book would not have seen the light of day.*

Last but foremost in mind; to God Almighty the invisible but invincible authority who gave me strength and sound health all throughout my research period and …… …

J. Anton Roseline

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Introduction

1. INTRODUCTION

Pigs are considered to be supreme amongst meat producing livestock and are efficient converters of various unconventional feedstuffs into valuable animal protein. The high prolificacy, short generation interval, fast growth rate and other biological advantages beneficially contribute to its ability to make up our animal protein deficiency by bridging the gap between the demand and supply of animal protein. Although India has achieved a level of self-sufficiency in its cereal production, the availability of animal protein with high biological value and compositional similarities with human body with regard to the amino acids profile has not reached the recommended level.

The pork industry as a meat producing enterprise is likely to develop at a rapid rate in India in the coming years. The development of a stress resistant and adapted pig to the feeding and management systems available in developing countries and provision of a stress free environment for the maximum exploitation of genetic potential of the pigs are the two areas demanding intervention by researchers.

Feed represents about 70 to 75 per cent of the total cost of production in swine (Krider and Carroll, 1971) and hence any attempt to reduce the feed cost will add to the benefit of farmers. Pig rearing based on a commercial pig ration with conventional feed ingredients is not profitable considering the present market values of pork, cost of feed ingredients and feed conversion efficiency of available genetic groups of pigs in Kerala. The need for formulating a low cost pig feed deserves top priority for enhancing pig husbandry in Kerala. In the search for cheaper sources of pig feed, the utilisation of unconventional feed in the diet of pigs is receiving considerable attention in India. Several unconventional feed sources like left over food from hostels, restaurants and catering establishments, infertile eggs and chicken waste can be exploited for this purpose. Swill is the cheapest and very easily available one with crude protein ranging from eight to 22 per cent. Infertile eggs and chicken waste are rich in nutrients and are relished by pigs.

Pigs are reared under a variety of production systems ranging from simple backyard pigs, pigs living on garbage belts to family operated farms or large scale integrated pig industries with sophisticated biosafety measures. Thus swine rearing is carried under a variety of adverse social, climatic and environmental conditions. All types of stressors adversely affect the growth of the pigs. There are three basic genetic groups of pigs in our country, viz., desi pigs, exotic pigs and non-standardized crossbred pigs. The desi pigs, by virtue of having evolved locally may have more adaptability to tropical conditions than the exotic pigs. But most of the organised pig farmers prefer to rear exotic stock as they have increased growth rate and body weight. Though the exotic pigs are now considered comparatively superior to others and seemed to have adapted to our climatic conditions it is on sacrifice of their original production potential. Hence it is high time to study the production performance of various breed combinations and to recommend ideal genotypes suited to the feeding and management conditions prevailing in the rural production system. Modifications of microenvironment including social environment to alleviate stress and to get the maximum production performance is also equally important.

Reports on the influence of different housing systems in India on pig production are scanty and few and the research on the effects of individual versus group penning on the performance of swine is limited. Different housing systems have been utilised to reduce the climatic stress on pigs. A comprehensive study involving different housing systems simultaneously can bring out the merits and demerits of each system. Housing and management have an important effect on efficient feed utilisation. A suitable piggery should have ample protection against environmental hazard, stress and should be provided with good sanitation and hygienic condition, sufficient space and minimal feed wastage.

In the light of the foregoing resume the present study was undertaken to assess the adaptability and production performance of two groups of Large White Yorkshire crossbred pigs, viz., CB_1 (Duroc 50% and Large White Yorkshire 50%) and CB_2 (Desi 50% and Large White Yorkshire 50%), to determine the effect of feeding conventional and unconventional feeds under different housing (group and individual) systems on the growth and carcass characteristics, to analyse the behavioural elements and production traits and to recommend an optimum breed - housing - feeding combination for better adaptability and productivity.

Review of Literature

2. REVIEW OF LITERATURE

Research reports on adaptability of crossbred pigs under different housing and feeding systems in tropical regions are scarce and scanty. Agrawala and Srivastava (1982) have suggested researchers to evolve the right type of pigs to meet the requirements of the bacon factories and determine the most economic methods of feeding and most efficient technique of production under our own conditions.

2.1 HOUSING OF PIGS

Elliot and Doige (1973) found that animals housed in a group had higher growth rates, greater feed intakes and better feed efficiency than individually penned pigs.

Siers (1975) found no differences in feed efficiency between individual and group penning.

Hemsworth and Beilharz (1977) inferred that the practice of rearing boars from three weeks of age in the absence of visual and physical contact with other pigs had an undesirable effect on sexual behaviour like reduced copulatory performance but growth rate to 30 weeks of age, testicle size and semen quality were not affected by rearing treatment.

Barnett *et al.* (1984) observed no significant differences in the average daily gain (ADG) and feed conversion ratio (FCR) between group and individually housed pigs.

Patterson (1985) reported that pigs penned individually are likely to exhibit a slightly improved absolute growth rate (679 vs. 653 g/day, $P<0.01$) and feed conversion efficiency (2.5 vs. 2.55 g dry matter per kg growth) in comparison with those penned in groups. He also suggested that individual penning gave great flexibility in the utilisation of available pen spaces and could prevent behavioural disorders such as fighting and tail biting.

Robertson *et al.* (1985) reported a decrease in gain and feed intake of individually penned pigs after weaning, which they attributed to the effect of changing from a litter to an individual environment.

Tonn *et al.* (1985) reported that individually penned boars consumed more feed (1.48 vs. 1.4 kg feed/kg of gain) and grew faster than that group penned but individual penning markedly reduced leg soundness.

Spicer and Aherne (1987) stated that pigs penned individually exhibited better ADG and average feed intakes compared to those penned in groups of four. The percentage of that the pigs were observed to be resting, active- non-feeding, or sitting did not differ ($P>0.05$) among treatments. Pigs penned in pairs spent significantly ($P<0.05$) more time feeding (16.3 per cent) compared to pigs penned individually or in groups of four (15.2 vs. 15.3 per cent).

Reinhart *et al.* (1989) found that pigs on limited feeding with individual penning had higher daily gains ($P<0.5$) than the group penning.

Courboulay *et al.* (2002) suggested that improvements in pen design or environmental enrichment appear to be less effective in limiting the aggression observed when pigs are grouped together. Both limited and excessive pen space lead to decreased growth rates. They recommended that the studies should integrate pen space, group size and feasibility and the influence of environmental consequences must also be taken into consideration.

Shrestha *et al.* (2002) reported that an improvement in housing provides a cost effective way to improve growth rate and body condition of breeding gilts without the need to supply extra feed. Improvement in housing can give benefits equivalent to at least a seven per cent improvement in efficiency of feed under traditional Nepalese circumstances for pig rearing.

Schmolke *et al.* (2003) found pigs reared in large groups of up to 80 pigs/pen, with adequate space for maximal growth had no evidence of reduced gain, increased variation in final weight or increased tail biting. The pigs in large groups showed no evidence of forming subgroups and restricting themselves to parts of the pen.

Ravindra *et al.* (2004a) found that significantly highest body weight in pigs maintained in pukka floor with asbestos followed by pukka floor with tiles roof and katcha floor with tiles roof.

2.1.1 Water wallow

Bray and Singletary (1948) suggested that environmental conditions existing inside the pens can influence the effect of temperature on feed intake: for example the provision of a water wallow may enable the pig to wet itself and so as to lose heat by evaporation, with the result the feed intake is increased.

Heitman and Hughes (1949) opined that under warm conditions when pigs are deprived of a water wallow they will urinate and roll in their urine and in this way achieve some evaporative cooling.

Heitman *et al.* (1962) observed the effects of modified summer environment on swine behaviour and revealed that, on hot days pigs might cool themselves by going into a wallow or under water sprinklers.

Ensminger (1970) had reported that hogs have very few sweat glands thus they cannot cool themselves by perspiration. Mature breeding animals and finishing hogs need a wallow during the hot summer months. Instead of permitting an unsanitary mud wallow, successful swine producers install hog wallows. This equipment will keep the animals cool and clean and make for faster and more economical gains. Shades, wallows and sprinklers should enhance summer coolness. The wallow should be in close proximity to shade, but in no case shade should be built directly over the wallow. Such an arrangement will cause all the hogs to lie in the water all day. Up to 50 growing- finishing pigs can be accommodated per 100 sq. ft. of wallow provided shade or shelter is nearby.

Hsia *et al.* (1974) reported that the pig has a natural inclination to seek wet places in hot weather and in practical pig husbandry is exploited by the use of wallows, hoses or automatic sprinklers. Of these wallows have tended to be less satisfactory because they tend to be occupied exclusively by certain dominant animals and they require much time and effort to keep clean. Periodic sprinkling of water on growing and finishing pigs for two minutes at the rate of 50 ml per pig significantly improved their average daily gain and feed conversion.

Chatterjee and Krishnamurthy (1997) indicated that pigs reared under warm weather need a wallow during summer months. Instead of permitting unsanitary wallows, a masonary wallow with proper drainage would be desirable. The size of the wallow will depend upon the number and size of the animals.

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

White *et al.* (1998) interpreted that the combination of water sprinklers and wallows used under shade in open-sided swine housing functioned effectively in a warm humid climate to enhance cooling of boars as evidenced by the reduced respiratory rate in sprinkled boars when compared with non-sprinkled boars. Combinations of shade, water sprinklers and wallows provided effective protection against high ambient temperature.

2.2 FEEDING OF PIGS

Kornegay *et al.* (1965) referred food waste (FW) as garbage, swill, and / or kitchen refuse and indicated that the digestibility of FW in swine was similar to that of a commercial swine diet.

Ensminger (1970) stated that hogs are efficient converters of wastes and byproducts like grain wasted by finishing cattle, garbage, garden waste and dairy byproducts such as skim milk, whey etc. into pork.

Ravindran and Kornegay (1983) opined that properly processed cassava tuber meal could be incorporated in swine diets at levels up to 40 to 70 per cent.

Price *et al.* (1985) described FW as any edible waste from food production, transportation, distribution and consumption.

De-Haer and De-Vries (1992) have reported that breed, with the exception of daily feed intake, significantly influenced the performance traits and feed intake pattern traits.

Ramachandran *et al.* (1992) reported that prawn waste ensiled with rice bran in equal proportion with the addition of tapioca flour at 10 per cent level could be incorporated in the pig ration.

AICRP (1995) recommended that 50 per cent jackfruit and 50 per cent rain tree fruit could be included in the pig ration in order to reduce the feed cost.

Preston (1995) argued that if all the world grain production were reserved for human consumption then there would be enough to feed the 10 billion inhabitants at which the world population is expected to stabilize. He also stated that the inclusion of the unconventional feeds like sugarcane, cassava and coconut palm wastes in pig ration would reduce the feed cost which in turn increase the availability of grains for human consumption.

Rodriguez and Preston (1996) found that the nutritive value of duckweed was found to be higher when fed to indigenous pigs and their crosses whereas the purebred exotic (Large White Yorkshire) pigs failed to adapt to the use of duckweed.

Joseph (1997) opined that the high prolificacy, fast growth rate, short gestation period and ability to thrive on the unconventional feedstuff are the merits of pigs.

Westendorf *et al.* (1998) observed that during the growing phase, the corn/soya meal fed group gained significantly higher than the FW plus supplement fed groups followed by groups fed with FW alone. They also suggested that pigs must consume nearly four times the volume of FW to obtain the same amount of dry matter of a conventional feed.

Viswanathan *et al.* (2001) reported that pigs could be fed with swill alone. They also opined that economy and productivity of backyard pig production system was based on feeding hostel/hotel/domestic waste.

Sastry and Singh (2002) have recommended cooking of garbages for preventing spread of diseases like vesicular exanthema in pigs. However cooking makes garbage costlier and somewhat less palatable.

Apple *et al.* (2003) suggested that as much as six per cent feather meal can be incorporated into diets of growing-finishing pigs without adversely impacting animal performance, carcass composition or pork quality like pork colour and water holding capacity.

Faustin *et al.* (2003) reported that the diet incorporation of maize or sorghum in swine ration would provide approximately 30 per cent of the pigs requirements of lysine and methionine, which are the most limiting amino acids in pig feeds. They also observed that supplementation of diet with 20 per cent from animal origin may increase the amino acid provision to about 80 per cent.

Kuriakose *et al.* (2003) found that hatchery waste along with rice bran can be included to 50 per cent in the ration of pig after proper treatment.

Rakesh *et al.* (2003) found that significantly highest body weight was observed in pigs (Tamworth x Desi) maintained on hotel waste with 25 per cent concentrate feed than pigs fed with concentrate alone followed by pigs fed with hotel waste adlib.

Ranjan *et al.* (2003) reported that crude protein value of hotel waste was 26.23 per cent and explained it may be due to the fact that hotel waste contain excellent quality feed material viz., meat, bread, panneer, vegetable, rice, pulse etc.

Moon *et al.* (2004) reported that during the growing period, pigs fed diets containing food waste showed lower ($p<0.05$) ADG than those fed the control diet. But feed conversion ratio was better ($p<0.05$) in pigs fed with FW than in the control group. During the finishing period, pigs in the wet fermented food waste + dry feeding group grew faster ($p<0.05$) than those in the control and wet fermented food waste fed groups. At the end of the experiment it was inferred pigs fed with the control diet showed better ADG ($p<0.05$) than those fed FW, but feed intake and FCR were vice versa.

Raju *et al.* (2004) evaluated nutritive value of kitchen waste and revealed that the average daily dry matter content of kitchen waste fed in liquid form constituted 1.5 kg, whereas the dry matter content of solid kitchen waste constituted 0.08 kg. The crude protein from both solid and liquid waste together constituted 0.16 kg/day.

Ravindra *et al.* (2004b) ascertained that significantly highest body weight and body measurements were observed in pigs maintained on hotel waste with 20 per cent farm concentrate than pigs maintained on paddy husk with 20 per cent farm concentrate, 55 per cent paddy husk + 25 per cent maize + 20 per cent farm concentrate and 30 per cent paddy husk + 50 per cent fermented rice water + 20 per cent farm concentrate.

2.3 BEHAVIOUR

2.3.1 Feeding behaviour

Mikesell and Kephart (1999) reported that penning barrows separately might have improved their growth performance and the pigs appeared to become less competitive and spend less time eating, as they grew heavier and the penning arrangement did not affect feeding behaviour.

According to Bornett *et al.* (2000), group housed pigs make less frequent feeder visits of longer duration and eat at a faster rate than pigs housed individually.

Dinesh (2000) observed that during feeding time all the animals tried to displace their pen mates from the manger.

According to Sukemori *et al.* (2001) the physical condition of feed such as form and hardness will influence the feeding behaviour and feed intake of pigs.

Deepa (2004) inferred that the pigs showed great excitement and eagerness towards feed as they were housed in groups.

2.3.2 Agonistic behaviour

Rushen (1987) observed that mutual chronic aggression affected growth rate than the intense fighting shortly after the pigs have been mixed.

Dinesh (2000) revealed that LWY pigs were the most aggressive animal at the time of feeding while Duroc pigs were comparatively quiet at the time of feeding.

Hayne and Gonyou (2003) suggested that the trauma caused by regrouping resulted in a generalization of fear associated with an environmental change.

2.3.3 Eliminative behaviour

Dinesh (2000) reported that pigs marked a definite area either near the waterers or near the wallowing tank for defaecation and urination.

Deepa (2004) conducted an experiment to study the effect of water sprinkling on the eliminative behaviour of pigs and observed among the sprinkled and non-sprinkled pigs, the non-sprinkled animals voided more quantity of dung.

2.3.4 Explorative behaviour

Beattie *et al.* (2000) observed that, environmental enrichment reduced time spent inactive and time spent involved in harmful social and aggressive behaviour while increasing the time in exploratory behaviour and appeared less fearful during the novel pen test by showing shorter latency to contact the novel object and spending more time in contact with it. But during the finishing period (15-21 weeks) mean daily feed intakes were higher and feed conversion ratios were lower for pigs in enriched environments compared with their counterparts from barren environments.

2.4 ENVIRONMENT

Schenck *et al.* (1992) interpreted that the optimum dietary regime for weaning pigs should be formulated based on the thermal environment in which the animals are housed as well as their stage of postnatal development. A cooler environment stimulates feed intake and results in lower concentration of dietary lysine necessary to meet the daily lysine requirement. So, the pigs housed in the cool environment consumed more feed ($P<0.01$), gained more weight ($P<0.01$), and utilised feed more efficiently ($P<0.01$) than those in the hot environment.

Ramesh (1998) compared the performance of pigs housed in conventional house with wallowing tank, conventional house with wallowing tank and sprinklers and range system. A significantly lower ($P<0.01$) microenvironment temperature was observed in sprinkler system (33.00^0C) when compared to conventional (35.00^0C) and range (34.35^0C) but there was no significant variation in relative humidity between the treatments. Even in conventional house with wallowing tank and sprinklers, the presence of sprinklers did not significantly increase the humidity inside the pens.

Collin *et al.* (2001) reported that, protein deposition was higher in pigs that were reared at 33^0C than in pigs reared at 23^0C. They also found that high temperature had no detrimental effect on nitrogen retention. The reduction in heat production of piglets at high ambient temperature is caused by a reduction in voluntary feed intake and differences in energetic efficiency.

Shrestha *et al.* (2002) reported that pigs are adversely affected by climatic factors, viz., low environmental temperature (hypothermia), high environmental temperature (hyperthermia), high wind speed, wet floor, diseases and energy intake.

Thomas *et al.* (2002) indicated that in intensive commercial or breeding farms for fast growing exotic purebred/hybrid pigs, housing becomes a very important factor and every detail of the design should be given proper attention. In tropical and subtropical India we must strive to minimize the adverse effect of climate by maximizing shade, ventilation and by cooling using showers.

2.4.1 Effect of environmental temperature on physiological parameters

2.4.1.1 Rectal temperature

According to West (1985) pigs show a variation in body temperature between 38.2°C to 40.5°C with an average of 39.7°C. They have also reported that diurnal variation in body temperature exist and is normal. The temperature was lowest in early hours and highest in the late afternoon.

Dukes (1996) noticed that rectal temperature of the pig began to increase at an environmental temperature of 85 to 90°F (29.4 to 32.2°C). If the relative humidity was 65 per cent or above, the pig could not tolerate prolonged exposure (seven hours) to an environmental temperature of 95°F (35°C) and at an environmental temperature of 105° F (40.5 °C) the pig was unable to withstand at any level of humidity.

Yan-Peishi and Yamamoti (2000) reported an increase of rectal temperature, respiration rate and evaporative heat loss in environmental temperature of 31°C. With an increase in environmental temperature, respiratory rate increased by 13 per minute for every one degree C rise in rectal temperature.

2.4.1.2 Respiration rate

Mukherjee and Banerjee (1980) reported that, at high environmental temperature, body responds to it by increasing respiration rate, pulse rate and body temperature.

Black *et al.* (1993) reported that as ambient temperature increases above the zone of thermal comfort, thermoregulation could be achieved only by increasing evaporative heat loss from lungs and skin. Pigs have few sweat glands, so evaporative heat loss is achieved through increase in respiratory rate and wetting of skin.

Brown-Brandl *et al.* (2001) reported acute heat stress had significant effect on total heat production, respiratory rate and body temperature of swine and found that respiration rate was a leading indicator of stress.

2.4.1.3 Pulse rate

Joseph (1997) reported higher pulse rates 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 STRESS

Duncan (1981) suggested that separation of boars from conspecifics for any prolonged period would be stressful. The extreme aggressiveness and intractable nature of stud boars is due to the isolated conditions in which they are all too often kept.

Sanford *et al.* (1986) reported that increased plasma levels of adrenocorticotrophic hormone and several of adrenocortical hormones have been used in the assessment of stress. Changes in plasma or cerebrospinal fluid levels of other naturally occurring neuroactive or endocrine agents may also prove to be helpful in their assessment.

Samuel *et al.* (1988) compared faecal versus serum levels of 17 β- estradiol (E_2) and progestins (P_4) in intact female pigtailed macaques and showed that repeated sampling of faecal steroids can be used to ascertain the occurrence and timing of ovulation. They can also be used to distinguish between mid-follicular and luteal phases of the menstrual cycle and to determine luteal phases of menstrual cycle and to determine luteal phase length.

Broom and Johnson (1993) reported that cortisol is predominantly produced in primates, dogs, cats and most ungulates, whereas corticosterone is produced in rodents and chickens while in pigs both glucocorticoids are produced.

Bustamate *et al.* (1996) reported that arithmetical differences in serum cortisol level for the group penned and the individually penned pigs were not different ($P>0.05$) suggesting that the isolation of individually penning and the competitiveness of group penning were not relatively stressful on a comparative basis and also reported that individual penning did not alter the thyroid status and feed efficiency.

Franz-Schwarzenberger *et al.* (1996) reported that the route of excretion of steroid hormone metabolites varies considerably among species, and also between steroids within the same species. Steroid concentration in faeces exhibit a similar pattern to those in plasma, but have a lag time, which depending upon the species, can be from 12 hours to more than two days.

Jensen *et al.* (1996) suggested that although adaptive,"noramlization" of the activity of the Hypothalamic-Pituitary-Adrenocortical (HPA) axis during long–term stress, which is accompanied by other long-term stress responses, has to be distinguished from habituation to the stressor. Consequently, used as separate measures, the basal level of plasma cortisol and the maximal capacity may not be reliable indicators of stress.

Palme *et al.* (1996) have shown that faecal steroids might be unevenly distributed in the faecal balls of horses, swine and elephants.

Ruis *et al.* (1997) examined the circadian rhythmicity of salivary cortisol in growing pigs. The cortisol values were 1.19 ± 0.05 ng/ml in 12 weeks and 1.03 ± 0.06 ng/ml in 24 weeks of age. The concentrations were 1.01 ± 0.05 ng/ml in barrows and 0.86 ± 0.04 ng/ml in gilts.

Mostl *et al.* (1999) suggested that the hormones that are most involved in the body's response to difficult conditions are glucocorticoids, which have been shown to be good indicators of stress in a wide variety of captive mammals. Although smaller amounts of these metabolites are present in faeces, Enzyme Immuno Assay (EIA) works quite well in horses and pigs. They also observed that there was a significant increase in the concentration of cortisol metabolites in bovine, equine and porcine faeces after storage for one hour, four hours and 24 hours respectively.

Palme *et al.* (1999) opined that as a large amount of time elapses between secretion in blood and excretion in faeces, faecal hormone levels are relatively unaffected by the collection of the faeces sample, making faeces the ideal excreta for measuring hormonal indicators of chronic stress. In faeces, steroid metabolites were present mainly in unconjugated form, but in blood and urine as conjugates. Mean retention time of faecal radioactivity suggested that the passage rate of digesta (duodenum to rectum) played an important role in the time course of excretion of steroids.

Beattie *et al.* (2000) observed that, pigs from enriched environment had significantly higher cortisol levels at slaughter ($P<0.001$) and it is suggested that chronic activation of the pituitary-adrenal axis in barren environments led to the suppression of cortisol responses to acute stress. The higher cortisol levels in pigs from enriched environment have resulted from greater levels of behavioural activity.

Mellor *et al.* (2000) suggested that corticosteroid responses could be used to evaluate stress and /or distress within a wide range of individual species. However, potential species-specific differences in the operational dynamics of the HPA system, including neural and neurohumoral inputs, hormonal outputs and metabolic clearance rates indicate that interpreting quantitative differences between species in the features of their corticosteroid responses is problematic.

Herskin and Jensen (2001) analysed the effect of different housing conditions on the stress level in weaned piglets. Piglets were divided into three groups namely isolated from each other (two), with assess restricted to contact through wire mesh (two), and penned together (four). They found that isolated animals showed signs of stress, while limited physical contact through the mesh made it easier for the animals to adapt to their new environment.

Klont *et al.* (2001) reported that pigs from the barren environment had a significantly higher increase in cortisol from farm to slaughter, but no differences in behaviour were observed during the lairage period.

Schatz and Palme (2001) suggested that measuring cortisol metabolites in faeces should be a useful non-invasive tool for monitoring stress in carnivores and a broad approach, including such non-invasive methods for elucidating endocrine changes, to questions such as animal welfare (housing, handling and human-animal interaction) or various stress reactions in domestic and wild carnivores should be possible.

Mostl *et al.* (2002) suggested that as faecal steroids may be unevenly distributed in the faecal balls, the sample might need to be mixed. As with urine, faecal samples can be preserved at -20°C.

Geetha (2003) found the minimum and maximum salivary cortisol values in piglets under different stress conditions were from 0.52 ± 0.19 to 3.5 ± 0.63 (μg/dl) at first week and from 0.42 ± 0.18 to 2.07 ± 0.13 (μg/dl) at eighth week respectively.

Armelle and Monica (2004) suggested that monitoring stress in animals in captivity, such as those in laboratories, farms and zoos, is extremely important, especially in light of the growing awareness of the need to improve animal welfare and considering that stressed animals are more susceptible to disease. Non- invasive techniques for assessing hormonal stress indicators have greatly improved, and the analysis of saliva, urine and faeces seems to be the best alternative, in that these biological materials can be collected without subjecting animals to additional stress, which can bias the results. Moreover, non-invasive techniques allow physiological imbalances due to stress to be rapidly assessed, before the appearance of other markers of stress, such as weight loss, poor health and infertility.

2.6 CARCASS QUALITY:

Cromwell *et al.* (1978) reported that dietary energy level did not affect muscle composition as much as did dietary protein, with pigs fed zero and 10 per cent fat had 18.5 and 20.65 fat and 66.6 and 64.8 per cent protein, respectively, in the longissimus.

Warriss *et al.* (1983) conducted an experiment with stress resistant and stress susceptible breeds reared in bare concrete pens and extensively under environmentally enriched conditions in an outside paddock. It was found that rearing environment had no effect on the ability of the pigs to respond to the stress of preslaughter handling based on measurements of adrenal ascorbic acid and plasma cortisol. Neither did it influence initial or ultimate pH or the water holding capacity of the meat. Overall, differences due to rearing environment were slight and not commercially important.

Gopalakrishnan and Lal (1985) stated that garbage including kitchen waste and other vegetable wastes are useful feeds for pigs when properly cooked and fed. The feeding value of garbage varies depending upon the content of inedible refuse present in it. Carcasses of garbage fed pigs dress out at slightly lower weight and were softer than cereal fed pig carcasses. However, considering the low cost of feed, garbage feeding was always profitable.

Patterson (1985) reported that the rump back joints from individually penned pigs had less lean ($P=0.068$) and significantly ($P<0.05$) more fat than those from group penned pigs. Differences in back fat thickness at P_2 position was small and not significant ($P>0.05$).

Syam and Sivaraman (1993) reported that the carcass characteristics like dressing percentage (66.9 vs. 67), half carcass weight (17.2 vs. 23.7 kg), carcass length (65.3 vs. 74.6 cm), back fat thickness (1.4 vs. 2.1 cm) and eye muscle area *(21.3 vs. 28.8) were found adversely affected in animals receiving dried prawn waste* when included at 6.6 per cent in their ration.

Westendorf *et al.* (1998) found that pigs fed with cafeteria food waste or a corn/soybean meal diet when slaughtered and the pork loins were removed for flavour and texture analysis, the meat quality from pigs fed with food waste was as acceptable and overall flavor comparable to pigs fed with corn/soybean meal ($P > 0.05$). These results indicate that food waste had nutritive value and may be useful in swine diets.

Jha *et al.* (1999) stated that live weight at slaughter and carcass weight were significantly higher in pigs fed with concentrate alone (M_1) followed by pigs fed with hotel waste and concentrate (M_2) and pigs fed with hotel waste alone (M_3). Similar trends were recorded with respect to carcass length and back fat thickness. But the dressing percentage was highest in M_1 followed by M_3 and M_2.

Myer *et al.* (1999) interpreted that dehydrated restaurant food waste (DFW) products were included at 40 per cent and 80 per cent of the diet. Carcass lean content and lean quality scores were not reduced ($P>0.1$) by feeding pigs with the DFW diets in either trial. Carcass fat became softer ($P<0.01$: linear) with increasing amount of DFW in the diet. Thus dehydrated restaurant food wastes had the potential to produce a nutritious feedstuff for pigs while offering a viable solid waste disposal option.

Beattie *et al.* (2000) observed that, pigs from enriched environments had higher levels of back fat than their counterparts from barren environments ($P<0.001$). Environmental enrichment during rearing had a small but significant effect on meat quality. Pork from pigs reared in barren environments were less tender and had greater cooking losses than pork from pigs reared in enriched environments ($P<0.01$).

Klont *et al.* (2001) reported that carcass characteristics did not differ between pigs from barren and those from enriched housing conditions. The percentage of drip loss at second and fifth day after storage of longissimus lumborum muscle from enriched-housed pigs was significantly lower than that of the barren-housed pigs. Similar tendencies were found for the back fat muscle from pigs kept in enriched environment, but these were not statistically significant. The housing system did not affect meat colour. On-farm improvement of animal welfare by environmental enrichment can also lead to beneficial economic effects after slaughter by improving the water-holding capacity of pork.

Maw *et al.* (2001) reported that the genetic component of the pig (breed) would appear to be an important factor in meat quality. Concrete floors gave rise to pig with the strongest taint, slatted floors the lowest. Accumulation of faeces and urine were most probably on solid concrete floors and least likely on slats.

From the foregoing review it is evident that a research gap exists in the area of adaptation of crossbred pigs in different feeding, housing and management.

Materials and Methods

3. MATERIALS AND METHODS

The resources and facilities available at the Department of Livestock Production Management, Centre for Pig Production and Research, Centre of Excellence in Meat Science and Technology (LPT) of the College of Veterinary & Animal Sciences, Mannuthy and Radio Tracer Laboratory, Kerala Agricultural University were utilised for the study.

3.1 LOCATION

The study was conducted at the Centre for Pig Production and Research (CPPR) of Kerala Agricultural University, Mannuthy located seven km east to Thrissur and is geographically situated

at longitude 76^0,05" to 70^0,45" E (east)

at latitude 10^0,20" to 10^0,56"N (north) and

at an altitude of 22.25 m above MSL (mean sea level).

The location of study is endowed with humid tropical climate with maximum rainfall by South West monsoon from June to August and North East monsoon from September to October.

3.2 CLIMATOLOGICAL DATA

The maximum and minimum temperature (^{0}C) and relative humidity (%) in the sties were recorded daily with the help of Digital Hygrotherm (Sisedo). The relative humidity was recorded at eight am (RH_1) and at two pm (RH_2). The daily mean relative humidity was calculated as an average of these two observations. The meteorological data over a period from June 2004 to April 2005 were obtained from the meteorological observatory unit attached to the College of Horticulture, Vellanikkara. Mean sunshine (hours) and rainy days were collected to study the effect of macro-climatological influence on the growth of pigs.

3.3 EXPERIMENTAL ANIMALS

Twenty-four crossbred weaned piglets each belonging to two genetic groups i.e. CB_1 (Duroc 50% and Large White Yorkshire 50 %) and CB_2 (Desi 50% and Large White Yorkshire 50%) were randomly selected from Centre for Pig Production and Research, Kerala Agricultural University, Mannuthy as uniformly as possible with respect to age, sex and bodyweight were utilised for the study.

3.3.1 Allocation of experimental animals to treatment groups

The piglets in each crossbred group were randomly divided into four groups of six animals each and allotted to one of the following treatments.

T_1- group housing with wallowing facility, fed with conventional feed (control)

T_2- group housing with wallowing facility, fed with unconventional feed (left over food from hostels and other organic food waste)

T_3- individual housing without wallowing facility, fed with conventional feed

T_4- individual housing without wallowing facility, fed with unconventional feed

3.4 MANAGEMENT

The pigs were allotted for four treatments maintained under different housing and feeding systems. Other management practices prevailing in the farm were followed throughout the experimental period. Piglets in T_1 and T_3 were fed with standard concentrate ration having 18 per cent crude protein up to the age of five months and with 14 per cent crude protein during the rest of the study period. Rests of the pigs were fed with left over food from hostels and restaurants with a supplementation of 10 boiled infertile eggs (obtained from hatchery) per day and chicken waste once in a week. Daily two times feeding was followed. Monthly *deworming and spraying of ectoparasiticides were practised.*

3.5 BEHAVIOUR

The feeding and agonistic behaviour of all the experimental animals were studied based on score chart described in Table 3.1 and 3.2.

Eliminative behaviour was quantified by recording the frequency of defaecation and the quantity of faeces voided. Behaviour sampling methods described by Martin and Bateson (1988) were used in the present study to observe each individual for a specified amount of time.

Table 3.1 Feeding behaviour

Sl.No	Description	Score
1.	*Eating greedily with drooling of saliva*	3
2.	Exploring the pen and eating with grunt and drooling of saliva	2
3.	Eating calmly	1
4.	Not showing any interest towards feeding	0

Table 3.2 Agonistic behaviour

Sl.No	Description	Score
1.	Ear biting, belly nosing and tail biting very frequently	3
2.	Ear biting, belly nosing and tail biting frequently	2
3.	Ear biting, belly nosing and tail biting occasionally	1
4.	Nil	0

3.6 SLAUGHTER STUDIES

Two animals from each group were selected randomly and slaughtered at the end of the experiment for evaluation of their carcass traits. The pigs were slaughtered humanely observing HACCP at the Centre of Excellence in Meat Science and Technology (LPT), College of Veterinary and Animal Sciences, Mannuthy. Carcass length (cm) was measured from the anterior border of the first rib at its vertebral end to the anterior edge of the cut end of the pubic symphysis. Back fat thickness (mm) was measured as mean of three measurements at the level of first rib, last rib and last lumbar vertebrae. Loin eye area (cm^2) was recorded as the mean of two measurements of traced impression of longissimus dorsi muscle in graph paper at tenth rib in both the split halves (Andrew, 1998).

3.7 PROXIMATE ANALYSIS

Proximate composition namely moisture, dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract of the conventional and unconventional feeds were estimated (A.O.A.C, 1990) in the Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy.

3.8 RADIOIMMUNOASSAY OF FAECAL CORTISOL

In order to assess the stress level in pigs reared in two different housing and feeding systems faecal cortisol level was estimated using radioimmunoassay (RIA).

3.8.1 Collection and storage of faecal sample

Faecal samples were collected once in a month from all the animals immediately after voidance. They were kept in polythene pouches and stored at -20^0C till extracted for RIA (Khan *et al.*, 2002).

3.8.2 Extraction of cortisol for radioimmuno assay

The faecal samples stored at -20^0C was crushed in the polythene pouch itself and thawed. Then 0.5 gram per 50 gram of homogenized wet faeces was extracted with two ml distilled water and three ml methanol after vortexing the mixture for 30 minutes it was centrifuged at 2500 rpm for 15 minutes. A 0.5 ml aliquot of the supernatant was taken and stored in a screw capped vial. The remaining supernatant was decanted and the faeces residue in the centrifuge tube was again extracted with three ml methanol only same as before. Again 0.5 ml of the supernatant was taken and mixed with the aliquot already taken in the screw capped vial. The methanol extracts were stored at –20^0C until RIA analysis (Palme et al., 1996).

3.8.3 Radioimmunoassay of faecal cortisol

Faecal cortisol concentrations were measured using Clinical Assays™ Gamma Coat ™ Cortisol ^{125}I RIA Kit (DiaSorin, Stillwater, Minnesota, USA). From the six different cortisol standards 0, 1, 3, 10, 25 and 60 (µg/dl) supplied with the kit, 10μl each were incubated with one ml tracer buffer reagent in six antibody-coated tubes (rabbit anti-cortisol serum). Similarly, 10μl of the methanol extract of faecal sample was incubated with tracer buffer reagent in antibody-coated tubes. The antibody was immobilized onto the lower inner wall of the Gamma Coat tube. After incubation for 45 minutes at 37 ± 2^0 C in a water bath, the contents of the tube were decanted. The counts per minute (cpm) bound for each tube were counted in 1480 WIZARD ™ Automatic Gamma Counter for one minute with the window suitably adjusted for iodine-125. A standard curve was plotted with cpm values and cortisol concentration on semi logarithmic graph paper. Unknown values were interpreted from the standard curve. Results were tested by analysis of variance (ANOVA) using the model.

3.9 OBSERVATIONS

Rectal temperature, pulse and respiration rate of animals were recorded twice on a day at eight am and two pm at weekly intervals throughout the experimental period.

Fortnightly body weights were recorded using a platform balance having a built- in cage.

Daily feed consumption was recorded. The average daily gain and feed conversion ratio were calculated. The total cost of production per kilogram live body weight, from weaning to slaughter was calculated.

The data obtained during the course of the study were statistically analysed as per the methods described by Snedecor and Cochran (1994) and results interpreted.

Results

4. RESULTS

The adaptability of crossbred pigs under different housing and feeding systems were studied. The piglets in each crossbred group were randomly divided into four groups of six animals each and allotted to one of the following treatments. T_1–group housing with wallowing facility, fed with conventional feed (control), T_2–group housing with wallowing facility, fed with unconventional feed (left over food from hostels and other organic food waste), T_3–individual housing without wallowing facility, fed with conventional feed and T_4–individual housing without wallowing facility, fed with unconventional feed. The results obtained in the study are furnished from Table 4.1 to 4.26.

4.1. CLIMATIC VARIABLES

Mean ± S.E. of monthly microclimatic changes such as maximum and minimum temperature (^{0}C) and relative humidity (%) recorded from each pen are represented in Table 4.1. The climatic data like sunshine (hours) and rainfall (monthly total, in mm) over the period from June 2004 to April 2005 are presented in the Table 4.2.

The mean daily maximum temperature observed varied between 28.75^{0}C and 36.75^{0}C and minimum temperature varied between 22.5^{0}C and 25.75^{0}C. The relative humidity (%) varied between 62.37 and 85.75. There were no significant differences (P>0.05) in microclimatic variables, viz., maximum and minimum temperature and the relative humidity between treatments.

The rainfall recorded during the period varied from zero mm in December, February and March to 786 mm in June.

4.2. RECTAL TEMPERATURE, RESPIRATORY RATE AND PULSE RATE

The mean rectal temperature (^{0}C), respiratory rate and pulse rate (per minute) of CB_1 and CB_2 pigs in all the treatment groups are furnished in Tables 4.3 and 4.4. The mean rectal temperature varied between 38.51^{0}C to 39.11^{0}C. The rectal temperature had no significant difference (P>0.05) in all the four treatments groups during the entire study period for both the breeds. It was numerically higher in the afternoon than the temperature recorded in the morning.

The mean pulse rate varied between 70.90 to 77.45 and the mean respiratory rate varied between 35.01 to 46.23. Significantly elevated (P<0.05) values were observed for pulse and respiratory rates in T_1 and T_2 treatment groups during the entire study period for both the breeds.

4.3. GROWTH

4.3.1 Feed Intake

The average daily feed intake (kg) on fresh and dry matter basis of CB_1 and CB_2 pigs in all the treatment groups in each fortnight are given in Tables 4.5, 4.5.1, 4.6 and 4.6.1. The average daily feed intake on fresh matter basis was significantly higher (P<0.05) in pigs fed with unconventional feed (T_2 and T_4 groups) but there were no significant differences (P>0.05) in the average feed intake on dry matter basis in between the treatments of both the breeds.

4.3.2 Body Weight

The fortnightly body weights of CB_1 and CB_2 pigs in all the treatment groups are presented in Tables 4.7 and 4.8 and depicted in Figures 4.1 and 4.2. Though there were no significant differences ($P>0.05$) between the treatments in the initial body weights in both the breeds there were significant differences ($P<0.05$) in the body weights of T_3 and T_4 groups (individually housed) of CB_1 from ninth fortnight. However, these differences were statistically not significant ($P>0.05$) in CB_2 pigs.

4.3.3 Average Daily Gain and Feed Conversion Ratio

The average daily gain (ADG) and feed conversion ratio (FCR) on dry matter basis are presented in Tables 4.9, 4.10, 4.11 and 4.12 and depicted in Figures 4.3, 4.4, 4.5 and 4.6 respectively. The FCR on fresh matter basis are presented in Tables 4.13 and 4.14. Significant differences ($P<0.05$) were observed in ADG between individually housed pigs and group housed pigs in CB_1 but there were no significant differences ($P>0.05$) in ADG between the treatments in CB_2 pigs though the ADG was numerically higher in individually housed pigs than group housed pigs.

There were no significant differences ($P>0.05$) in the feed conversion ratio (FCR) on dry matter basis between the treatments of both the breeds but the FCR on fresh matter basis was significantly higher ($P<0.05$) in the groups fed with unconventional feed in both the breeds.

4.4. BEHAVIOUR

The group averages of feeding, agonistic and eliminative behaviour of CB_1 and CB_2 pigs in all the treatment groups are presented in Tables 4.15, 4.16, 4.17, 4.18, 4.19 and 4.20 respectively. The pigs in group housing with wallowing facility were found floundering during the hot hours of the day whereas the individually housed pigs without any wallowing facility rested in the shady areas and near the waterers of the pens. All the four groups were active and exhibited playful behaviour at the time of cleaning the pen.

4.4.1 Feeding Behaviour

Pigs fed with unconventional feed showed higher feeding behavioural scores than pigs fed with conventional feed. Pigs housed in groups ate at a faster rate than the individually housed animals.

4.4.2 Agonistic Behaviour

The group housed pigs were found to be more restless and engaged in agonistic encounters. The highest number of aggressive encounters were found at the time of feeding.

4.4.3 Eliminative Behaviour

The pigs defaecated either in the wallowing tank or near the gate of the pen. Among the conventional and unconventional feed fed pigs the former group voided more quantity of dung and the frequency of urination was higher in the latter group.

4.5. CARCASS CHARACTERISTICS

The carcass characteristics of CB_1 and CB_2 pigs in all the treatment groups are presented in Tables 4.21 and 4.22.

Slaughter weight (kg) varied between 60.5 to 71 in CB_1 and 58.5 to 63 in CB_2 pigs.

Hot carcass weight(kg) varied between 42.45 to 48.95 in CB_1 and 42.7 to 48.65 in CB_2 pigs.

The slaughter weight and hot carcass weight were significantly higher ($P<0.05$) in the T_3 and T_4 of CB_1 pigs but these traits were higher in T_4 followed by T_3, T_2 and T_1 of CB_2 pigs. There were no significant differences ($P>0.05$) in the rest of the carcass traits between the treatments of both the breeds.

Dressing percentage ranged from 68.94 to 73.34 in CB_1 and 71.88 to 77.25 in CB_2 pigs. The pigs fed with unconventional feed had lower dressing percentage than the pigs fed with concentrate feed in both the breeds.

Carcass length (cm) ranged from 76 to78.5 in CB_1 and 62 to 68 in CB_2 pigs.

Back fat thickness (mm) ranged from 10 to 11.83 in CB_1 and 26.67 to 29.16 mm in CB_2 pigs. Individually housed pigs had relatively higher back fat thickness in both the breeds.

Loin eye area (cm^2) ranged from 31.25 to 32.89 in CB_1 and 28.79 to 29.52 in CB_2 pigs.

Meat yield (percentage) ranged from 56.09 to 59.18 in CB_1 and 56.49 to 58.84 in CB_2 pigs.

Meat bone ratio ranged from 3.4 to 3.61 in CB_1 and 4.3 to 4.73 in CB_2 pigs.

4.6. COST OF PRODUCTION

The cost of production per kg (Rs.) live body weight of CB_1 and CB_2 pigs in all the treatment groups were worked out and are furnished in Tables 4.23 and 4.24 and depicted in Figures 4.7 and 4.8. Pigs maintained on unconventional feeding groups (T_2 and T_4) were profitable as the cost of producing one kg of live body weight ranged from Rs. 10.32 to 11.36 compared to 27.34 to 30.45 for pigs fed with conventional feed in CB_1 pigs and 10.24 to 10.56 vs. 24.99 to 26.55 in CB_2 pigs. Rearing pigs in individual housing system further reduced the cost of production per kg live body weight to considerable amount than maintaining them in group housing system.

4.7. CHEMICAL COMPOSITION OF FEEDS

The chemical composition of the swill, chicken waste, infertile egg, grower and finisher rations are presented in Table 4.25.

The moisture content (percentage) of swill, chicken waste and infertile egg were 72.03, 71.88 and 59.87 respectively.

The crude protein (percentage) of swill, chicken waste and infertile egg were 8.36, 21.3 and 16.68 respectively.

The ether extract (percentage) of swill, chicken waste and infertile egg were 2.39, 41.22 and 29.47 respectively.

The crude fibre (percentage) of swill, chicken waste and infertile egg were 4.1, 3.7 and 0.03 respectively.

The nitrogen free extract (percentage) of swill, chicken waste and infertile egg were 8.94, 26.99 and 29.93 respectively.

4.8. FAECAL CORTISOL LEVEL (μg/dl)

The monthly faecal cortisol levels (μg/dl) of animals in all treatments of both the genetic groups are furnished in Table 4.26 and depicted in Figures 4.9 and 4.10. There were no significant differences ($P>0.05$) in the faecal cortisol level between the treatments in both the breeds. The mean faecal cortisol concentration at first, second, third, fourth and fifth months were 0.125, 0.114, 0.083, 0.05 and 0.033 μg/dl in CB_1 and 0.113, 0.103, 0.067, 0.055 and 0.032 μg/dl in CB_2 pigs.

Table 4.1 Mean and S.E. of microclimatic changes

Months	Treatment groups	Maximum temperature ^0C	Minimum temperature ^0C	Relative humidity %
June	T_1	29.50 ± 0.27	23.63 ± 0.22	85.50 ± 0.18
	T_2	29.50 ± 0.27	23.63 ± 0.22	85.30 ± 0.18
	T_3	29.75 ± 0.27	23.65 ± 0.22	85.30 ± 0.18
	T_4	29.75 ± 0.27	23.75 ± 0.22	85.25 ± 0.18
July	T_1	29.25 ± 0.14	23.13 ± 0.13	85.75 ± 0.26
	T_2	29.38 ± 0.14	23.13 ± 0.13	83.87 ± 0.26
	T_3	29.40 ± 0.14	23.13 ± 0.13	84.75 ± 0.26
	T_4	29.45 ± 0.14	23.13 ± 0.13	84.75 ± 0.26
August	T_1	28.75 ± 0.27	22.75 ± 0.20	85.25 ± 0.26
	T_2	28.75 ± 0.27	22.75 ± 0.20	85.50 ± 0.26
	T_3	28.88 ± 0.27	22.88 ± 0.20	85.25 ± 0.26
	T_4	28.75 ± 0.27	22.88 ± 0.20	85.25 ± 0.26
September	T_1	31.50 ± 0.26	22.50 ± 0.27	78.25 ± 0.26
	T_2	31.50 ± 0.26	22.50 ± 0.27	78.25 ± 0.26
	T_3	31.50 ± 0.26	22.75 ± 0.27	77.50 ± 0.26
	T_4	31.75 ± 0.26	22.75 ± 0.27	78.25 ± 0.26
October	T_1	30.58 ± 0.26	23.13 ± 0.17	82.75 ± 0.26
	T_2	30.83 ± 0.26	23.13 ±0.17	82.75 ± 0.26
	T_3	30.83 ± 0.26	23.25 ± 0.17	82.50 ± 0.26
	T_4	30.75 ± 0.26	23.38 ± 0.17	82.25 ± 0.26
December	T_1	32.50 ± 0.33	23.75 ± 0.30	69.25 ± 0.25
	T_2	32.50 ± 0.33	24.00 ± 0.30	69.25 ± 0.25
	T_3	32.75 ± 0.33	24.25 ± 0.30	69.25 ± 0.25
	T_4	32.75 ± 0.33	24.25 ±0.30	69.25 ± 0.25
January	T_1	32.75 ± 0.28	24.25 ± 0.27	62.25 ± 0.22
	T_2	32.88 ± 0.28	24.25 ± 0.27	62.25 ± 0.22
	T_3	33.25 ± 0.28	24.50 ± 0.27	62.25 ± 0.22
	T_4	33.00 ± 0.28	24.50 ± 0.27	62.00 ± 0.22
February	T_1	34.25 ± 0.26	24.00 ± 0.31	62.25 ± 0.25
	T_2	34.38 ± 0.26	24.50 ± 0.31	63.25 ± 0.25
	T_3	34.38 ± 0.26	24.25 ± 0.31	63.75 ± 0.25
	T_4	34.50 ± 0.26	24.50 ± 0.31	62.75 ± 0.25
March	T_1	35.75 ± 0.34	25.75 ± 0.25	63.75 ± 0.27
	T_2	35.75 ± 0.34	25.25 ± 0.25	63.75 ± 0.27
	T_3	36.13 ± 0.34	25.75 ± 0.25	63.50 ± 0.27
	T_4	36.25 ± 0.34	25.75 ± 0.25	63.50 ± 0.27
April	T_1	36.50 ± 0.28	24.50 ± 0.27	64.50 ± 0.35
	T_2	36.50 ± 0.28	24.50 ± 0.27	64.50 ± 0.35
	T_3	36.75 ± 0.28	24.75 ± 0.27	63.50 ± 0.35
	T_4	36.50 ± 0.28	24.75 ± 0.27	63.50 ± 0.35

Non-significant at 5 per cent level

Table 4.2 Environmental variables during the period of experiment

Months	Max. Temp.(^{0}C)	Min. Temp. (^{0}C)	Mean. Temp. (^{0}C)	RH1 (%) 8.00 am	RH2 (%) 2.00 pm	Mean RH (%)	Total number of rainy days	Sun shine (hrs)	Amount of rainfall (mm)
June	29.6	22.3	25.95	93	76	85	24	98.9	786
July	29.3	22.9	26.10	94	75	85	24	66.4	369.6
August	28.5	23.1	25.80	92	73	83	14	137.1	386.9
September	30.8	23.6	27.20	91	69	80	10	154.0	208.8
October	31.4	23.4	27.40	82	65	74	11	185.3	493.2
November	30.1	23.7	26.90	74	56	65	3	211.9	71.7
December	32.1	22.6	27.35	68	42	55	0	275.9	0
January	33.2	22.6	27.90	71	40	56	1	264.0	7.6
February	37.6	17.4	27.50	71	34	53	0	280.7	0
March	35.7	24.6	30.15	84	42	63	0	272.4	0
April	33.7	24.8	29.25	88	60	74	10	208.2	171.4

RH1- Mean morning atmospheric humidity
RH2- Mean evening atmospheric humidity

Table 4.3 Mean temperature, ^{0}C, pulse rate and respiratory rate, per minute of CB_1 pigs

CB1	T_1	T_2	T_3	T_4
Temperature (FN)	38.83^a	38.83^a	38.77^a	38.72^a
Temperature (AN)	39.38^a	39.27^a	39.33^a	39.22^a
Mean	**39.11^a**	**39.05^a**	**39.05^a**	**38.97^a**
Pulse rate (FN)	67.53^a	67.21^b	66.91^c	66.00^d
Pulse rate (AN)	87.36^a	87.14^a	86.36^b	85.26^c
Mean	**77.45^a**	**77.18^a**	**76.64^b**	**75.63^b**
Respiratory rate (FN)	39.82^a	39.65^a	37.59^b	34.60^c
Respiratory rate (AN)	52.63^a	52.47^a	51.59^b	51.30^b
Mean	**46.23^a**	**46.06^a**	**44.59^b**	**42.95^b**

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.4 Mean temperature, ^{0}C, pulse rate and respiratory rate, per minute of CB_2 pigs

CB2	T_1	T_2	T_3	T_4
Temperature (FN)	38.44^a	38.50^a	38.30^a	38.30^a
Temperature (AN)	38.83^a	38.77^a	38.72^a	38.72^a
Mean	**38.60^a**	**38.64^a**	**38.51^a**	**38.51^a**
Pulse rate (FN)	65.13^b	65.47^a	65.62^a	65.19^b
Pulse rate (AN)	77.61^a	76.88^c	77.08^b	76.61^c
Mean	**71.37^a**	**71.18^c**	**71.35^b**	**70.90^c**
Respiratory rate (FN)	32.29^a	30.09^c	30.70^b	30.55^b
Respiratory rate (AN)	44.20^a	39.93^c	41.57^b	41.87^b
Mean	**38.25^a**	**35.01^c**	**36.14^b**	**36.21^b**

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.5 Average daily feed intake of CB_1 pigs, kg on fresh matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	0.25	2.75	0.25	2.75
2.	0.50	2.75	0.50	2.75
3.	0.50	3.25	0.50	3.25
4.	0.50	3.25	0.50	3.25
5.	1.00	4.75	1.00	4.75
6.	2.00	4.75	2.00	4.75
7.	2.00	4.75	2.00	4.75
8.	2.00	6.75	2.00	6.75
9.	3.00	6.75	3.00	6.75
10.	3.00	6.75	3.00	6.75
Mean ± S.E.	1.48 ± 0.33^{b}	4.65 ± 0.51^{a}	1.48 ± 0.33^{b}	4.65 ± 0.51^{a}

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4. 5.1 Average daily feed intake of CB_1 pigs, kg on dry matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	0.225	0.84	0.225	0.84
2.	0.450	0.84	0.450	0.84
3.	0.450	1.00	0.450	1.00
4.	0.450	1.00	0.450	1.00
5.	0.900	1.40	0.900	1.40
6.	1.800	1.40	1.800	1.40
7.	1.800	1.40	1.800	1.40
8.	1.800	2.00	1.800	2.00
9.	2.700	2.00	2.700	2.00
10.	2.700	2.00	2.700	2.00
Mean ± S.E.	1.30 ± 0.30^{NS}	1.38 ± 0.14^{NS}	1.30 ± 0.30^{NS}	1.38 ± 0.14^{NS}

NS - Non-significant at 5 per cent level

Table 4. 6 Average daily feed intake of CB_2 pigs, kg on fresh matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	0.25	2.75	0.25	2.75
2.	0.25	2.75	0.25	2.75
3.	0.50	2.75	0.50	2.75
4.	0.50	3.75	0.50	3.75
5.	1.00	3.75	1.00	3.75
6.	1.00	4.75	1.00	4.75
7.	2.00	4.75	2.00	4.75
8.	2.00	4.75	2.00	4.75
9.	2.00	5.75	2.00	5.75
10.	2.00	5.75	2.00	5.75
Mean ± S.E.	1.15 ± 0.24^{b}	4.2 ± 0.37^{a}	1.15 ± 0.24^{b}	4.2 ± 0.37^{a}

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4. 6.1 Average daily feed intake of CB_2 pigs, kg on dry matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	0.225	0.84	0.225	0.84
2.	0.225	0.84	0.225	0.84
3.	0.450	0.84	0.450	0.84
4.	0.450	1.10	0.450	1.10
5.	0.900	1.10	0.900	1.10
6.	0.900	1.40	0.900	1.40
7.	1.800	1.40	1.800	1.40
8.	1.800	1.40	1.800	1.40
9.	1.800	1.70	1.800	1.70
10.	1.800	1.70	1.800	1.70
Mean ± S.E.	1.03 ± 0.22^{NS}	1.23 ± 0.10^{NS}	1.03 ± 0.22^{NS}	1.23 ± 0.10^{NS}

NS - Non-significant at 5 per cent level

Table 4.7 Body weights of CB_1 pigs, kg

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
Initial	12.66 [a]	12.66 [a]	12.90 [a]	12.80 [a]
1.	14.90 [a]	15.10 [a]	15.20 [a]	15.10 [a]
2.	17.40 [a]	17.90 [a]	17.70 [a]	17.90 [a]
3.	20.90 [a]	22.00 [a]	21.20 [a]	22.10 [a]
4.	24.80 [a]	25.80 [a]	25.10 [a]	25.90 [a]
5.	29.50 [a]	31.10 [a]	30.10 [a]	31.50 [a]
6.	34.90 [a]	35.80 [a]	35.50 [a]	35.90 [a]
7.	40.90 [a]	41.20 [a]	42.50 [a]	43.00 [a]
8.	46.90 [a]	47.10 [a]	48.89 [a]	50.50 [a]
9.	54.50 [b]	54.80 [b]	58.89 [a]	60.50 [a]
10.	63.00 [b]	62.66 [b]	68.66 [a]	70.50 [a]

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.8 Body weights of CB_2 pigs, kg

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
Initial	8.00 [a]	8.00 [a]	8.25 [a]	8.00 [a]
1.	10.50 [a]	10.75 [a]	11.10 [a]	10.92 [a]
2.	13.00 [a]	13.75 [a]	13.92 [a]	13.92 [a]
3.	15.50 [b]	16.58 [a]	16.80 [a]	16.92 [a]
4.	19.00 [b]	20.66 [a]	20.83 [a]	21.83 [a]
5.	25.33 [a]	26.50 [a]	25.83 [a]	26.33 [a]
6.	31.33 [a]	32.33 [a]	32.50 [a]	32.50 [a]
7.	37.66 [a]	38.50 [a]	39.66 [a]	38.66 [a]
8.	42.83 [a]	43.83 [a]	45.33 [a]	44.66 [a]
9.	48.00 [a]	49.83 [a]	50.50 [a]	50.66 [a]
10.	53.66 [a]	55.70 [a]	56.17 [a]	57.00 [a]

Figures having different superscripts in a row differ significantly ($P<0.05$)

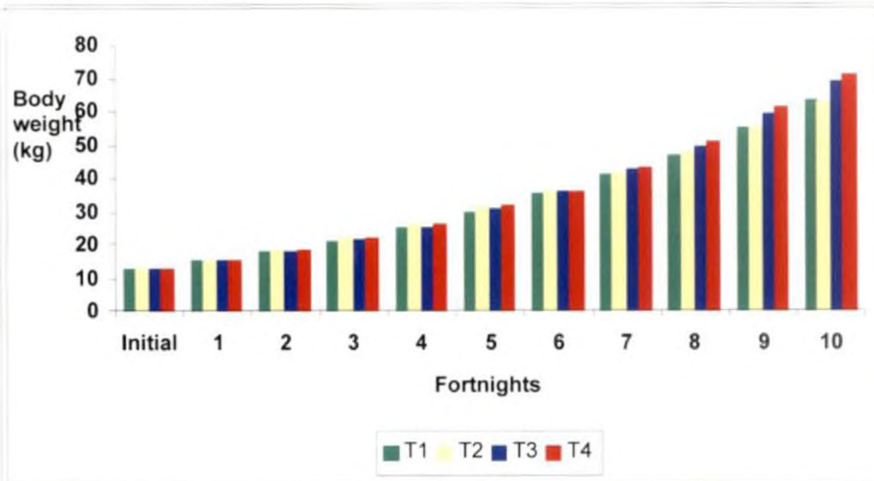

Fig. 4.1 Body weights, kg of CB_1 pigs

T_1-group housing with wallowing facility, fed with conventional feed

T_2-group housing with wallowing facility, fed with unconventional feed

T_3-individual housing without wallowing facility, fed with conventional feed.

T_4-individual housing without wallowing facility, fed with unconventional feed.

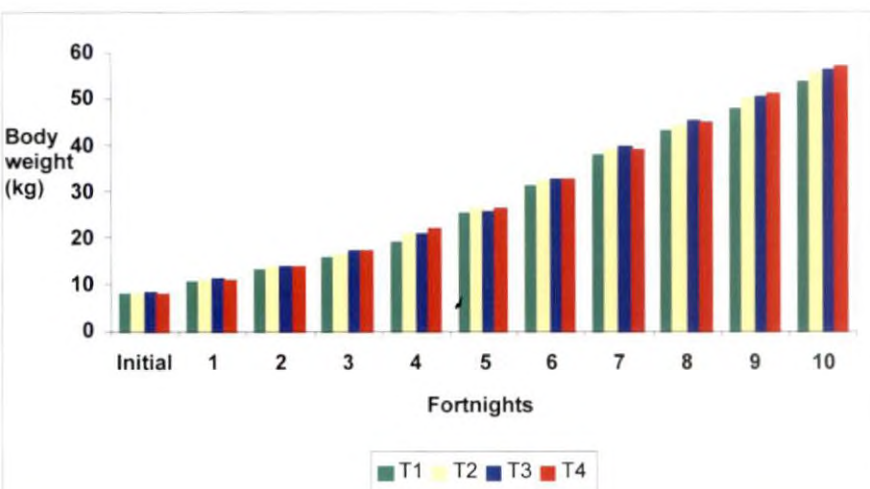

Fig. 4.2 Body weights, kg of CB_2 pigs

Table 4.9 Average daily gain of CB_1 pigs, kg

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	0.153 [a]	0.162 [a]	0.150 [a]	0.153 [a]
2.	0.166 [a]	0.186 [a]	0.166 [a]	0.183 [a]
3.	0.233 [a]	0.273 [a]	0.233 [a]	0.280 [a]
4.	0.260 [a]	0.253 [a]	0.277 [a]	0.253 [a]
5.	0.313 [a]	0.353 [a]	0.333 [a]	0.373 [a]
6.	0.360 [a]	0.313 [a]	0.360 [a]	0.300 [a]
7.	0.400 [a]	0.320 [b]	0.466 [a]	0.466 [a]
8.	0.400 [b]	0.393 [b]	0.426 [b]	0.500 [a]
9.	0.506 [b]	0.510 [b]	0.666 [a]	0.660 [a]
10.	0.566 [b]	0.520 [b]	0.651 [a]	0.666 [a]
Mean ± S.E	0.33 ± 0.04	0.33 ± 0.03	0.37 ± 0.05	0.38 ± 0.05

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.10 Feed conversion ratio of CB_1 pigs on dry matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	1.4	5.0	1.5	5.4
2.	2.7	4.5	2.7	4.5
3.	1.9	3.6	1.9	3.5
4.	1.7	3.9	1.6	3.9
5.	2.8	3.9	2.7	3.7
6.	5.0	4.4	5.0	4.6
7.	4.5	4.3	3.8	3.0
8.	4.5	4.8	4.2	3.8
9.	5.3	3.7	4.0	3.0
10.	4.7	3.6	4.1	3.0
Mean ± S.E.	3.40 ± 0.47 [NS]	4.17 ± 0.15 [NS]	3.20 ± 0.38 [NS]	3.80 ± 0.25 [NS]

NS- Non significant at 5 per cent level

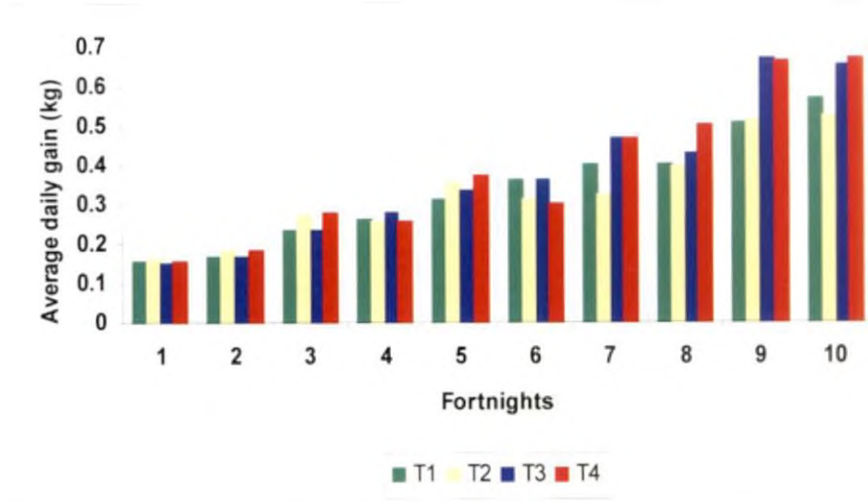

Fig.4.3 Average daily gain of animals, kg of CB_1 pigs

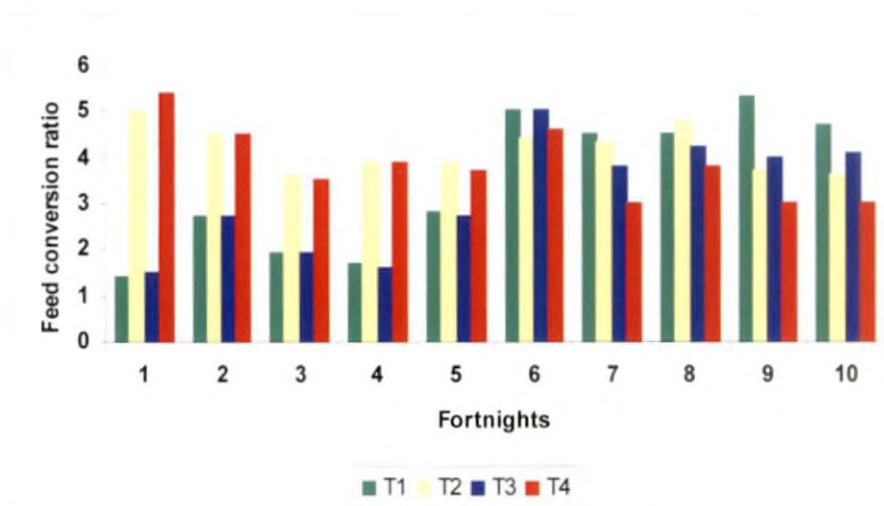

Fig 4.4 Feed conversion ratio of CB_1 pigs on dry matter basis

Table 4.11 Average daily gain of CB_2 pigs, kg

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	0.166^{a}	0.183^{a}	0.189^{a}	0.194^{a}
2.	0.166^{b}	0.200^{a}	0.189^{a}	0.200^{a}
3.	0.166^{b}	0.188^{ab}	0.189^{ab}	0.200^{a}
4.	0.233^{b}	0.271^{ab}	0.272^{ab}	0.328^{a}
5.	0.422^{a}	0.389^{ab}	0.333^{bc}	0.300^{c}
6.	0.400^{a}	0.389^{a}	0.444^{a}	0.411^{a}
7.	0.422^{a}	0.411^{a}	0.478^{a}	0.411^{a}
8.	0.344^{a}	0.355^{a}	0.378^{a}	0.400^{a}
9.	0.344^{a}	0.400^{a}	0.344^{a}	0.400^{a}
10.	0.377^{a}	0.400^{a}	0.377^{a}	0.422^{a}
Mean ± S.E	0.30 ± 0.03	0.32 ± 0.02	0.32 ± 0.03	0.33 ± 0.02

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.12 Feed conversion ratio of CB_2 pigs on dry matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	1.37	4.60	1.23	4.38
2.	1.36	4.25	1.26	4.25
3.	2.72	4.50	2.44	4.25
4.	2.43	4.13	1.65	3.40
5.	2.23	2.80	2.75	3.70
6.	2.28	3.59	2.16	3.40
7.	4.33	3.40	4.09	3.40
8.	5.35	3.90	5.35	3.50
9.	5.36	4.25	5.34	4.25
10.	5.32	4.25	4.98	4.02
Mean ± S.E.	3.30 ± 0.51^{NS}	3.90 ± 0.17^{NS}	3.12 ± 0.52^{NS}	3.80 ± 0.12^{NS}

NS- Non significant at 5 per cent level

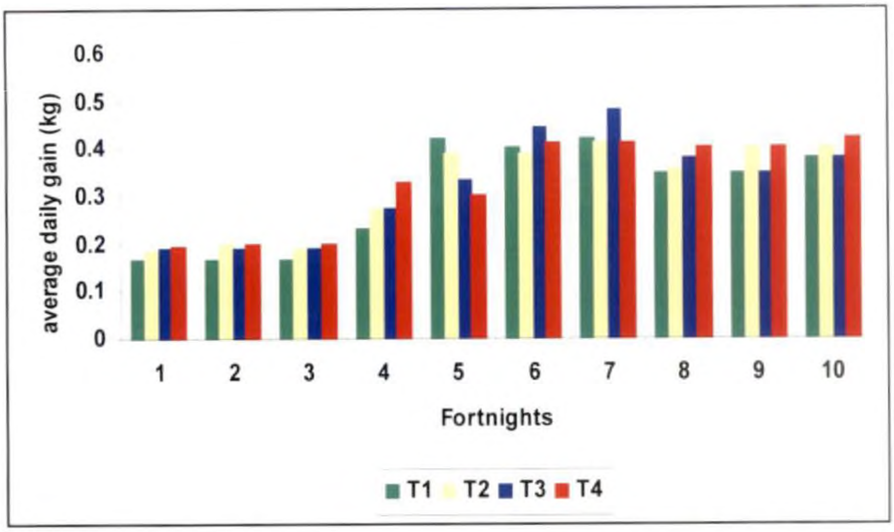

Fig.4.5 Average daily gain of animals, kg of CB_2 pigs

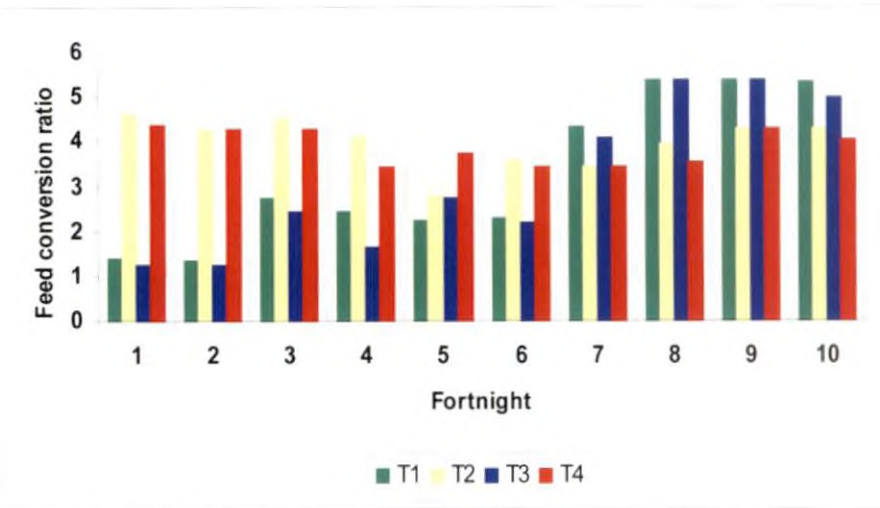

Fig 4.6 Feed conversion ratio of CB_2 pigs on dry matter basis

Table 4.13 Feed conversion ratio of CB_1 pigs on fresh matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	1.6^{c}	16.9^{a}	1.6^{c}	17.00^{b}
2.	3.6^{c}	14.7^{a}	3.0^{b}	14.70^{b}
3.	2.1^{c}	11.9^{a}	2.1^{b}	11.65^{b}
4.	1.9^{b}	12.8^{a}	1.8^{c}	12.80^{bc}
5.	3.1^{b}	13.4^{a}	3.0^{b}	12.73^{a}
6.	5.5^{b}	15.1^{a}	5.5^{b}	16.20^{a}
7.	5.0^{b}	14.8^{a}	4.2^{b}	10.10^{a}
8.	5.0^{b}	17.1^{a}	4.7^{b}	13.50^{a}
9.	5.9^{c}	13.2^{b}	4.5^{c}	10.22^{a}
10.	5.3^{b}	12.9^{ab}	4.6^{b}	10.13^{a}
Mean ± S.E.	3.90 ± 0.38	14.20 ± 0.79	3.50 ± 0.43	12.90 ± 0.59

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.14 Feed conversion ratio of CB_2 pigs on fresh matter basis

Fortnights	Treatment groups			
	T_1	T_2	T_3	T_4
1.	1.50^{b}	15.00^{a}	1.32^{b}	14.17^{a}
2.	1.50^{b}	13.70^{a}	1.33^{b}	13.75^{a}
3.	3.00^{b}	14.60^{a}	2.64^{b}	13.75^{a}
4.	2.36^{b}	13.80^{a}	1.83^{b}	11.43^{a}
5.	2.46^{c}	9.60^{b}	3.00^{c}	12.50^{a}
6.	2.52^{b}	12.20^{a}	2.25^{b}	11.50^{a}
7.	4.73^{b}	11.50^{a}	4.18^{b}	11.50^{a}
8.	5.80^{b}	13.30^{a}	5.29^{b}	11.50^{a}
9.	5.80^{b}	14.30^{a}	5.80^{b}	11.80^{a}
10.	5.30^{b}	14.30^{a}	5.30^{b}	13.60^{a}
Mean ± S.E.	3.40 ± 0.54	13.20 ± 0.72	3.20 ± 0.55	12.80 ± 0.55

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.15 Feeding behavioural scores of CB_1 pigs

Months	Treatment groups			
	T_1	**T_2**	**T_3**	**T_4**
1.	2.500	3.000	2.666	3.000
2.	2.500	2.833	2.500	2.833
3.	2.833	3.000	2.833	2.833
4.	2.666	2.833	2.500	2.833
5.	2.666	2.833	2.666	2.833
Mean ± S.E.	2.63 ± 0.05^{a}	2.90 ± 0.03^{a}	2.63 ± 0.05^{a}	2.87 ± 0.03^{a}

Table 4.16 Agonistic behavioural scores of CB_1 pigs

Months	Treatment groups			
	T_1	**T_2**	**T_3**	**T_4**
1.	2.66	3	0	0
2.	2.5	2.5	0	0
3.	2.33	2.66	0	0
4.	2.5	1.66	0	0
5.	2	1.83	0	0
Mean ± S.E.	2.40 ± 0.09	2.33 ± 0.22	0	0

Non significant at 5 per cent level

Table 4.17 Eliminative behaviour of CB_1 pigs

Months	Treatment groups			
	T_1	T_2	T_3	T_4
*Quantity of faeces voided (g. per 24 hr)	2240± 70.0	2170±82.5	2320 ±	2120 ±84.5
*Frequency of defecation per 24 hr	6.6± 0.9	6.83 ±0.8	7±0.8	6 ±0.7

*Group averages

Table 4.18 Feeding behavioural scores of CB_2 pigs

Months	Treatment groups			
	T_1	T_2	T_3	T_4
1.	2.500	2.833	2.333	3.000
2.	2.666	2.666	2.000	3.000
3.	2.500	2.500	2.000	3.000
4.	2.500	2.500	1.666	2.833
5.	2.000	2.333	2.000	2.833
Mean ±S.E.	2.43 ± 0.10^{a}	2.57 ± 0.07^{a}	2.23 ± 0.16^{a}	2.93 ± 0.03^{a}

Non significant at 5 per cent level

Table 4.19 Agonistic behavioural scores of CB_2 pigs

Months	Treatment groups			
	T_1	T_2	T_3	T_4
1.	1.500	1.500	0	0
2.	1.500	1.330	0	0
3.	1.330	1.330	0	0
4.	1.330	1.166	0	0
5.	1.166	1.330	0	0
Mean ± S.E.	1.37 ± 0.05	1.33 ± 0.04	0	0

Table 4.20 Eliminative behaviour of CB_2 pigs

Months	Treatment groups			
	T_1	T_2	T_3	T_4
*Quantity of faeces voided (g. per 24 hr)	2250±73.0	1986±80.0	2246±81.5	2125±84.0
*Frequency of defaecation per 24 hr	6.1±0.8	5.8±0.7	6.0±0.7	6.0±0.6

*Group averages

Non significant at 5 per cent level

Table 4.21 Carcass characteristics of CB_1 pigs

Carcass traits	T_1	T_2	T_3	T_4
Slaughter weight (kg)	60.50 [b]	61.00 [b]	67.50 [a]	71.00 [a]
Hot Carcass weight (kg)	42.45 [b]	42.60 [b]	48.18 [a]	48.95 [a]
Dressing percentage	70.17 [a]	69.80 [a]	73.34 [a]	68.94 [a]
Carcass length (cm)	78.00 [a]	77.00 [a]	76.00 [a]	78.50 [a]
Back fat thickness (mm)	10.00 [a]	11.83 [a]	11.83 [a]	11.00 [a]
Loin eye area (cm^2)	32.89 [a]	31.25 [a]	32.18 [a]	32.45 [a]
Meat yield (%)	56.09 [a]	59.18 [a]	57.60 [a]	58.16 [a]
Meat bone ratio	3.40 [a]	3.61 [a]	3.60 [a]	3.60 [a]

Figures having different superscripts in a row differ significantly ($P<0.05$)

Table 4.22 Carcass characteristics of CB_2 pigs

Carcass traits	T_1	T_2	T_3	T_4	
Slaughter weight (kg)	58.50	59.00	61.50	63.00	NS
Hot Carcass weight (kg)	42.75	42.75	46.05	48.65	NS
Dressing percentage	73.08	71.88	74.91	77.25	NS
Carcass length (cm)	60.50	62.00	62.50	68.00	NS
Back fat thickness (mm)	26.67	26.67	29.00	29.16	NS
Loin eye area (cm^2)	28.79	29.12	29.52	29.10	NS
Meat yield (%)	58.84	56.49	58.32	57.29	NS
Meat bone ratio	4.70	4.3.00	4.70	4.73	NS

NS- Non significant at 5 per cent level

Table 4.23 Cost of production per kilogram live body weight of CB_1 pigs

	Treatment groups			
	T_1	T_2	T_3	T_4
Number of animals	6	6	6	6
Total initial body weight (kg)	76	76	77.5	77
Total final body weight (kg)	378	376	412	423
Total body weight gain (kg)	302	300	334.5	346
Total feed intake (kg)	1327.5	4185	1327.5	4185
Total feed cost (Rs.)	10,367.7	3348	10,367.7	3348
Cost of feed per kg (Rs.)	7.81	0.80	7.81	0.80
Feed Conversion Ratio	3.9	14.2	3.5	12.9
*Cost of production on feed basis (FCR x Cost of feed/kg) (Rs.)	30.45	11.36	27.34	10.32

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

Table 4.24 Cost of production per kilogram live body weight of CB_2 pigs

	Treatment groups			
	T_1	T_2	T_3	T_4
Number of animals	6	6	6	6
Total initial body weight (kg)	48	48	49.5	48
Total final body weight (kg)	322	334	337	342
Total body weight gain (kg)	274	286	287.5	294
Total feed intake (kg)	1035	3735	1035	3735
Total feed cost (Rs.)	8083.35	2988	8083.35	2988
Cost of feed per kg (Rs.)	7.81	0.80	7.81	0.80
Feed Conversion Ratio	3.4	13.2	3.2	12.8
*Cost of production on feed basis (FCR x Cost of feed/kg) (Rs.)	26.55	10.56	24.99	10.24

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

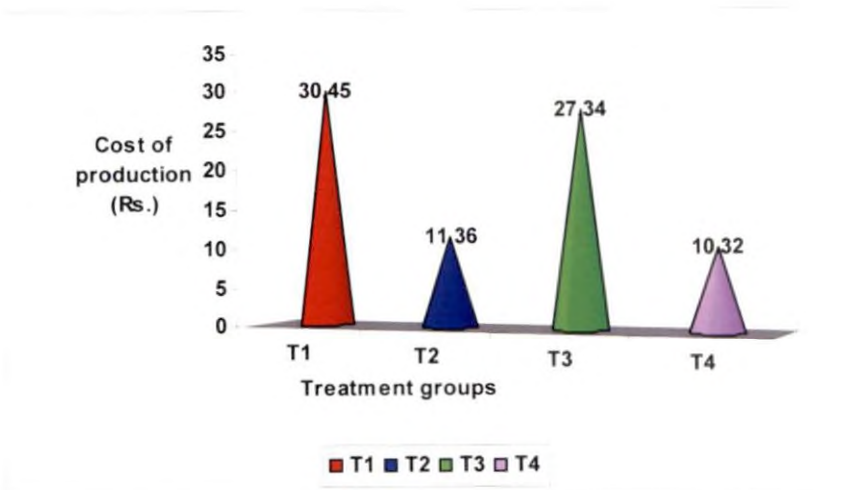

Fig 4.7 Cost of production per kilogram live body weight of CB_1 pigs

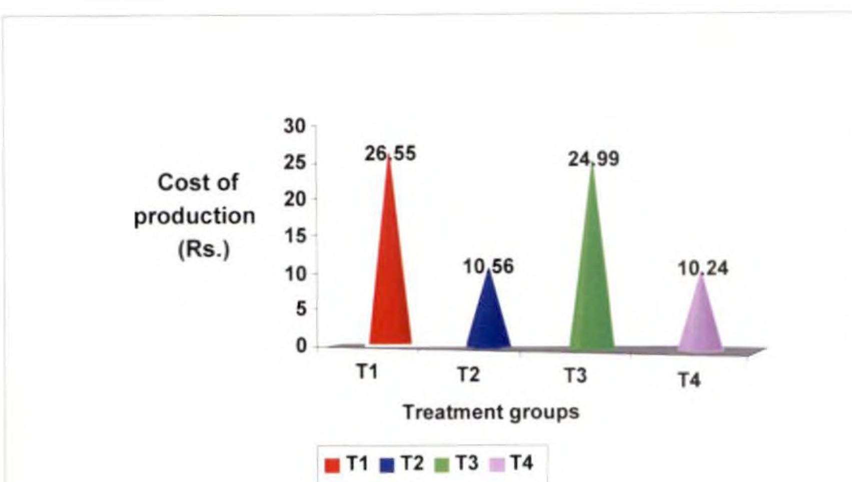

Fig 4.8 Cost of production per kilogram live body weight of CB_2 pigs

Table 4.25 Chemical composition of feeds

Ingredients	Swill	Chicken waste	Infertile egg	Grower ration	Finisher ration
Dry matter	27.97 ± 0.03	28.12 ± 0.05	40.13 ± 0.05	90.50 ± 0.03	90.72 ± 0.03
Moisture	72.03 ± 0.05	71.88 ± 0.06	59.87 ± 0.05	9.51 ± 0.05	9.28 ± 0.05
Crude Protein	8.36 ± 0.04	21.30 ± 0.05	16.68 ± 0.04	18.20 ± 0.04	14.10 ± 0.03
Ether Extract	2.39 ± 0.03	41.22 ± 0.05	29.47 ± 0.04	5.86 ± 0.03	2.23 ± 0.03
Crude Fibre	4.10 ± 0.06	3.70 ± 0.05	0.03 ± 0.04	6.93 ± 0.05	12.00 ± 0.04
Nitrogen Free Extract	8.94 ± 0.04	26.99 ± 0.03	29.93 ± 0.04	57.51 ± 0.03	61.09 ± 0.04
Total Soluble ash	4.19 ± 0.01	6.79 ± 0.03	23.89 ± 0.02	11.50 ± 0.03	10.58 ± 0.02
Acid insoluble ash	0.46 ± 0.01	0.68 ± 0.01	0.91 ± 0.02	5.74 ± 0.02	5.36 ± 0.01

Table 4.26 Mean and S.E. of faecal cortisol level, μg/dl of CB_1 and CB_2 pigs

BREED	Treatments	Month					
		1	2	3	4	5	
CB_1	T1	0.133 ± 0.01	0.116 ± 0.01	0.083 ± 0.01	0.05 ± 0.01	0.033 ± 0.01	NS
	T2	0.116 ± 0.01	0.115 ± 0.01	0.083 ± 0.01	0.05 ± 0.01	0.033 ± 0.01	NS
	T3	0.133 ± 0.01	0.110 ± 0.01	0.083 ± 0.01	0.05 ± 0.01	0.033 ± 0.01	NS
	T4	0.116 ± 0.01	0.115 ± 0.01	0.083 ± 0.01	0.05 ± 0.01	0.031 ± 0.01	NS
CB_2	T1	0.116 ± 0.01	0.103 ± 0.01	0.066 ± 0.01	0.05 ± 0.01	0.033 ± 0.01	NS
	T2	0.110 ± 0.01	0.103 ± 0.01	0.070 ± 0.01	0.06 ± 0.01	0.033 ± 0.01	NS
	T3	0.116 ± 0.01	0.103 ± 0.01	0.070 ± 0.01	0.05 ± 0.01	0.031 ± 0.01	NS
	T4	0.110 ± 0.01	0.103 ± 0.01	0.060 ± 0.01	0.05 ± 0.01	0.031 ± 0.01	NS

NS- Non- significant at 5 per cent level

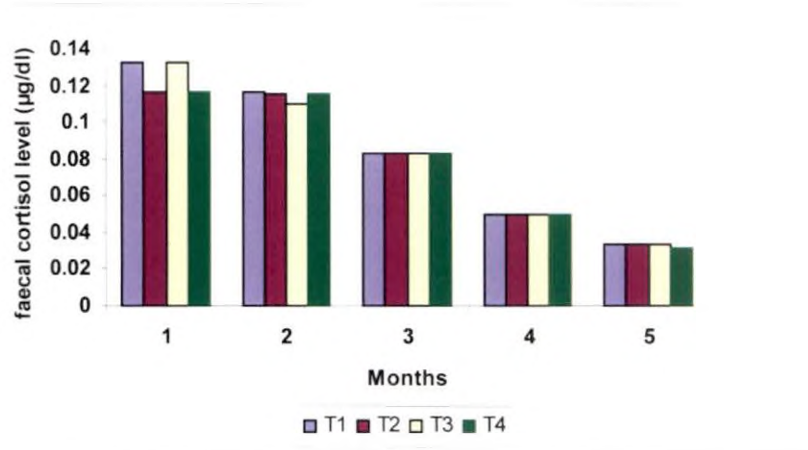

Fig.4.9 Faecal cortisol level of CB_1 pigs, μg/dl

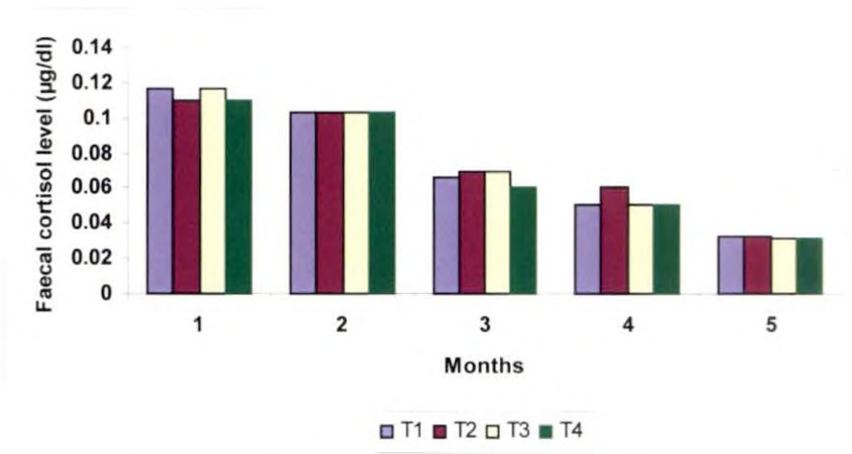

Fig.4.10 Faecal cortisol level of CB_2 pigs, μg/dl

Discussion

5. DISCUSSION

5.1 CLIMATIC VARIABLES

The mean daily maximum temperature observed varied between 28.75^{0}C and 36.75^{0}C and minimum temperature varied between 22.5^{0}C and 25.75^{0}C. There were no significant differences (P>0.05) in microclimatic variables, viz., maximum and minimum temperature and the relative humidity between treatments. This was in accordance with Ramesh (1998) who observed no significant variation (P>0.05) in relative humidity between the conventional house with wallowing tank and conventional house with sprinklers and wallowing tank. There was a trend for higher relative humidity in treatment T_1 and T_2 that might be due to the wallowing facilities provided in those groups.

The data on climatic variables presented in Table 4.2 is a clear indication of the seasonal differences from June 2004 to April 2005. The rainfall recorded during the period varied from zero mm in December, February and March to 786 mm in June. Similar observations were reported by Dinesh (2000). The rainy season was from June to November and the dry season was from December to April. These climatic variables observed were similar to that reported by Deepa (2004).

5.2 RECTAL TEMPERATURE, RESPIRATORY RATE AND PULSE RATE

From the Tables 4.3 and 4.4 it was noticed that significantly (P<0.05) elevated values were observed for pulse rates and respiratory rates while the rectal temperature had no significant difference (P>0.05) in all the four treatment groups during the entire study period for both the breeds. The pulse and the respiratory rates were found to be greater only in the group housed pigs provided with wallowing facility. This may be due to wallows tend to be occupied exclusively by certain dominant animals. In individual housing system pigs seemed to occupy the waterer during the hot hours and might have reduced their body temperature, pulse and respiratory rate. The temperature was numerically higher in the afternoon than the morning temperature. Similar observations were made by West (1985). The pulse and respiratory rates were significantly higher ($P<0.05$) in the afternoon supports the opinion of Yan-Peishi and Yamamoti (2000). These results also indicate that the respiratory rate and pulse rate were found to be an indicator of stress when compared to body temperature and hence these parameters, i.e. (respiration and pulse rate) may be more valid in assessing the environmental stress on animals. These results are in agreement with Mukherjee and Banerjee (1980) and Brown-Brandl *et al.* (2001).

5.3 GROWTH

5.3.1. Average daily feed intake

The average daily feed intake (kg) on fresh matter basis (Tables 4.5 and 4.6) in T_1, T_2, T_3 and T_4 groups were 1.48 ± 0.33, 4.65 ± 0.51, 1.48 ± 0.33 and 4.65 ± 0.51 for CB_1 and 1.15 ± 0.24, 4.2 ± 0.37, 1.15 ± 0.24 and 4.2 ± 0.37 for CB_2 pigs respectively and on dry matter basis (Table 4.5.1 and 4.6.1) were 1.30 ± 0.30, 1.38 ± 0.14, 1.30 ± 0.30 and 1.38 ± 0.14 for CB_1 and 1.03 ± 0.22, 1.23 ± 0.10, 1.03 ± 0.22 and 1.23 ± 0.10 for CB_2 pigs respectively. It was observed that there was significant difference ($P<0.05$) in average daily intake on fresh matter basis only, between the intake of unconventional and conventional feed and it was approximately three times more than that of conventional feed. This is in close agreement with Westendorf *et al.* (1998) who suggested that pigs must be fed with food waste nearly four times the volume of concentrate feed.

5.3.2. Body weight

The average initial weights (Table 4.7 and 4.8) of T_1, T_2, T_3 and T_4 groups were 12.66 ± 1.13, 12.66 ± 0.08, 12.90 ± 1.13 and 12.80 ± 0.70 for CB_1 and 8.00 ± 0.53, 8.00 ± 0.9, 8.25 ± 0.89 and 8.00 ± 1.0 for CB_2 respectively at weaning (56th day). These initial weights did not differ significantly (P>0.05) in both the breeds. The animals showed a progressively increasing weight with advancing age. There were significant differences (P<0.05) in the body weight of T_3 and T_4 groups (individually housed) of CB_1 from ninth fortnight. However, these differences were statistically not significant (P>0.05) in CB_2 although individually housed pigs showed better growth. The reason may be of least social stress for individually housed animals as reported by Patterson (1985) and Bustamate *et al.* (1996).

The final body weights of T_1, T_2, T_3 and T_4 groups were 63.00 ± 2.27, 62.66 ± 2.0, 68.66 ± 1.45 and 70.50 ± 0.47 for CB_1 and 53.66 ± 2.54, 55.70 ± 2.5, 56.17 ± 3.68 and 57.00 ± 1.48 for CB_2 respectively. It was observed that pigs fed with unconventional feed in both the breeds showed highest body weight, which may be due to better nutrients and higher dry matter content of the waste which was collected from hostel supplemented with boiled infertile hatchery egg and chicken waste and also indicates a better growth rate to production systems with unconventional feed resources. This was in support to the findings of Ranjan *et al.* (2003) and Ravindra *et al.* (2004). They reported that significantly highest (P<0.05) body weight was observed in pigs maintained on hotel waste with 20 per cent concentrate.

5.3.3. Average daily gain and feed conversion ratio

From the Table 4.9 and 4.11 it can be seen that the average daily gain (ADG) of T_1, T_2, T_3 and T_4 were 0.33 ± 0.04, 0.33 ± 0.03, 0.37 ± 0.05 and 0.38 ± 0.05 for

CB_1 and 0.30 ± 0.03, 0.32 ± 0.02, 0.32 ± 0.03 and 0.33 ± 0.02 for CB_2 respectively. The CB_1 in individually housed pigs fed with unconventional feed had significantly highest ($P<0.05$) ADG indicating the suitability of this genetic composition in production system with unconventional feed and least social stress. Better ADG in both the breeds fed with unconventional feed again supports its adaptation to unconventional feeding systems. The ADG in individually housed pigs was higher than group housed pigs. This might be due to uneven sharing of feed amongst pigs in group housing and more energy retention in individually penned pigs. This result is similar to the reports of Patterson (1985), Spicer and Aherne (1987) and Reinhart *et al.* (1989).

It can be seen from Tables 4.10 and 4.12 that the feed conversion ratio (FCR) on dry matter basis of T_1, T_2, T_3 and T_4 were 3.40 ± 0.47, 4.17 ± 0.15, 3.20 ± 0.38 and 3.80 ± 0.25 for CB_1 and 3.30 ± 0.51, 3.90 ± 0.17, 3.12 ± 0.52 and 3.80 ± 0.12 for CB_2 pigs respectively. The FCR was highest in group housed pigs fed with unconventional feed and least in individually housed conventional feed groups of both the breeds. This finding is in conformity with the findings of Moon *et al.* (2004). They stated that FCR was better in pigs fed with food waste. A trend for reduction in FCR towards later stages of growth in animals maintained on unconventional feed in both housing systems may be due to variation in the nutritive value of the swill fed to the animals and also deficiencies of essential elements arising from it as reported by Westendorf *et al.* (1998). It also indicated that an intervention in the feeding regime by supplementing the unconventional feed with deficient nutrients after periodical nutritional analysis of the feed is essential for sustaining the feed conversion efficiency for throughout the growth period. There was an improvement in the feed conversion efficiency of the pigs housed in individual pens. This supports the report of Becker *et al.* (1964) who reported an improvement in the conversion of feed to live weight gain with individual penning.

5.4 BEHAVIOUR

It can be seen from the tables 4.15 and 4.18 that pigs fed with unconventional feed showed better feeding behavioural scores. This may be due to the palatability of unconventional feed. But statistically the differences between the treatment groups were not significant ($P>0.05$). This observation was akin to that of Mikesell and Kephart (1999). The group housed pigs ate at a faster rate than the pigs housed individually as found by Bornett *et al.* (2000).

There were no significant differences ($P>0.05$) in the agonistic behaviour scores (Tables 4.16 and 4.19) between the T_1 and T_2 groups. Frequent attempts of tail biting, belly nosing and ear biting were recorded at the time of feeding. The aggressive behaviour of the group housed pigs at the time of feeding throw some light on the stress level of these pigs.

The eliminative behaviour shown by the animals were similar to that reported by Dinesh (2000). The frequency of defaecation and the quantity of faeces voided are presented in Tables 4.17 and 4.20. On statistical analysis, the differences between the treatments were found to be not significant ($P>0.05$). Even then, the pigs fed with conventional feed voided more quantity of faeces due to the increased bulkiness (fibre content).

5.5 CARCASS CHARACTERISTICS

The carcass traits of CB_1 and CB_2 pigs in all the treatment groups are presented in Tables 4.21 and 4.22.

The colour of pork was greyish pink in all the groups irrespective of their housing and feeding treatments of both the breeds. The consistency of fat was firm in pigs slaughtered from groups fed with conventional feed whereas the consistency of fat was soft and oily in pigs slaughtered from groups fed with unconventional feed in both the breeds because of increase in unsaturated fatty acid content in the fat as reported by Myer *et al.* (1999) who reported that carcass fat became softer with increasing amount of food waste in the diet.

The slaughter weight and hot carcass weight were significantly higher ($P<0.05$) in the T_3 and T_4 of CB_1 pigs but these traits were numerically higher in T_4 followed by T_3, T_2 and T_1 of CB_2 pigs. The pigs fed with unconventional feed had lower dressing percentage than the pigs fed with concentrate feed in both the breeds as stated by Gopalakrishnan and Lal (1985) and Jha *et al.* (1999). This may be due to increase in gut weight in the pigs fed with unconventional feed. A trend for higher carcass length in T_4 (individually housed pigs fed with unconventional feed) in both the breeds may be due to their higher live body weight at slaughter.

The increased back fat thickness noted in T_3 (individually housed pigs fed with conventional feed) and T_4 (individually housed pigs fed with unconventional feed) may be attributed to their higher slaughter weight and energy retention due to decreased movement in social interaction as opined by Patterson *et al.* (1985).

A higher loin eye area indicated a higher lean content in CB_1 pigs might be attributed to their genetic composition.

A higher value for meat yield (percentage) in T_3 and T_4 in both the breeds may be attributed to relatively higher live weight at feeding regime and also the housing system.

A trend for higher meat bone ratio in CB_2 compared to CB_1 may be attributed relatively due to their lower bone weight compared to CB_1 pigs.

5.6 COST OF PRODUCTION

It can be seen from Tables 4.23 and 4.24 that the cost of production of T_1, T_2, T_3 and T_4 groups (Rs.) per kilogram live body weight were 30.45, 11.36, 27.34 and 10.32 for CB_1 pigs and 26.55, 10.56, 24.99 and 10.24 for CB_2 pigs respectively. The cost of production is considered to be the basic measure of economic efficiency in swine husbandry. The production cost per kg of live body weight depends on the total body weight gain. Rearing of pigs under unconventional feeding system proved to be the most profitable as it costs 20 Rs. less for producing one kg of body weight. Similar observations were made by Viswanathan *et al.* (2001). Rearing pigs in individual housing system further reduced the cost of production per kg of live body weight to one rupee than maintaining them in group housing system. This result is in agreement with the findings of Spicer and Aherne (1987).

5.7 CHEMICAL COMPOSITION OF FEEDS

From Table 4.25 it can be seen that though the moisture level was more in swill followed by chicken waste and infertile egg the pigs tolerated with the high moisture content of the food waste by drinking less water and excreting more urine. This was in agreement with the observation of Rakesh *et al.* (2003). The crude protein and ether extract were highest in chicken waste followed by infertile egg and swill. Though the crude protein of the swill was low the animals were able to cope up with the unconventional feed due to their nutritive supplementation, which was in agreement with Faustin *et al* (2003)

5.8 FAECAL CORTISOL LEVEL (μg/dl)

From the Table 4.26 it can be seen that there were no significant differences ($P>0.05$) in the faecal cortisol concentration between the treatments of both the breeds indicating that there was no apparent stress on animals with respect to housing system or feeding regime provided to the animals. This is in conformity with the findings of Bustamate *et al.* (1996).

Summary

6. SUMMARY

An investigation was carried out to assess the adaptability and production performance of two crossbred pigs, viz., CB_1 (Duroc 50% and Large White Yorkshire 50 %) and CB_2 (Desi 50% and Large White Yorkshire 50%).

Twenty-four crossbred weaned, piglets from each genetic group were randomly selected from Centre for Pig Production and Research, Kerala Agricultural University, Mannuthy as uniformly as possible with respect to age, sex and bodyweight were utilised for the study. The piglets in each crossbred group were randomly divided into four groups of six animals each and allotted to one of the following treatments. T_1–group housing with wallowing facility, fed with conventional feed (control), T_2–group housing with wallowing facility, fed with unconventional feed (left over food from hostels and other organic food waste), T_3–individual housing without wallowing facility, fed with conventional feed and T_4–individual housing without wallowing facility, fed with unconventional feed.

Hence, the animals were maintained under two housing and feeding systems. Groups maintained with conventional feed were fed with usual farm grower and finisher ration whereas, unconventional feed fed groups were fed with restaurant and hostel waste daily and was supplemented with 10 boiled infertile eggs daily and chicken waste once in a week.

The changes in environmental variables all throughout the study period revealed that the animals were exposed to stress due to high humidity from June to October and high temperature from December to April. There were no significant differences ($P>0.05$) in microclimatic variables viz., maximum and minimum temperature and the relative humidity between the treatments.

There were no significant differences ($P>0.05$) in body temperature of the pigs between the treatments but the pulse and respiratory rates were significantly higher ($P<0.05$) in group housed pigs than the individually housed pigs in both the breeds.

The average weaning weights of T_1, T_2, T_3 and T_4 groups were 12.66 ± 1.13, 12.66 ± 0.08, 12.90 ± 1.13 and 12.80 ± 0.70 for CB_1 and 8.00 ± 0.53, 8.00 ± 0.9, 8.25 ± 0.89 and 8.00 ± 1.0 for CB_2 pigs respectively. The animals showed a progressively increasing weight with advancing age.

By the end of the experimental period, the body weights of T_1, T_2, T_3 and T_4 groups were 63.00 ± 2.27, 62.66 ± 2.0, 68.66 ± 1.45 and 70.50 ± 0.47 for CB_1 and 53.66 ± 2.54, 55.70 ± 2.5, 56.17 ± 3.68 and 57.00 ± 1.48 for CB_2 pigs. There were significant differences ($P<0.05$) in the growth between the individually housed pigs and group housed pigs from ninth fortnight in CB_1 but the differences were not statistically significant ($P>0.05$) in CB_2 between the individually housed pigs though they showed better growth than the group housed pigs.

The average daily gain (ADG) of T_1, T_2, T_3 and T_4 were 0.33 ± 0.04, 0.33 ± 0.03, 0.37 ± 0.05 and 0.38 ± 0.05 for CB_1 and 0.30 ± 0.03, 0.32 ± 0.02, 0.32 ± 0.03 and 0.33 ± 0.02 for CB_2 pigs respectively. Individually housed pigs fed with unconventional feed had better ADG. Overall the pigs fed with unconventional feed had better ADG. The ADG in individually housed pigs was higher than group housed pigs.

The feed conversion ratio (FCR) on dry matter basis of T_1, T_2, T_3 and T_4 were 3.4 ± 0.47, 4.17 ± 0.15, 3.2 ± 0.38 and 3.8 ± 0.25 for CB_1 and 3.3 ± 0.51, 3.9 ± 0.17, 3.12 ± 0.52 and 3.8 ± 0.12 for CB_2 pigs respectively. The feed conversion ratio was found to be more in groups fed with unconventional feed than groups fed with conventional feed in both the breeds and there was an improvement in feed conversion efficiency of pigs in individual housing when compared to group housing system.

The feeding behavioural scores were numerically better in unconventional feed fed pigs. The agonistic behavioural scores for pigs housed in individual house were nil it was seen in group housed pigs only. The conventional feed fed pigs voided more quantum of dung. Statistically no significant differences ($P>0.05$) were obtained for all the feeding, agonistic and eliminative behavioural characteristics.

The colour of pork was greyish pink in all the groups irrespective of their feeding treatments of both the breeds. The consistency of fat was firm in pigs slaughtered from groups fed with conventional feed whereas the consistency of fat was soft and oily in pigs slaughtered from groups fed with unconventional feed in both the breeds. The slaughter weight and hot carcass weight (kg) were significantly *higher* ($P<0.05$) *in the* T_3 *and* T_4 *of* CB_1 *pigs but these traits were higher in* T_4 followed by T_3, T_2 and T_1 of CB_2 pigs. Back fat thickness (mm) was lesser in CB_1 than CB_2. Individually housed pigs had relatively higher back fat thickness in both the breeds. The loin eye area (cm^2) was numerically higher in CB_1 than CB_2. The dressing percentage was lower in groups fed with unconventional feed (T_2 and T_4) and meat yield (percentage) was higher in T_3 and T_4 in both the breeds. Bone weight was less in CB_2 when compared to CB_1. Hence the meat bone ratio was high in CB_2 when compared to CB_1pigs.

The cost of production of T_1, T_2, T_3 and T_4 groups (Rs.) per kg live body weight were 30.45, 11.36, 27.34 and 10.32 for CB_1 pigs and 26.55, 10.56, 24.99 and 10.24 for CB_2 pigs respectively. Feeding pigs with unconventional feed proved relatively more economic and profitable system and is affordable by poor small-scale marginal farmers as it costs Rs. 20 less for producing one kg of body weight. Rearing pigs in individual house further reduced the cost of production per kg of body weight to one rupee than maintaining them in group housing system.

Though the moisture level was more in unconventional feed the crude protein and ether extract was highest in chicken waste followed by infertile egg. So the animals were able to cope up with the unconventional feed with nutritive supplementation.

Different penning and feeding systems had no significant effect (P>0.05) on faecal cortisol concentration with any indication of stress.

From the overall results it can be seen that CB_1 (Duroc 50% and Large White Yorkshire 50%) pigs have got good adaptation potential to the unconventional feeding regime as they have got better growth rate and higher lean meat production when compared to CB_2 pigs. Animals in individual housing system perform better than those housed in group housing system. But the cost of production per kilogram of body weight was found to be relatively less in CB_2 pigs indicating a better economic feasibility.

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ADAPTABILITY OF CROSSBRED PIGS UNDER DIFFERENT HOUSING AND FEEDING SYSTEMS

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Abstract of the thesis submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
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2005

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ABSTRACT

A study was conducted to find out the adaptability of two crossbred pigs, viz., CB_1 (Duroc 50% and Large White Yorkshire 50 %) and CB_2 (Desi 50% and Large White Yorkshire 50%) under different housing and feeding systems. Twenty-four weaned piglets from each genetic group were randomly divided into four groups of six animals each and were subjected to four treatments, i.e., group housing with wallowing facility, fed with conventional feed (T_1), group housing with wallowing facility, fed with unconventional feed (T_2), individual housing without wallowing facility, fed with conventional feed (T_3) and individual housing without wallowing facility, fed with unconventional feed (T_4).

The climatological data, rectal temperature, pulse and respiratory rate at weekly intervals, daily feed intake, fortnightly body weight and behavioural scores of the animals were recorded. The average daily gain (ADG), feed conversion ratio (FCR), total cost of production per kg of live body weight, proximate principles of the feeds and faecal cortisol level were estimated. On attaining the slaughter weight two animals from each group were slaughtered for studying the carcass characteristics.

There were no significant differences ($P>0.05$) in microclimatic variables, viz., maximum and minimum temperature and relative humidity between the treatments. There were no significant differences ($P>0.05$) in rectal temperature between the treatments but the pulse and respiratory rates were significantly higher ($P<0.05$) in group housed pigs than the individually housed pigs in both the genetic groups. Significantly higher ($P<0.05$) growth rate in T_3 and T_4 groups (individually housed) of CB_1 and a trend for higher growth rate in T_3 and T_4 groups (individually housed) of CB_2 were observed.

The ADG was highest in T_4 followed by T_3, T_2 and T_1 and the FCR on dry matter basis was highest in T_2 followed by T_4, T_1 and T_3 in both the genetic groups. Though there were no significant differences (P>0.05) in the behavioural scores, the feeding behavioural score was better was higher in pigs fed with unconventional feed. The quantity of dung voided was highest in pigs fed with conventional feed.

The slaughter weight and hot carcass weight (kg) were significantly higher (P<0.05) in the T_3 and T_4 of CB_1 pigs but these traits were numerically higher in T_4 followed by T_3, T_2 and T_1 of CB_2 pigs. Back fat thickness (mm) was lesser in CB_1 than CB_2. Individually housed pigs had relatively higher back fat thickness in both the breeds. The loin eye area (cm^2) was numerically higher in CB_1 than CB_2 pigs. The dressing percentage was lower in groups fed with unconventional feed (T_2 and T_4) and meat yield (percentage) was higher in T_3 and T_4 in both the breeds. The meat bone ratio was numerically higher in CB_2 when compared to CB_1 pigs.

The moisture level was more in swill (72.03%) followed by chicken waste (71.88%) and infertile egg (59.87)%. The crude protein and ether extract were highest in chicken waste followed in infertile egg and swill. There were no significant differences (P>0.05) in the faecal cortisol level between the treatments of both the breeds.

From this study it is concluded that both genetic combination had better performance when they were maintained on unconventional feed irrespective of their housing and feeding systems. Among these two breeds Desi 50% and Large White Yorkshire 50%(CB_2) seemed to be economical under unconventional feeding in both the housing systems, considering the cost of production per kg live body weight.