EVALUATION AND IMPROVEMENT OF INTEGRATED PIG FARMING SYSTEMS IN KERALA

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

Doctor of Philosophy

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University, Thrissur

2005

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DECLARATION

I hereby declare that the thesis entitled **"EVALUATION AND IMPROVEMENT OF INTEGRATED PIG FARMING SYSTEMS IN KERALA"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled **"EVALUATION AND IMPROVEMENT OF INTEGRATED PIG FARMING SYSTEMS IN KERALA"** is a record of research work done independently by **A. Kannan,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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ACKNOWLEDGEMENT

I express gratitude to the Chairman, Dr. Francis Xavier, Professor and Head, Department of Livestock Production Management, College of Veterinary and Animal Sciences, Pookot, whose highly perceptive mind in planning, guiding and supervising the research work, suggestion and most generous contribution of time and valid thoughts have helped me immeasurably in my endeavour to prepare and finalise this manuscript.

I express my foremost sincere gratitude to members of the advisory committee Dr. P. C. Saseendran, Dr. T. V. Viswanathan, Dr. Joseph Mathew and Dr. Samuel Mathew for their expert guidance, constant encouragement, constructive, inspiring and motivating advice and ready help during the period of this study and preparation of the thesis.

I am most thankful to, Dr. M. R. Rajan, Associate Professor and Head, Centre for pig production and Research, Mannuthy for all the facilities and help provided.

I am grateful to Dr. K. S. Sebastian, Research Co-ordinator (Veterinary) and Dr. K. S. Anil, Associate Professor, Department of Livestock Production Management for their support and help during the study period.

I would like to express my sincere thanks to Dr.T. R. Gopalakrishnan, Associate Professor and Head, Department of Olericulture, College of Horticulture, Vellanikara and Dr. A.D. Antony, Associate Professor, Communication Centre, Mannuthy for the supply of seed materials and Dr S. Baskaran, Associate Professor and Head, Central Training Institute, KAU, Mannuthy and Dr. K. P. Mani, Associate Professor, College of Co- operation Management and Banking.

I am cordially obliged to Dr. E. Nanu, Dean i/c, College of Veterinary and Animal sciences, Mannuthy for providing facilities for research work.

The whole hearted cooperation, help and motivation offered to me by my colleagues Dr. T. V. Raja, Dr. P. Veeramani, Dr. Richard Churchil and Dr. Murugan and my friends Drs. Koushik Raj, Acty George, Cijo K. Joseph, Deepak Mathew D. K., Cyel V. Yohannan and Bilony Chako is thankfully acknowledged.

I take great pleasure in appreciating the staff and labourers of Centre for pig production and Research, Mannuthy for their cooperation and assistance.

I owe my sincere gratitude to veterinary Surgeons and Staff, Department of Animal Husbandry, Government of Kerala and Pig farmers for their wholehearted participation in the survey. I wish to express my thanks to the farmers in Kaiparambu and Kuzhoor panchayats of Thrissur district for their co-operation in the field trials.

I express my deep gratitude to my parents, wife and children for their understanding, sacrifice and heartful blessings.

A. KANNAN

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Introduction

1. INTRODUCTION

Pig rearing is a promising source of meat production in India with their inherent characteristics for faster multiplicity, higher growth rate and efficient feed conversion ability (Yadav *et al.,* 1991). India has 16 million pigs which form 1.7 per cent of world pig population of 901.1 millions. About seven per cent of overall meat production in India is from pigs. In India a total of 4.38 M.T. of meat is produced for human consumption. If the proportion of non- vegetarian is considered as 70 per cent of the total population, the per capita availability of meat works out to be eight gram per day. This is very low against the recommended level of 125 g by the Indian Council of Medical Research (FAO, 2000). This indicates that there is a wide gap between production and need.

Pork is an important source of high quality animal protein. Mutton, Beef and chicken meat alone cannot meet the animal protein requirement of India's growing population. In this context, the quick growing multi-parous pig is one of the best choices to meet the requirement for animal protein. Pig acts as a "costless fertilizer factory moving on hooves" (FAO, 1977).

The rising demand of food for the increasing population calls for maximising production of food by the efficient utilization of farm resources. In Kerala since the small farmers have only limited and fragmented land holdings to cultivate, maximum productivity could be achieved by proper integration of several farm enterprises.

In most of the pig enterprises, feed accounts for nearly 80 per cent of the total cost of production. Proper formulation of cheaper rations based on locally available materials and efficient use of agricultural by-products and food waste offers the best possibility of reducing the cost of production to a greater extent, because the pigs are efficient converters of agricultural by-products and garbage in to high quality meat / protein. In view of ever increasing cost of concentrates,

farmers are entering into contract with restaurants, hotels and hostels for supply of food / kitchen waste to feed the pigs. Integration of pig production with other agricultural activity is gaining importance as it provides cheaper input for either of the activities.

Integration of the different enterprises in a farm ensures recycling of residues, optimum resource utilisation, higher employment, minimisation of risk and uncertainties and provides stable farm income (Nagaraja *et al.*, 1997). Integrating livestock, crop and fish in smallholder farming system has ecological and economic advantage.

The logic of adapting an integrated approach to livestock/crop/fish raising lies in the fact that the region has tremendous potential for the development of truly indigenous and self reliant method of integration to increase production at the small farm level. One of the promising methods is backyard raising of livestock without competition on humans food but utilising all farm waste and by products. When pig raising is integrated with crop/fish farming, the manure of pig is major source of organic manure for grain/vegetable and feed for fish production.

Meagre systematic work has been carried out in Kerala to investigate the productivity and economic viability of integrated pig-crop/vegetable-fish farming system. A systematic study considering various resources like land, agriculture, animal, human etc is highly essential for integrated development of the farmers and the improvement of overall productivity of the farming systems in our rural sector.

In this context the present study was undertaken in the farmer's premises with the following objectives

1. To study the existing pig farming systems in Kerala

2. To study the production performance of pigs in integrated models of pig farming.

3. To assess the economic efficiency of different models of integrated pig farming

4. To find out the feasibility of integrating pig farming with crop/vegetables, fish/broiler chicken farming in the field condition.

Review of Literature

2. REVIEW OF LITERATURE

2.1 PIG PRODUCTION SYSTEM

In South East and East Asian countries 80 to 95 per cent of the farms belong to small farm categories (Devendra, 1993).

Pig population in Kerala is 142784; out of this 97.45 per cent are concentrated in the rural areas (Livestock census staff, 1997).

Taneja (1998) observed that in the rural areas of Haryana around 73 per cent of household depend on livestock farming for supplementary income and about 19 per cent of the total income earned by a household is from piggery.

A study conducted among pig farmers in Enugu State of Nigeria showed that male family members performed major tasks like initiation, planning and organizing of pig production within households in patriarchal system (Agwu, 1999).

Saadullah and Saad (2000) reported that the pig production system in tropical countries are characterized by small number of animals with no or minimum inputs, low outputs and periodic mortality. Typically the litter size is small with each household containing five to six pigs.

Harikumar *et al.* (2000) indicated that the resources for pig production should be exploited and a scientific intervention will beneficially contribute to the pig production systems in rural sector.

2.1.1 Socio-economic and Educational Status of Pig Farmers

Chylek *et al.* (1996) evaluated the educational status among women centered livestock farms in Eastern and Western Provinces of Poland and

observed that 51.1 per cent had full secondary, 30.8 per cent elementary and 6.7 per cent higher education.

Pig farming was a part time occupation of 73.33 per cent of pig farmers in peri-urban settings of Zaria, Northern Nigeria (Duru *et al.*, 1999). They also observed that Muslims did not take up this occupation. Farmers considered pig rearing as a source of security on crop failure. About 73 per cent of the pig farmers were civil servants, students and traders.

Panday and Ramkumar (1999) indicated that education and family income of pig owners played a positive role in the adaptation of pig rearing practices. They found that pig farmers who have educational level beyond seventh standard owning large herd size of more than 10 pigs utilized veterinary facilities more efficiently.

Harikumar (2001) reported higher socio-economic and educational status of the pig farmers in two adopted villages of Thrissur District in Kerala. Their major occupations were agriculture and allied activities. Feeding and housing were cost effective and suited well for the rural sector.

Thomas (2004) listed major factors influencing the adaptation of scientific procedures, as education, annual income, extension contribution, market orientation and knowledge of technology.

2.1.2 Drove Size

Ravindran *et al.* (1995) reported that the herd size ranged from 14 to 55, with an average herd strength of 36 in smallholder pig farmers in Sri Lanka. Animals consisted of Large White, Landrace and crossbreds.

The average drove in North Taiwan had 902 pigs (Hsieh *et al.*, 1997). Farmers bought weaned pigs directly from other farms and sold them after 10.5 months.

The average number of pigs per farm in Slovenia was 4.4. There were 1012 pig farmers with at least 20 breeding sows or 80 fatteners (Salehar *et al.*, 1997).

According to Zhang-XiaoHui and Zhang (1998), in China the common farmers raised two to five pigs per household and the specialized farmers had 719.3 pigs per household.

In a study conducted among pig farmers in Zaria, Northern Nigeria, Duru *et al.* (1999) it was noticed that 85.0 per cent of them purchased their foundation stock from other farms in the locality, 10 per cent inherited and five per cent got their stock as gifts. Mainly 60 per cent of them were Large White, eight per cent Landrace, 10 per cent Hampshire and 22 per cent of their various crosses. The mean drove size of sows was 2.92±0.21 and of boars was 1.4±0.19.

Rohilla *et al.* (2000) pointed out that small and marginal farmers of North East Hill region of India mostly raised local pigs, while well-organised farms produced exotic breeds.

Harikumar (2001) reported that exotic pigs purchased from large farms were the main stock of majority of the pig farmers in two adopted villages of Thrissur District in Kerala.

2.1.3 Feeding Practices

Sebastian (1972) suggested that conventional feed like tapioca starch waste could be incorporated in the swine ration up to 15 per cent by replacing maize without affecting the performance of pigs.

Dried tapioca can be safely and profitably incorporated in swine ration at a level of 40 per cent replacing conventional cereal grain like maize (Devi, 1981).

Miller and De Boer (1988) recommended that a maximum of four to five per cent meat and bone meal, zero to two per cent feather meal 3.5 percent blood

meal and zero to 2.5 per cent poultry byproduct meal can be included in the ration of sows and finisher pigs above 50 kg and in the case of grower pigs 2.5 to five per cent, zero to one per cent, zero per cent and zero to 2.5 per cent respectively.

The most promising alternative to cereal grains in intensive feeding of pigs in the tropics are organic waste from urban household, restaurants and canteens, cassava roots and its byeproducts (Devendra, 1993). Sugarcane molasses, whole fruit and byproducts of African oil palm were also alternate feed (Rodriguez and Preston 1995).

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

The cassava, its byproducts of starch processing and sugarcane juice and/or molasses can replace cereals in the diets of growing pigs (Le-Duc-Ngoan *et al.,* 1996).

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

The availability of cheap local feed resources and low fixed costs are the positive factors in pig production (Loc *et al.,* 1996). It was found that cassava root, the cheapest feed is the most under-utilized feed resource for pigs in central Vietnam.

Hsieh *et al.* (1997) reported that in North Taiwan pigs were fed primarily on kitchen waste when body weight reached about 28 kg. After attaining 41 kg of body weight they were fed only kitchen waste. They reached market weight of about 135 kg.

Poultry offal could be used to replace up to 300g per kg DM in commercial grower diet without affecting performance or health of the pigs (Lallo *et al.*, 1997).

Mishra *et al.* (1997) recommended scavenging system of rearing of local pigs with supplementation of 300 to 500 g concentrates to save 40 per cent of the concentrate feed with no loss of body weight.

In a comparative study of grain and garbage feeding of pigs Sharma *et al.* (1997) observed that feed costs were lower for garbage fed group, though the labour costs and pig mortality were higher.

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

Viswanathan *et al.* (2001) reported that pigs could be fed with swill alone. The economy and productivity of backyard pig production system based on hostel/hotel/domestic waste is suited for ordinary small-scale farmers.

2.1.4 Housing

Pathiraja *et al.* (1986) observed that most pig farmers preferred locally available materials for housing to save cost of production.

In pig production the floor space requirements had no significant effect on the performance of pigs (Leena, 1992).

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

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

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

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

Harikumar *et al.* (2000) reported that 66.6 per cent of the pig farmers in two adopted villages of Thrissur District in Kerala were having permanent housing structure. The floors were made of concrete with thatched or tiled roof.

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

Comparison of housing pattern showed that all pig houses in the field were not provided with uncovered area, wallowing tank and manger and more than 80 per cent of them had thatched roof (Anil, 2005).

2.1.5 Breeding

Most of the sows maintained in small pig farms in Haryana, farrowed twice with average litter size ranged 6.5 to seven and in medium and in large farms it was two and 6.6 to 8.5 respectively (Rajiv and Pandey, 1998).

Duru *et al.* (1999) observed that 31.67 per cent of the pig farmers in Zaire, in Northern Nigeria did not keep boar/boars for breeding.

Tropical farmers preferred natural mating because of inaccessible artificial insemination facilities (Saadullah and Saad, 2000) Farmers usually selected breeding gilts from their own drove.

2.1.6 Health

Srinongkote *et al.* (1992) observed that the post weaning diarrhoea was the main problem for pig production in small farms in the tropical countries. Massango *et al.* (1997) reported that the survival rate of piglets was 33 per cent in smallholdings of Mozambique.

Only 48 per cent of producers reported parasitic problems in their pig farms in Saskatchevan, Canada and 62 per cent of farmers used a planned deworming treatment (Wagner and Polley, 1997).

Helminthiasis, skin diseases and tick infestation were the common disease problems noticed by the pig farmers in Northern Nigeria. Almost 91 per cent of the farmers dewormed their herd twice a year, while nine per cent dewormed thrice. Only 10 per cent used antiseptics, while remaining 90 per cent did not, because they could not afford costly antiseptics (Duru *et al.*, 1999).

Jain and Bajpai (2000) reported that incidence of diarrhoea was lowest 30 per cent on cement flooring and was highest in paddy straw flooring. Hoof abnormalities like cracks (60 per cent) and deformities (20 per cent) were noticed on cement flooring. The incidence of infestation of mange was 100 per cent on

cement concrete flooring followed by 40 per cent on paddy straw and paddy husk floor system.

Harikumar (2001) studied health problems of pigs of two adopted villages of Thrissur District in Kerala. He reported that health problems were only occasional and the predominant problem was digestive disorders followed by respiratory, skin and reproductive problems.

2.1.7 Marketing

Pathiraja *et al.* (1986) quoted the mean prices for live pigs were Rs.38.84±5.02, Rs.2048±99.5 and Rs.1351.35±40.48 for piglets, sows and boars respectively.

In Slovenia, there were good market demand for all the three categories *viz.*, weaners, fatteners and heavier fatteners for fattening, slaughter and sale for home consumption respectively (Salehar *et al.*, 1997).

Duru *et al.* (1999) reported booming market need for pigs and pig products in the villages of Northern Nigeria. Farmers sold pigs based on live weight to local butchers.

2.1.8 Constraints

Poor marketing conditions, housing, poor know-how on breeding and management and health services were the major problems associated with pig production in Enugu State of Nigeria (Agwu, 1999).

The major constraints in pig productions in peri-urban settings of Northern Nigeria were poor feeds, lack of capital and management skill, improper record keeping, lack of land and religious aversion to pigs (Duru *et al.*, 1999).

Saadullah and Saad (2000) reported that in urban piggery environmental constraints are the main problems in tropical countries.

In two adopted villages of Thrissur District in Kerala, the social problems and other constraints encountered by the pig farmers were found to be minimum. He also reported that the farmers followed scientific practices to certain extent and were interested in developmental activities of their piggery units (Harikumar, 2001).

2.2 PERFORMANCE OF PIGS ON UNCONVENTIONAL FEEDING

2.2.1 Body Weight Gain and Unconventional Feed

Food waste was also referred to as garbage, swill and or kitchen refuse (Kornegay *et al.,* 1965). Balazs *et al.* (1971) stated that the garbage was a very heterogeneous product. Food discarded from restaurants, hostels, supermarkets, institutions, military establishments, meat and fish markets and homes made up garbage.

In Kerala Agricultural University Pig Farm, Large White Yorkshire pigs with 30.9 kg body weight at 170 days gained 564 gm per day to reach 320.5 kg in 71 days period, when fed with the hostel food waste (Thomas and Xavier, 1980).

Price *et al.* (1985) stated that the food waste could be described as any edible waste from production, transportation, distribution and consumption.

Kirby (1981) reported that the average daily weight gain was 0.55 kg in Large White Yorkshire pigs fed with boiled liquid swill.

A study on growth performance of Large White Yorkshire pigs fed with different feeding regimes *viz.* concentrate, kitchen waste plus fish meal, kitchen waste plus lysine, kitchen waste plus fish meal plus lysine group respectively, was conducted at Bangalore by Gloridos and Das (1983). They observed a

growth rate of 211,299, 210 and 259 g respectively. They concluded that kitchen waste plus 50g fishmeal had higher growth rate.

Prabhakar (1984) recorded a live weight of 78.43±7.08 at the slaughter age in Large White Yorkshire pigs reared intensively in Andra Pradesh.

In indigenous pigs reared under three different feeding regimes of concentrate, garbage feeding and scavenging in Allahabad Agricultural Institute, it was observed that the daily weight gain was 110, 140 and 47g in the three groups respectively. It was concluded that the garbage fed pigs were superior in average daily weight gain than the other two groups (Srinivas and Sagar, 1991).

Average weight gain of 198.77 and 383.77g were obtained in Large White Yorkshire pigs feeding with garbage received from vegetarian and non-vegetarian hotels respectively, where as pigs fed with concentrate feed only, resulted in a gain of 126 g only (Sinha *et al.*, 1993).

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

The average daily growth rate of Large White Yorkshire pigs fed with garbage was 238 compared to an average daily gain of 277g in pigs fed with finisher mash (Sarma *et al.*, 1996).

Loc *et al.* (1996) reported that the mean daily gain in Large White Yorkshire x Hong Cai pigs under traditional feeding system, was lower (202 and 230 g) in two villages of Central Vietnam, but significantly increased to 363 and 366 g by giving protein supplement.

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

Hsieh *et al.* (1997) reported that in North Taiwan pigs were fed primarily on concentrates upto the body weight of about 28 kg, followed by combination of concentrate and kitchen waste upto about 40 kg and only kitchen waste after 41 kg of body weight to the market weight of about 135 kg.

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

Mishra *et al.* (1997) reported that in piglets raised upto 24 weeks of age after weaning showed the average daily gain of 169.87 ± 9.51 g in females and 149.11 ± 21.75 g in males under Scavenging system using local breeds.

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

Singh *et al.* (1997) observed that in Large White Yorkshire pigs had a slaughter weight of 114.31±1.01 kg.

Jha *et al.* (1999) observed that pigs reared on concentrates had a mean slaughter live weight value of 90.83 kg compared with pigs reared on hostel waste (86.7 kg)

More *et al.* (1999) recorded a growth rate of 5.7 and 5.5 kg for pigs reared in two areas of Philippines.

A study conducted the University of Florida, Gainesville by Myer *et al.* (1999) revealed that the average daily gain from concentrate feeding, dehydrated food waste in 40% and 80 % level were 0.91 0.91 and 0.90 kg respectively.

Protein from unsalted dried fish when replaced by silk worm pupae by 50 per cent and 100 per cent level, a cumulative average daily gain of 510.1 and

495.7g respectively, obtained in Large White Yorkshire pigs (Ramamurthi, 1999).

Hati *et al.* (2000) observed that when maize from conventional feed was replaced by marva 33.3 per cent, 66.6 and 100 per cent levels there was significant weight gain in last two groups from 16^{th} to 28^{th} weeks of age. However difference between maize feed and 33.3 per cent substituted by marva and between 66.6 and 100 per cent substitution were non significant at all ages. The values recorded with respect to back fat thickness, carcass length and loin eye area were non significant among groups.

Bhar *et al.* (2001) reared pigs on wheat bran based diets and deoiled rice bran diets. They found that on feeding DORB based diets all the responses were adversely affected and the animals could attain only 16.5 to 26.3 kg body weight by 112^{th} day of feeding in comparison to 35.24 to 37.15 kg in wheat bran based diets after 105 day of feeding.

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

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

In the comparative study between pigs in the organized farm and field units in two adopted villages of Thrissur district, the pigs reared in small field unit on 40 per cent chicken offal and 60 per cent restaurant waste recorded a significantly higher weight gain (Harikumar, 2001). In another study on the same area, the Large White Yorkshire pig in the field attained more weight (66.37 and

72.25 kg) at slaughter when they were fed with concentrate and swill feeding respectively (Anil, 2005)

2.2.2 Body Measurements

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

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

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

Sinha *et al.* (1993) in Bihar reported that in pigs raised on hotel waste, of vegetarian and non-vegetarian composition, the body length was 81.44±1.04 and 107.88±1.70 cm chest girth 77.22 ± 5.92 and 99.56 ± 1.14cm and height at withers 59.87 ± 3.38 and 74.44 ± 0.82 cm respectively, when compared to the concentrate feeding 71.90 ± 1.56, 61.20 ± 1.61, and 54.45 ± 1.04 cm respectively.

Sinthiya (1998) recorded length, girth and height in pigs, which ranged from 76.8 to 82.0, 86 to 88.5 and 54.3 to 57.3 cm respectively, for those maintained on rations containing varying proportions of carcass meal. Similar values were also reported by Subramanian (1998).

Bora *et al.* (2000) found that there was no significant difference in linear body measurements between boar and gilts fed with concentrate.

Among the three body measurements body length and chest girth were very important for predicting the body weight in pigs (Singh *et al.,* 2001)

Mili *et al.* (1999) reported that the body length differed significantly in Hampshire barrows of the same age group; they concluded that this was due to castration at different age groups where as heart girth and height at wither did not differ significantly.

Studies in Kerala Agricultural University revealed that the body weight was well correlated with body measurements. Significant difference in length was observed from fifth month onwards and the trend continued till slaughter. Harikumar (2001) and Anil (2005).

2.2.3 Garbage Feeding on Feed Efficiency

Gloridoss and Das (1983) observed that the dry matter consumed (kg) per kg of live weight gain was highest (3.38 kg) in kitchen waste plus lysine fed group of Large White Yorkshire pigs and showed that the diet was least efficient compared to 3.03 and 2.54 kg in concentrate and kitchen waste plus fish meal group respectively. This indicated that kitchen waste plus fish meal were better than the concentrate feeding.

Srinivas and Sagar (1991) studied the efficiency of food utilization in indigenous pigs at Allahabad Agricultural Institute and found that the efficiency was relatively high in concentrate fed group (3.8kg) than in garbage fed group (4.2kg). In contrast Ravi and Reddy (1997) reported that the *ad libitum* garbage feeding in crossbred pigs (Large White x desi) had lower feed conversion ratio (5.49:1).

Shoremi and Adana (2001) studied the utilization of wheat waste as substitute for maize grain at 25, 50, 75 and 100 per cent level. No significant

difference was observed in feed conversion ratio. The authors concluded that replacement of maize grain by wheat waste in the diet of weaner pigs was beneficial and cost effective at 50% level.

Harikumar (2001) reported that the feed conversion efficiency of pigs maintained in the field units of adopted villages in Thrissur district was better on 60 per cent chicken and 40 per cent hotel waste when compared with that of concentrate fed Large White pigs.

Anil (2005) observed that the feed conversion efficiency in concentrate fed was lower than that of garbage feeding (4.94 Vs 3.91) in the field units of Thrissur district.

2.2.4 Proximate Analysis

Michael *et al.* (1973) in Tamil Nadu estimated that the proximate composition of 76.29, 11.95, 1.52, 7.59, 6.95, 71.96 and 1.73 per cent for moisture, CP, CF, EE, total ash, NFE and insoluble ash in garbage and 20,50, 3.96, 5.04, 6.52, 54.09, 9.80 per cent in swine mash feed respectively.

Cunha (1977) reported that the garbage varies considerably in nutritional content depending on its source and usually contains moisture of 70-85% or more

Gloridoss and Das (1983) in Bangalore estimated the percentage of dry matter, CP, EE, CF, NFE, ash, acid insoluble ash, Ca, P, digestible energy (Kcal/g) were 92.85, 21.20, 3.88, 3.92, 63.73, 7.27, 1.38, 2.94, 0.08 per cent and 3229 kcal/g respectively in standard concentrate diet whereas it was 19.62, 18.01, 9.35, 3.62, 59.72, 9.28, 0.38, 2.13, 0.54 per cent and 3957 kcal/g in kitchen waste samples respectively.

Lyso and Homb (1986) reported that one kg dry matter from good waste had a calculated value of 1.30 to 1.36 Fu with digestible CP of 120-140g/Fu and 4200-4300 kcal's ME/kg dry matter.

Srinivas and Sagar (1991) in Allahabad reported that the proximate composition of concentrate (on per cent of DM basis) was 92.40, 16.90, 6.02, 3.86, 62.20, and 11.02 respectively for DM, CP, EE, CF, NFE, Ash and for garbage it was 24.60, 13.60, 11.90, 0.82, 70.43, 3.25 respectively.

Singh *et al.* (1994) in Assam reported that the proximate composition of processed garbage was 85 per cent moisture, 13.07 per cent CP, 2.13 per cent CF, 5.96 per cent ether extract and 6.98 per cent of total ash respectively. Corresponding values for the concentrate was 18.12 per cent, 5.21 per cent, 3.82 per cent and 8.62 per cent respectively.

Fanimo and Tewe (1996) suggested that chicken-offal with DM 88.2 per cent, CP 60 per cent, EE 8.46 per cent, CF 6.11 per cent, NFE 11.03 per cent and ME 2900 kcal per kg can be effectively utilized in the ration of weaner piglets.

Sarma *et al.* (1996) in Andhra Pradesh reported that garbage had 5.25crude protein while the finisher mash was having 11.70 per cent crude protein on fresh matter basis.

Myer *et al.* (1996) suggested that dehydration of food residuals has the potential to produce a nutritious feedstuff for swine while offering a viable solid waste disposal option. The average composition of dehydrated food residues was 11.4 per cent moisture, 15 per cent protein, 13.8 per cent crude fat, 10.4 per cent crude fibre and 5.8 per cent ash.

Rivas *et al.* (1996) assessed dehydrated edible restaurant waste (DERW) as a feedstuff for swine by determining the nutrient composition and digestibility. The chemical composition of DERW was 92.1, 22.4, 23.2, 2.3 and 5.4 per cent for dry matter, crude protein, crude fat, crude fiber and ash respectively.

Ravi and Reddy (1997) analysed the proximate composition of the garbage kitchen waste in Andhra Pradesh and found 78.92, 9.68, 3.13, 6.96, 76.36 and 3.87 per cent respectively for moisture, CP, CF, EE, NFE and total ash.

Ravi *et al.* (1999) in Andhra Pradesh stated that proximate composition of grower ration was 18.69, 6.67, 5.32, 9.54, 59.88 and 3.78 per cent CP, CF, EE, Total ash, NFE and Acid insoluble ash of respectively.

Harikumar (2001) in Kerala, reported that the proximate analysis of chicken offal was recorded a crude protein content of 35.63 per cent and ether extract of 30.9 per cent. Concentrate, restaurant waste and hostel waste were recorded a higher NFE content

Chinnamani (2003) reported that the pigs fed with swill feed had the chemical composition of feedstuff was evaluated in terms of per cent DM, CP, CF, EE, NFE, Total ash and moisture. The values were 20.34,14.06,3.33,16.17,61.32,5.10 and 77.65 respectively.

Ranjan *et al.* (2003) studied Tamsworth and Desi bred of pigs with different feeding practices of hotel waste and rice fermented wastes. The CP and EE of hotel waste was 26.23 and 6.12 and that of rice fermented waste 18.76 and 6.12 respectively.

Proximate analysis of different feedstuffs in the field units of Thrissur district in Kerala revealed high moisture content for vegetable waste followed by hotel waste and chicken offal. Chicken offals had the highest CP followed by vegetable waste and hotel waste. The ether extract value was highest for chicken offal (40.2) followed by hotel and vegetable waste at 21.2 and 22.32 per cent respectively (Anil, 2005).

2.2.5 Carcass Characteristics

Carcass weight of Large White Yorkshire and indigenous pigs fed with hotel waste food was studied by Prabhakar (1984) in Andhra Pradesh and he found that the carcass weight was higher in Large White Yorkshire pigs (57.57) than in indigenous pig (54.63 kg) and recorded a dressing percentage of 70.39,

loin eye area 16.56 cm^2 and back fat thickness 3.10 cm. in indigenous pigs reared traditionally on food wastes and scavenging.

Srinivas and Sagar (1991) observed higher carcass weight of 14.20 kg in garbage fed group, 12.07 kg in concentrate fed group and 6.89 kg in scavenging group respectively. And observed back fat thickness of garbage fed pig was 130 followed by 70 in concentrate fed pigs and 10 mm in scavenging pigs. The muscle fat was higher in garbage feeding than concentrate feeding, which in turn was higher than those in scavenging.

The higher dressing percentage of 75.12 per cent was obtained in Large White Yorkshire pigs fed with non vegetarian hotel waste followed by 70.35 and 68.15 with vegetarian hostel waste and concentrate feeding group (Sinha *et al.*, 1993). A higher back fat thickness of 2.20 cm with vegetarian garbage feeding and 2.00 and 1.30 cm in non-vegetarian and concentrate feed groups in Large White Yorkshire pigs respectively were reported. The carcass length in Large White Yorkshire pigs maintained on vegetarian and non-vegetarian hotel waste as 67.15, 72.55 cm respectively compared to 59.00 cm in concentrate fed groups.

Sarma *et al.* (1996) in Andhra Pradesh observed that the back fat thickness of Large White Yorkshire pigs fed with garbage feeding as 1.80±0.24 cm and finisher fed pig as 1.83± 0.38 cm respectively.

Bhadoria (1996) reported a slaughter weight of 41-50, 51-60, 61-70, 71-80, 81-90 kg and corresponding carcass weight of 28.76±0.21, 38.01±0.33, 49.26±0.86, 55.40±0.71, 66.05±0.67 kg, Dressing percentage of 61.58%, 64.77%, 68.14%, 71.90%, 73.38% and back fat thickness was1.23±0.06 cm, 1.60±0.06 cm, 2.28±0.08 cm, 2.48±0.07 cm, and2.78±0.08cm respectively

Sarma, *et al.* (1996) studied carcass characteristics of Large White Yorkshire pigs reared on garbage in Andhra Pradesh. The characters studied included dressing percentage, proportion of ham, undercut and bacon over

dressed weight and the estimates were found to be 71.44 to 73.05, 17.53 to 18.81, 0.82 to 0.94 and 10.12 to 12.03 per cent respectively.

Jha *et al.* (1999) in Bihar observed that the back fat thickness was significantly higher in concentrate fed group (29.55 ± 1.033 mm) than hotel waste plus concentrate fed group (24.12± 0.74 mm) and kitchen waste plus grazing group (19.28 ±0.68mm). A longer carcass length in concentrate fed group as 87.16± 1.05cm followed by hotel waste plus concentrate fed group 80.21±1.10cm and the carcass length in kitchen waste plus grazing group was 63.06±1.11cm. The highest loin eye area was in concentrate fed group (27.55±0.99 cm^2) followed by hotel waste plus concentrate fed (23.29±0.91 cm^2) and kitchen waste plus grazing (15.31±0.49 cm^2) groups.

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

Hati *et al.* (2000) observed that when maize from conventional feed was replaced by marva 33.3, 66.6 and 100 per cent. The values recorded with respect to back fat thickness, carcass length and loin eye area were non significant among groups.

Harikumar (2001) reported that pigs maintained in the field units of Thrissur district fed on 40 per cent chicken offal and 60 per cent restaurant waste were recorded a maximum value for dressing percentage (75.52±0.41). Pigs fed on concentrate ration attained a maximum of 19.36±2.2cm2 for loin eye area and a minimum of 28.0±0.22mm for back fat thickness. Meat bone ratio was the lowest in pigs fed on hostel food waste (3.53±0.19). Hot carcass weight (55.66±2.49kg) and carcass length (65.00±0.83cm) was more in pigs fed on 40 per cent chicken offal and 60 per cent restaurant waste.

Carcass characteristics did not vary significantly among the animal fed on concentrate and swill feeding animals with respect to the carcass length, loin eye area, hot deboned meat and meat bone ratio. Swill fed animals had a significantly higher back fat thickness than the concentrate fed animals in Kerala Agricultural University study (Anil, 2005).

2.2.6 Integrated Pig Farming with Crop/Vegetable-Fish-Poultry

The Food and Agricultural Organisation have stressed long back the necessity for the adoption of integrated farming in Asian regions. Integration of livestock and fish raising with crop production should be revitalized and reoriented to meet the changing needs of small farmers in Asia. Integrated farming is based on the concept that "there is no waste", and "waste is only a misplaced resource which can become a valuable material for another product" (FAO, 1977).

It is estimated that in a pig- fish integrated farming system the manure from 15-25 pigs will supply sufficient feed material for one-hectare fish pond (FAO 1978).

From a three-tier rearing system in the Central Plain of Thailand (Delmendo, 1980) consisting pigs, fish and chicken; the total production of a 1.5 rai (2400 m^2) pond area is 4 t of *Pangasius pangasius* (equivalent to 16.67 t of fish/ha/year), 8 t of pigs (42 pigs/2400 m^2 of pond, equivalent to 33.3 t of pigs/ha/year) and 15,330 chicken eggs from 60-hens/2400 m^2 (equivalent to 63,875 eggs per ha/year) were recorded.

Trenching of paddy field and raising of Indian major carps has been successful with two crops of paddy from the same field by irrigating the field with water from the trench (Natarajan and Ghosh, 1980).

Usefulness of livestock wastes such as cowdung, poultry and pig excreta, goat and sheep pellets, in fish culture to enhance the production of fish food

organisms, as well as, in cutting down the expenditure on costly feeds and fertilizers have been well documented (Kapur, 1981, 1984; Kapur and Lal, 1986).

Polyculture of Indian and common carps (at a stocking density of 6,340 fingerlings/ha) raised with ducks (100/ha) have yielded 4,323 kg of fish/ha/year, 250 kg of ducks (live weight) and 1,835 eggs (Jhingran and Sharma, 1980). The rationale behind integrated farming is to minimize wastes from the various subsystems on the farm. Wastes or by-products from each subsystem are used as inputs to other subsystems to improve the productivity and lower the cost of production of the outputs of the various subsystems (Edwards, 1980).

The manure produced by 20–30 pig in a year produce the same fertilization effect as one tonne of ammonium sulphate applied to the soil. Collective as well as individual pig rearing is promoted where the pigs are largely fed on kitchen wastes, aquatic plants and crop wastes (Delmendo, 1983).

The highest productions obtained so far in integrated fish farming are with pigs, ducks and chicken, a very widespread technique in Asia (Edwards, 1983, Edwards *et al.* 1986). The main fish species stocked in animal-fish pond systems, either in mono or polyculture are the common carp, the Chinese and Indian carps and *Oreochromis niloticus*. A number of other species such as *Pangasius sp., Clarias gariepinus* Burchell, hybrid of Tilapia, and grey mullet are raised as polyculture.

Castillo (1985) reported that a five ha semi-commercial demonstration unit at NDRI. Combining cropping of maize with cowpeas, berseem with mustard and Lucerne with oats with milking 30 Karan Swiss crossbred cows has been very successful.

The cost of feed production and processing has become prohibitive in most Third World countries because of the high prices of fuel, feed and fertilizer, usually imported from the developed countries. Chan (1985) proposed integrated

farming system as a means of reducing the cost of fuel, seed and fertilizer with the minimum capital investment.

More intensive efforts are needed by the dairy and dairy beef industries to close the increasing gap between animal protein demand and supply in the developing world. Guzman (1986) suggested implementation of integrated farming systems incorporating dairy and dairy beef production to overcome their problem in Asian and Pacific region.

Yadava (1987) observed that 100 ducks per hectare of water body would be needed to excrete duck droppings (6000 Kg/ha/yr), to meet the 'safe' level dose of the duck wastes for one year.

Monoculture of *Clarias gariepinus* with pigs yielded 7,510 kg (7.51 t) of fish per ha/year in Central Africa. The grow out period was 90 days and the daily growth rate of *C. gariepinus* was 2.9 g/day (Vincke, 1988).

Sharma *et al.* (1988) suggested production of fodder under mixed farming system on smallholdings to reduce the effect of livestock pressure on land.

Steinfeld (1988) found out that the prevailing farming system of Zimbabwe is based on smallholder mixed farming systems using animal draught power and minimum of purchased inputs.

Singh and Gangwar (1989) suggested a number of integrated farming systems suitable for the socio-agro climatic conditions of the Andaman and Nicobar Islands, seven were plantation crops based, four were fruit crop based, one was forest based and one crop based.

Best result of pig- fish integration was obtained with 60 pigs and 20,000 fish/ha to produce 1.9 mt fish/ha/90 days and 60 piglets with a total live weight gain of 2.2mt/90 days. Three cycles of 90 days, produced 3.9 mt of fish, 6.7 mt live weight gain of fish was recorded (Cruz and Shahadesh, 1990).

Manure from goat and sheep is also potential for integrated animal-fish farming system but this is not yet used in widespread integration with fish culture. Libunao (1990) reported that the fish feed produced in the ponds with goat manure is efficiently utilized by the fish biomass. He also mentioned that the growth of Tilapia, increased with the rate of goat manure loading. The highest total fish yield of 1170 kg/ha was obtained for a combination fo 20,000 Nile tilapia and 300 goats per ha.

Deoghare *et al.* (1990) studied the crop-dairy, crop-poultry and crop-dairy-poultry integrated farming systems in Karnal, Haryana and found that crop dairy-poultry combination was the most successful and economically viable under conditions of limited land resources.

Lee and Zhen (1990) reported that in pig- fish integrated system, fish yield of 6.5-14.5 mt/ha/year were recorded.

The average egg production of Khaki Campbell duck was 240 eggs/ducks/year .After several trials it has been found that the average fish yield of 5.68 tons/ha/year from duck-fish experiment. This yield was 5–7 times higher than the normal fish production (Nuruzzaman, 1991).

The ducks are mainly dependent on organisms of water origin like snails, oysters, algae, small fishes etc. and homestead waste to meet their daily feed requirement (Huque, 1991).

According to Mann (1991) the integration of crops and livestock in a changing economic environment requires an understanding of the inter relationships in the system and how they can be best utilized.

A model 0.20 ha irrigated coconut based mixed farming system was developed by Salam (1992). The model was self-consumptive, self –sustaining

and recycling agro-ecosystem that was agronomically productive, economically efficient, technically viable and environmentally safe.

In Tamil Nadu, Jayaraman *et al.* (1993) found an increase of 25% of fish production by integrating poultry production with aquaculture.

Sinha *et al.* (1993) reported that excreta from 50-70 pigs with or without fermentation can supply adequate fertilizer and feed for fish in one hectare pond. Around 4-cows/40 sheeps/250 ducks or 500 poultry or 40 pigs can sustain fish production levels to the extent of 3-6 t/ha/year (Tripathi, 1993).

Devasenapthy *et al.* (1995) observed that adoption of an integrated farming system combining groundnut-blackgram-maize or groundnut-gingelly-ragi with livestock enterprises (poultry, fish, dairy or rabbit production) results in higher net return than the conventional groundnut cotton or sorghum-cotton cropping systems and provides additional employment opportunities.

When low protein basal diets such as sugar cane and sugar palm products and by-products are fed to monogastric animals, the total protein needed is reduced considerably. This is because the ratio of essential amino acids is close to the optimum when the animal is supplemented with tree foliage and water plants such as Nacedero (*Trichantera gigantea*), duckweed (*Lemna ssp.*), water spinach (*Ipomea aquatica*) and azolla (*Azolla anabaena*). All these sources of protein are available in the ponds or around the households, which are fertilized with the effluent from the plastic biodigester (Preston, 1995).

According to Pillay (1995) the basic principles involved in integrated farming are the utilization of the synergetic effects of inter-related farm activities, and the conservation, including the full utilization of farm wastes. The major benefit of pig- fish integrated farming is easy access to manure which fertilizers the pond and produces plankton and other microorganisms to feed the fish.

Omar (1996) suggested that dried poultry manure can be included at 10 per cent level in fish diets without any diverse effects on survival rate and growth performance of Nile Tilapia and common carp.

Atkinson and Watson (1996) identified the principal livestock production factors influencing environmental impact as the balance between different farm animal type and the husbandry practices used for these species- the extent to which animal production can be integrated into more holistic farming system.

The feasibility of different diversified farming system were studied by the Reddy and Maraty (1996) and found that the combination of paddy with sheep and goat as the most profitable farming system to small farmers and paddy with poultry to medium and large farmers of Andhra Pradesh.

Devendra (1997) has pointed out the advantages of integrated farming systems as diverse and efficient resource use, reduced risk, better use of farm labour, improved use of space, increased and economic output and development of stable farm household.

In a fish-vegetable integrated system the component ratios of fish and vegetable production can be manipulated to favour fish or vegetable in a recirculating water system in areas of limited water supply and high demand for quality food (Murty *et al.,* 1997).

Vaccaro (1997) suggested that a holistic, integrated concept of production is the most important single factor of harnessing resources and catalyzing change.

The overall biomass conversion efficiencies of *Catla catla, Labeo rohita, Cyprimus carpio and Cirrhinus mrigala* were statistically similar under different fish pond fertilization-broiler manure, buffaloe manure and N:P:K (25:25:0). But the efficiency was better under feed supplementation (Mahaboob and Sheri, 1998).

The crop - animal production systems for different countries were recommended by Devendra (2000)

Indonesia: Rice-fish-duck-goats

Philippines: Rice-buffaloes-pigs-chicken-ducks-fruit trees-fish

South China: Rice-maize-pigs-vegetables-sweet potato-dairy cattle

Thailand: Rice-fish-pigs-ducks-vegetables

Vietnam: Pigs-ducks-vegetables-fruit trees-fish-goats.

Suraj (2000) studied that the integrated farming system centered on pigs suitable for a small-scale farmer with different components of pigs, fish and vegetable crops in Kerala.

Singh *et al.* (2000) reported that fish production has increased to 2727kg/ha with wash water of the farms. The study revealed that fish-cum-pig farming increased the fish production and provided an additional income and employment through pig rearing.

Santhakumar (2000) examined the importance of the integrated farming in India such as fish-cattle-fodder, fish-pig and fish-poultry. By adopting simple technology involving minimum of capital outlay, an efficient integration of fish-pig can be achieved.

Antony (2002) who reported that natural productivity of the pond was increased by application of organic waste from animal sheds. Similarly Sinha and Ramachandran (2002) observed that the excellent growth rate in a pond receiving animal shed waste. Air breathing fishes like Murrel (*Channa spp*) and Magur (*Clarias spp*) were well suited variety for integrated system.

Sharma *et al.* (2004) experimented that integrated system of duck-cum-fish farming at Ranchi, Bihar, it was observed that overall performance of fishes were higher under integrated farming system than intensive farming system.

Sherief (2005) stated that the integration of livestock into a farming system ensues a regular supply of organic matter, which facilitates effective recycling of biomass which in turn enhances soil fertility and yield and is therefore considered a vital component for organic farming.

2.2.7 Economics

Grewal and Sandhu (1977) compared the economic viability of crop and farming, mixed farming and specialized livestock farming. The comparative analysis indicated a steep rise in the net profit of the entrepreneur moved from crop farming to specialized farming through mixed farming.

Rai and Singh (1982) observed that by integrating the livestock enterprise with crop farming and by adoption of the new dry land agricultural production techniques increased the farm income in Haryana.

According to Srivastava (1988) farmers who keep a dairy or poultry enterprise on a predominantly cropping farm, are better able to stand adverse economic conditions than are those who specialize purely in crop production irrespective of holding size.

Govindan *et al.* (1990) reported that the poultry cum fish in rice farming, was found to be more profitable than the existing farming practices in the Cauvery delta of Tamilnadu .

The role of duck-cum-fish culture as a component of a rice farming system was examined by Ganesan *et al.* (1991) and found that the system was economically viable for a small farmer. The introduction of duck fish culture as a component of the mixed farming system increased income per day from Rs.37.78 for arable farming to Rs.66.67 for mixed farming.

Kadian *et al.* (1992) compared the profitability of arable farming with mixed farming involving crossbred cows or with buffaloes. Arable farming included cereals, legumes and cotton, while both mixed farming systems and fodder based cropping system were used in 50-70% of the 1 ha area. Net returns were highest from mixed farming with buffaloes followed by mixed farming with cows and least from arable farming.

Thien *et al.* (1996) reported that integration of rice-fish-pigs- vegetable-ducks system yielded three times the benefits from the non-integrated system in Vietnam.

Economics worked out for an integrated farming system involving coconut, banana, fodder and livestock under the bund and channel systems of Kuttanad Kerala by Oomen *et al.* (1996) showed that compared to the monoculture of coconut on bunds there is an increase of 157 per cent in net profit in a period of three years.

Rangasamy *et al.* (1996) reported that a net profit of Rs.11755 was obtained from rice-poultry-fish-mushroom integrated farming system in 0.40 ha area compared to conventional cropping system with rice-rice-green manure/pulses giving a net profit of Rs.6334 per year from the same area.

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

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

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

Nagaraja *et al.* (1997) reported that increase in the income by 124 per cent for the crop with poultry system in marginal farms, 53 per cent for crop with sericulture system in small farms and 85 per cent for crop, dairy with sericulture system in medium farms in rural district of Karnataka.

Zheng *et al.* (1997) studied the economic benefits of a rice-fish-duck system in China and reported that rice yield increased by over 10% with an additional increase of 1036.5kg/ha of fish and 238.9-489.3 kg/ha of adult duck by using this co-growth ecosystem. The output and economic benefits were largely increased and it was considered to be a well-recycled and highly effective agro-ecosystem.

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

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

Hati *et al.* (2000) used Marua (*Eleusine coracana*) at different levels to substitute maize as a source of energy from conventional feeds to bring down cost of production. The cost per kg of weight gain when standard diet (18.19%

protein with 60% maize) was given was Rs.15.05. In the other groups when maize was replaced with marua at 33.3, 66.6 and 100% w/w the cost per kg of weight gain was Rs.13.57, 11.19 and 9.79 respectively.

Rearing pigs entirely on concentrate feed was uneconomical, but the integration of fish and vegetable to the production could improve the productivity of such systems with the improvement in overall economic efficiency. Integration of piggery with agriculture and fish is the most economical integrated pig farming system in Kerala (Suraj *et al.*, 2000)

Yadav *et al.* (2001) reported cost per kg gain in rupees as 34.55, 34.99, 36.39 and 40.06 with conventional concentrate mixture (control), conventional concentrate mixture supplemented with GNC and soya flakes, GNC alone and soya flakes alone respectively.

Harikumar (2001) studied that higher level of productivity and feasibility of pig production under swill fed regime. The performance of pigs reared in small field unit on 40 per cent chicken offal and 60 per cent restaurant waste was found better than concentrate and hotel waste alone in field units of Thrissur district.

Behera *et al.* (2004) observed better standard of living in marginal farmers having one acre of land with mushroom-poultry-duckry and honey integrated systems in Eastern India.

Sharma *et al.* (2004) reported increased duck and fish production and decreased input cost on fish culture operation by integrating fish culture with duck rising in Bihar.

Anil (2005) reported that the average cost of production of one kg fattener pig was Rs.64.56 and Rs.66.16 for Crossbred and Large White Yorkshire in the orgainsed farm and Rs.21.92 and Rs.23.45 for Crossbred and Large White Yorkshire maintained on swill feeding in the field.

Materials and Methods

3. MATERIALS AND METHODS

3.1 LOCATION

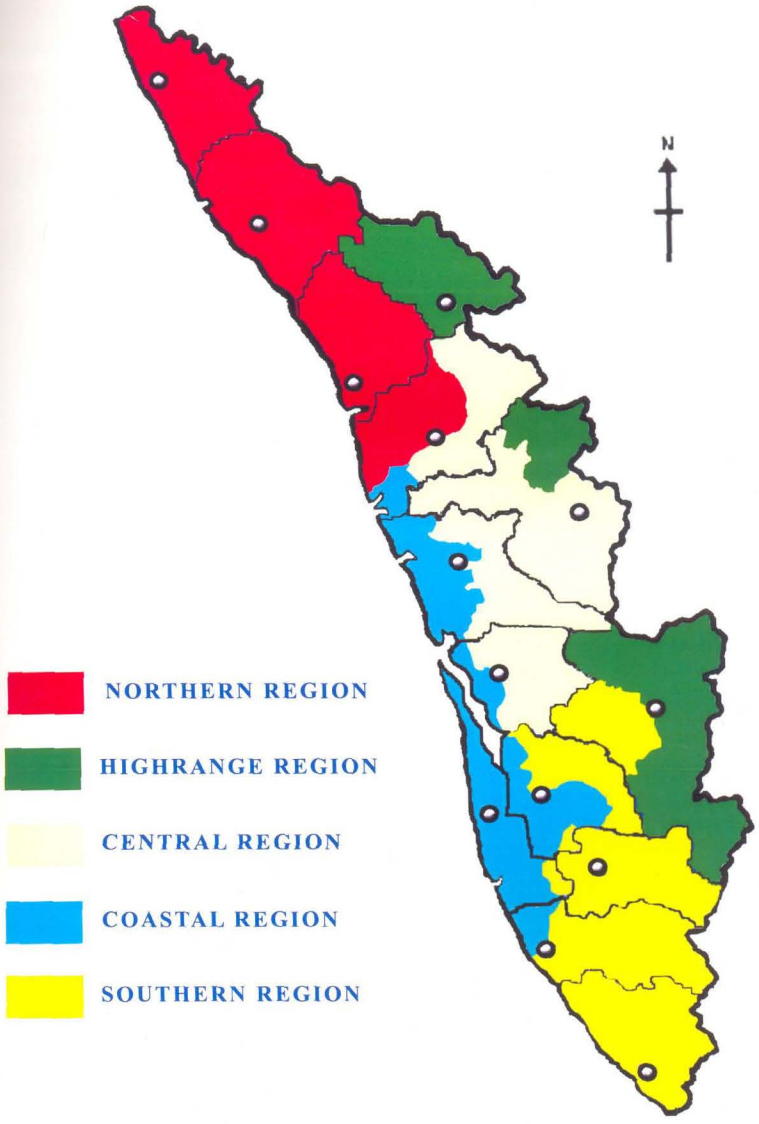
National Agricultural Technology Project (NATP) has adopted *Kaiparambu* and *Kuzhoor* panchayats in Thrissur district of Kerala for this research on pig farming systems and these two panchayats were selected for the present study. The *Kaiparambu* panchayat is eight kilometres away from Thrissur town towards north and *Kuzhoor* panchayat is located about 45 kilometres southwest to Thrissur town. Geographically Thrissur is located at Longitude 76.16°E, Latitude 10.32°N, Altitude 22.25 meter above Mean Sea Level (MSL). The study was for a period of one year from May 2002 to April 2003.

3.2 PIG FARMING SYSTEM UNDER DIFFERENT AGRO CLIMATIC ZONES OF KERALA

An insight into pig farming systems in Kerala, employing field survey in five different agro climatic zones (NARP, 1989) was obtained. Stratified random sampling was employed to select 200 samples from different zones. A well-designed questionnaire (Annexure I) and personal interview supplemented the survey. Socio-economic and educational levels of pig farmers and management practices including feeding, housing, breeding and marketing were analysed. The problems and constraints in pig production were also evaluated.

Fig.1. Agro - climatic zones of Kerala

(NARP - ICAR, 1989)



3.3 EVALUATION OF INTEGRATED PIG FARMING SYSTEM

3.3.1 Pig

Twelve progressive farmers each from *Kaiparambu* and *Kuzhoor* Panchayat were supplied with eight Large White Yorkshire grower pigs which were reared under different combinations as follows:

T1 - Pig farming alone as control group.

T2 - Pig rearing and Crop/vegetables cultivation.

T3 - Broiler chicken, Pig and Fish farming along with crop/vegetables cultivation.

All the animals in the group were raised on swill and other waste generated from other components.

3.3.2 Monthly Body Weights

Body weights were measured using a portable balance in metric units

3.3.4 Linear Body Measurements

Linear body measurements like body length, chest girth and height at wither were measured in cm by using a standard measuring tape at the time of weighment.

3.3.4.1 Body Length

Body length was measured from top of the head in between the ears to the base of the tail.

3.3.4.2 Chest Girth

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

3.3.4.3 Height at Wither

Height of the animal was measured in centimetres at the top of the wither to the ground level of hoof.

3.3.5 Average Daily Weight Gain of Pigs

An average daily weight gain of pigs, was calculated by the following formula (Brody, 1945).

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

W_1 – Initial body weight T_1 – Initial time unit

W_2 – Final body weight T_2 – Final time unit

3.3.6 Average Daily Feed Intake

Average daily feed intake was calculated on both fresh weight and dry matter basis. The difference between the total quantity of feed given and the amount of feed left after 24 hours was taken to calculate the average daily feed intake.

3.3.7 Feed Conversion Efficiency of Pigs

Feed conversion efficiency of pigs groups were worked out on dry matter basis of feed (Banerjee, 1998).

$$\text{Feed efficiency} = \frac{\text{Feed consumed}}{\text{Body weight gain}}$$

3.3.8 Proximate Analysis of Feed Sample

Representative pooled samples from all types of feed *viz.* hotel waste, chicken offals and vegetable waste were analysed for proximate principles (A.O.A.C. 1990).

3.3.9 Carcass Characteristics of Pigs

For the evaluation of carcass traits two animals from each treatment group were randomly selected at the age of eight months and slaughtered as per the procedure put forth by Singh *et al.* (1983); at Meat Technology Unit, College of Veterinary and Animal Sciences, Mannuthy. Pigs were given sufficient rest prior to slaughter.

3.3.9.1 Slaughter Weight

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

3.3.9.2 Dressing Percentage

Dressing percentage was calculated using the formula

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

3.3.9.3 Carcass Length

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

3.3.9.4 Loin Eye Area

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

3.3.9.5 Back Fat Thickness

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

3.3.9.6 Meat Bone Ratio

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

3.3.9.7 Weight of Offals

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

3.3.10 Crop

Banana (*Nendhran*) was selected as the crop and 50 rootstocks were given for five cents of land. The cultivation and management practices of the crop were done as per Package of Practices recommendation (2002) by KAU without any supplementation of chemical fertilizer.

3.3.11 Vegetables

Amaranthus (Arun), Brinjal (Haritha), Bindi – Okra (Kiran), Chilli (Ujwala) were selected as the vegetables. The cultivation and management practices of the vegetables were done as per package of practices recommendation (2002) by KAU without any supplementation of chemical fertilizer.

3.3.12 Fish

Indian catfish (*Clarias batrachus*), and Assam Vazha (*Pangasius pangasius*) were chosen to be distributed. Seventy five fingerlings of each species were supplied to every farmer and they were put at stocking density of $5/m^3$. The fish in the tank were reared using the manure, washings from the pig's unit and residues from other units.

3.3.13 Broiler Chicken

A total of 500 Vencob broiler chicken per batch were raised for this study. The parameters like yield, biomass and survival rate of different combinations were taken for analysis.

3.3.14 Economics

The economics of pig production under different integrated farming systems were calculated. The total income obtained in different models was worked out. The economic feasibility was also analysed using double log regression method considering the total input and revenue obtained in each integrated pig farming models.

3.3.15 Statistical Analysis

The data was analysed statistically as per the methods outlined by Snedecor and Cochran (1994).

Results

4. RESULTS

4.1 EXISTING PIG FARMING SYSTEMS IN KERALA

4.1.1 Socio Economic Status of Pig Farmers in Different Zones

The socio economic status of pig farmers in different agroclimatic zones of Kerala considering factors *viz*., age, religion, average monthly income (Rs) and land holding (cents) expressed in percentage; are presented in Table 4.1.1. In Kerala the farmers belonging to the age group of 31 to 50 years readily took up pig farming. Among, religious sects, Christians were engaged in pig farming followed by Hindus while none of the Muslims took up pig farming. The farmers with average monthly income between Rs.4001 to 6000 were more involved in pig farming, and the percentage ranged from 37 in South zone to 53 in North zone. With respect to land holding, farmers having land area of above 100 cents were relatively more involved with pig farming. In this group of farmers, the percentage was highest (55%) in Highrange zone and lowest (26%) in North zone.

4.1.2 Type of Agriculture and Animal Husbandry Activities

Type of agriculture and animal husbandry activities of the pig farmers are presented in Table 4.1.2. Farmers engaged in pig farming were largely involved in coconut, banana, vegetables and arecanut cultivation. Majority of farmers maintained cattle besides pig rearing except in coastal region where fish farming was the main subsidiary animal husbandry activity.

4.1.3 Rationale Behind Rearing of Pigs

Rationale of rearing of pigs are shown in Table 4.1.3. It was mainly a source of additional income, and the percentage of farmers taking up pig farming as additional income ranged from 45 in South zone to 56 in North zone, followed

by as self-employment with a range of 29 to 39. As a main source of income, the range was from five to nine and as waste utilization the range was between six and nine among different zones. Among all the experienced groups, the percentage of farmers having an experience of nine to 12 years was more in all the zones with a minimum of 47 per cent in High range zone to a maximum of 62 per cent in North zone.

4.1.4 Details of Type, Source and Strength of Herd

Details of type, source and strength of herd are summarized in Table 4.1.4. Exotic crosses were chiefly preferred to the Desi crosses. Drove was obtained equally from both the government and private farms. A high percentage (44 to 59 %) of pig farmers maintained herd strength of more than 50 animals followed by 10 to 50 animals (20 to 41 %).

4.1.5 Needs and Type of Farming

Farmers maintained the stock for both fattening and breeding and none were involved in breeding alone. A batch system of rearing was favoured over the all-in-all-out system for fattening of the stock. The details of needs and type of farming are given in Table 4.1.5.

4.1.6 Litter Traits

Most farms surveyed had nine to 12 litter size at birth and seven to nine litter size at weaning. Table 4.1.6 details the litter traits.

4.1.7 Feeding Strategies

Swill feeding was found to be the major feeding system (74 to 85 %). followed by a combination with concentrate feed ingredients (15 to 26 %) and none of the units practiced concentrate feeding alone. The particulars of feeding strategies are given in Table 4.1.7. In frequency of feeding the stock, twice a day feeding was found to be common. With regard to the commuting distance for

carrying feed materials, it was found that the distance ranged between six and ten km from the farm premises and three wheelers were the mode of transportation. However in coastal regions, two wheelers were found to be the chief mode of feed transportation.

4.2 HOUSING OF PIGS

Housing pattern adopted by pig farmers are given in Table 4.2. Animals were kept under permanent type of houses; (72 to 79 %) on concrete floor (53 to 68 %) and thatch roof (72 to 81 %).

4.3 DISPOSAL OF ANIMALS

Preferential disposal of the stock was followed based on live weight (47 to 65 %) Carcass weight was the second preferential mode of disposal (9 to 40%). The particulars of disposal of animals are given in Table 4.3.

4.4 TYPES OF LABOUR

Types of labour utilized are presented in Table 4.4. The family labour ranged between 53 and 73 % and hiring of labours was not a preferred method in any of the system.

4.5 HEALTH MANAGEMENT PRACTICES

The health management practices of pig farmers in different agroclimatic zones are presented in Table 4.5. It is noticed that digestive disorder is the major problem in pigs and piglet mortality is mainly due to 'Mastitis, Metritis and Agalactia' (MMA), Scour Crushing and Deficiency. 60 to 80 % of the farmers were seeking veterinary help for treatment of these animals.

4.6 TRAINING REQUIREMENTS

The training requirements of pig farmers are presented in Table 4.6. Prime concern was on breeding management rather than on health, feeding and meat processing.

4.7 CONSTRAINTS

The constraints in pig production systems are presented in Table 4.7. The prime constraint in pig rearing was financial problem (56 to 68 %), followed by availability of stock (18 to 29 %) and social risk factor (14 to 17 %).

4.8 SCIENTIFIC MANAGEMENT PRACTICES

The scientific management practices adopted are presented in Table 4.8. The farmers have adopted scientific management practices in all agroclimatic zones but the awareness is lacking in vaccination (5.3 to 24 %) and control of ectoparasites (11.8 to 32 %). Interestingly majority of the farmers have adopted integrated farming in all the agroclimatic zones. Integrated farming (69.6 to 89.5%), biogas production (71.1 to 85.3 %), expansion of farm (56.3 to 76.5 %) and management through cooperative societies assistance (41.2 to 76 %) were the managemental concern of the surveyed groups.

4.9 EVALUATION OF INTEGRATED PIG FARMING

4.9.1 Mean Body Weight of Large White Yorkshire Pigs

The mean body weights (kg) of Large White Yorkshire pigs under integrated farming system are presented in Table 4.9.1 and its graphical representation is given in Fig. 5. It is observed that there is no significant difference between treatments from three months to eight months of rearing. Hence it is concluded that integration of pigs with vegetable/crops and pigs with vegetable/crops, fish and broiler chicken are equally effective in promoting the growth of pigs compared to pigs without integration.

4.9.2 Average Monthly Gain of Large White Yorkshire Pigs

The average monthly weight gains (kg) of Large White Yorkshire pigs are shown in Table 4.9.2 and its graphical representation is given in Fig. 6. There were no significant differences in average monthly gain between treatments in two study areas.

4.9.3 Average Daily Weight Gain of Large White Yorkshire Pigs

The average daily weight gain (gm) of Large White Yorkshire pigs are shown in Table 4.9.3. The average daily gain of pigs alone did not differ significantly over integration with vegetable/crops and vegetable/crops, fish and broiler chicken. However, at eight months of age, the average daily weight gain in pig with fish, broiler chicken and vegetable/crops integration was numerically higher than integration of pigs with vegetable/crops and pigs without integration.

4.9.4 Average Daily Feed Intake of Large White Yorkshire Pigs

The average daily feed intake (kg) of Large White Yorkshire pigs is presented in Table 4.9.4. Integration had no significant effect on daily feed intake of pigs compare to pigs without integration.

4.9.5 Feed Conversion Efficiency

The feed conversion efficiency on dry matter basis under different treatment between two Panchayath is presented in Table 4.9.5 and its graphical representation is given in Fig. 7. It is seen that they were not statistically significant and inferred that integration had no significant effect on feed conversion efficiency compared to pigs without integration.

4.10 LINEAR BODY MEASUREMENTS

The linear body measurements *viz.*, body length, chest girth and height (cm) were recorded at monthly intervals from three to eight months of rearing,

are presented in Table 4.10.1, 4.10.2 and 4.10.3 respectively. Integration had no significant effect on linear body measurements of pigs in different treatments.

4.11 PROXIMATE COMPOSITION OF FEED SAMPLES

The proximate composition of feed samples (DM basis) are presented in Table 4.11 and its graphical representation is given in Fig. 8. The samples consisted of chicken offal, hotel waste and vegetable waste. Chicken waste had higher crude protein (25.26 $\pm$ 2.84) than hotel waste (9.60 $\pm$ 0.91) and vegetable waste (9.76 $\pm$ 1.02). The pooled sample had a crude protein value of 14.80 $\pm$ 1.42 per cent.

4.12 CARCASS TRAITS

4.12.1 Carcass Characteristics of Pigs

Carcass characteristics *viz.*, slaughter weight (kg), carcass length (cm), back fat thickness (mm), loin eye area (cm^2), hot carcass weight (kg), dressing percentage, deboned meat (percentage), meat bone ratio were received from different treatments groups and are presented in Table 4.12.1. It was observed that there was no significant difference between treatments in the carcass traits studied.

4.12.2 Weight of Offals

The weight of offals (% body wt) under different treatments are shown in Table 4.12.2. The weight of offals *viz.*, kidney, spleen, lungs, stomach and intestine and liver and bone did not differ significantly between treatments.

4.13 AVERAGE YIELD OF CROP/ VEGETABLES

The average yield of crop/ vegetables ($kg/10m^2$) in different treatment are presented in Table 4.13. The average yield of crop and vegetables *viz.*, Amaranthus, Brinjal, Bindi and Chilli were not statistically significant.

4.14 BIOMASS PRODUCTION OF CROP/ VEGETABLES

The biomass production of crop/ vegetables (kg/10m^2) recorded under integrated farming are presented in Table 4.14. The biomass production of Banana, Amaranthus, Brinjal, Bindi and Chilli on wet and dry basis were analysed statistically and found that there is no difference between treatments.

4.15 FISH PRODUCTION

4.15.1 Yield of Fish

The yield of fish (kg/30m^3) under integrated farming is presented in Table 4.15.1. It showed that there was no significant difference in total yield and average yield of fish between treatments. However, within treatment the total and average yields differed statistically.

4.15.2 Mean Body Weight of Fish at 12 Weeks Interval

The mean body weights (kg) of fish at 12 weeks interval are presented in Table 4.15.2. There was no significant difference between treatments for both the varieties of fish. However, the body weight of both the varieties were significantly different within different age groups.

4.16 MEAN BODY WEIGHT OF BROILER CHICKEN

The mean body weights (kg) of broiler chicken maintained under integrated farming are presented in Table 4.16. The total yields of broiler (kg) per batch were 826.5 $\pm$ 13.42 and 794.64 $\pm$ 16.26, average body weight were 1.74 $\pm$ 0.09 and 1.68 $\pm$ 0.06 and livability (%) were 95 and 94.6 in *Kaiparambu* and *Kuzhoor* panchayat respectively but they were not differing significantly in yield, per batch and their average body weight.

4.17 ECONOMICS OF INTEGRATED PIG FARMING

4.17.1. Average Total Income from Different Integrated Units

The average total income (Rs) from different integrated units are shown in Table 4.17.1 It was observed that integration of pigs with two crops of eight numbers, banana in five cents, vegetables in five cents, fish reared in 30 m^3 and broiler in three batches of 500 numbers had total income of Rs. 10527 $\pm$440.81, 6188 $\pm$ 227.49, 1772 $\pm$ 61.77, 6582 $\pm$ 89.64 and 8241 $\pm$ 396.69 respectively.

4.17.2 Economics of Production from Different Models of Integrated Pig Farming

The economics of production from different models of integrated pig farming are presented in 4.17.2 and their analysis of variance are presented in Table 4.17.3. The graphical representation for the same is presented in Fig. 16. The data shows that there is a significantly higher total income between different integrated systems compared to pigs without integration. The total income for pigs without integration; pigs with banana crop; pigs with vegetables; pigs with banana, fish and chicken and pigs with vegetables, fish and broiler chicken are Rs. 10527.38 $\pm$ 440.81, 16715.88 $\pm$ 432.46, 12306.38 $\pm$ 432.34, 31476.87 $\pm$ 751.60 and 27129.88 $\pm$ 640.99 respectively.

4.17.3 Economic Feasibility for Different Models of Integrated Pig Farming Systems

The economic feasibility for different models of integrated pig farming systems using double log regression equation is shown in Table 4.17.4. It was observed that combination of pig with banana crop had relatively higher return than pig without integration; pig with vegetable; pig with banana crop, fish and broiler chicken and pig with vegetables, fish and broiler chicken.

Table 4.1.1 Socio economic status of pig farmers in different agroclimatic zones of Kerala

Age	Years	South	Central	North	Highrange	Coastal
	< 30	20	14	12	16	6
	31-50	39	56	62	58	78
	>50	41	30	26	26	16
Religion						
	Christian	67	72	82	71	78
	Hindu	33	28	18	29	22
	Muslim	0	0	0	0	0
Average monthly income (Rs)						
	<2000	20	18	9	24	22
	2001-4000	35	32	29	26	25
	4001-6000	37	42	53	40	44
	>6000	8	8	9	10	9
Land holding (Cents)						
	<20	12	12	18	10	19
	21-50	11	18	26	11	28
	51-100	28	26	30	24	16
	>100	49	44	26	55	37

values in percentage

Table 4.1.2 Type of agriculture and animal husbandry activities

Type of Agriculture	South	Central	North	Highrange	Coastal
Coconut	80.4	76	85.3	73.68	81.3
Banana	82.6	88	76.5	34.21	87.5
Vegetables	60.9	68	73.5	84.21	75.0
Arecanut	45.7	58	52.9	57.89	37.5
Rubber	26.1	32	23.5	18.42	0.0
Rice	8.7	22	17.6	7.89	56.3
Cashew	15.2	6	35.3	15.79	0.0
Type of Animals					
Cattle	73.9	76	52.9	34.21	34.4
Buffalo	6.5	12	5.88	10.53	15.6
Goat	4.35	8	17.6	21.05	28.1
Poultry	19.6	24	11.8	23.68	6.25
Fish	19.6	28	14.7	10.53	43.8

multiple response not to total; values in percentage

Table 4.1.3 Rationale for pig farming

Reason for Pig farming	South	Central	North	Highrange	Coastal
Main source of income	9	8	6	5	6
For extra income	45	50	56	48	54
To utilize waste	7	6	9	8	9
For employment	39	36	29	39	31
Rearing experience Years					
<4	11	12	12	5	9
4-8	21	22	26	24	25
9-12	48	48	62	47	50
>12	20	18	0	24	16

values in percentage

Table 4.1.4 Details of type, source and strength of herd

Pig type	South	Central	North	Highrange	Coastal
Exotic cross	83	80	84	79	75
Desi cross	0	0	0	0	0
Both	17	20	16	21	25
Herd strength (no)					
<10	15	18	21	11	18
10-50	41	38	20	42	35
>50	44	44	59	47	47
Animal source					
Government	17	16	18	5	16
Private	24	26	32	26	28
Both	59	58	50	69	56

values in percentage

Table 4.1.5 Need and type of farming

Purpose of rearing	South	Central	North	Highrange	Coastal
Breeding only	0	0	0	0	0
Fattening	37	38	47	37	44
Both	63	62	53	63	56
Fattener system					
All in - all out	37	40	53	34	41
Batch system	63	60	47	66	59

values in percentage

Table 4.1.6 Litter traits

Litter size at birth (no)	South	Central	North	Highrange	Coastal
<8	14	13	6	17	5
9-12	62	58	55	54	56
>12	24	29	39	29	39
Litter size at weaning (no)					
<6	31	35	50	37.5	38
7-9	48	46	44	37.5	46
>9	21	19	6	25	16

values in percentage

Table 4.1.7 Feeding strategies

Type of feeding	South	Central	North	Highrange	Coastal
Concentrate alone	0	0	0	0	0
Swill alone	78	80	85	74	84
Both	22	20	15	26	16
Feeding frequency per day					
Once	0	0	0	0	0
Twice	74	76	85	68	78
As available	26	24	15	32	22
Distance to the feed source (km).					
<5	15	18	21	11	22
6-10	50	50	67	50	50
>10	35	32	12	39	28
Mode of feed transport					
Two wheeler	22	18	29	18	72
Three wheeler	54	50	71	53	28
Four wheeler	24	32	0	29	0

values in percentage

Fig. 2. Homestead Pig Farming

Fig. 3. Transportation of Swill Feed

Table 4.2 Housing of pigs

Type of Housing	South	Central	North	Highrange	Coastal
Permanent	76	74	70	79	72
Temporary	24	26	30	21	28
Type of floor					
Concrete	67	62	53	68	56
Stone pavement	25	26	32	24	32
Mud	8	12	15	8	12
Type of roofing					
Covered	61	56	50	60	50
Semi covered	30	32	35	37	34
Uncovered	9	12	15	3	16
Roofing material					
Thatched	73	76	79	72	81
Tiled	5	5	5	0	6
Asbestos	3	3	0	4	0
Tin sheet	19	16	16	24	13

values in percentage

Table 4.3 Disposal of animals

Type	South	Central	North	Highrange	Coastal
As animal (number)	8	12	17	5	15
On live weight	52	52	65	47	53
On carcass weight	33	30	9	40	22
As meat	7	6	9	8	10

values in percentage

Table 4.4 Type of labour

Type	South	Central	North	Highrange	Coastal
Family labourr	73	68	53	73	56
Hired	0	0	0	0	0
Both	27	32	47	27	44

values in percentage

Table 4.5 Health management practices

Occurrence of disease type	South	Central	North	Highrange	Coastal
Digestive disorder	80.4	76	61.8	63.2	65.6
Skin problem	39.1	32	23.5	15.2	15.9
Respiratory disease	19.6	12	17.6	17.4	13.6
Deficiency	10.9	14	11.8	6.5	9.1
Sudden death	8.7	16	8.8	8.7	13.6
Piglet mortality					
MMA	82.8	83.9	83.3	79.1	88.9
Scour	75.9	77.4	77.8	70.8	83.3
Crushing	65.5	64.5	66.7	58.3	66.7
Deficiency	41.4	54.8	50.0	37.5	50.0
Attendance of treatment by whom					
Veterinary surgeon	74	76	82	74	84
Livestock inspector	17	16	12	18	9
Experienced farmer	9	8	6	8	7

multiple response not to total; values in percentage

Table 4.6 Training requirements

Type	South	Central	North	Highrange	Coastal
Breeding	61	60	56	58	53
Feeding	9	8	9	8	6
Health	23	24	26	24	21
Meat processing	7	8	9	10	10

values in percentage

Table 4.7 Constraints

Constraints	South	Central	North	Highrange	Coastal
Financial	61	60	56	68	56
Social	17	16	15	14	16
Availability of stock	22	24	29	18	28

values in percentage

Table 4.8 Scientific management practices adapted and intended

Adaptation of scientific practices	South	Central	North	Highrange	Coastal
Deworming	69.6	74	64.7	63.3	56.3
Vaccination	17.4	24	11.8	5.3	6.3
Iron injection	63.0	62	52.9	63.1	50.0
Sanitation	53.2	56	76.5	31.6	53.1
Spraying ectoparasiticide	13.0	32	11.8	18.4	15.6
Waste disposal	26.1	54	79.4	68.4	43.8
Integration	69.6	84	79.4	89.5	81.3
Castration	52.2	76	47.1	44.7	43.8
Interest in activities					
Integrated farming	80.4	84	82.4	84.2	87.5
Co-operative society	56.5	76	41.2	44.7	50.0
Meat plant	13.0	24	52.9	57.9	12.5
Biogas	76.1	80	85.3	71.1	81.3
Farrowing house	69.6	74	61.8	78.9	68.8
Expansion	60.9	58	76.5	76.3	56.3

multiple response not to total; values in percentage

Fig.4. Integrated Pig Farming

Fig. 9. Pig - Vegetable Integration

Table 4.9.1 Mean body weights of Large White Yorkshire pigs (kg)

Age (Months)	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
3	17.21 ± 1.25	18.25 ± 1.20	17.53 ± 1.05	16.95 ± 0.82	17.37 ± 1.19	17.60 ± 0.91
4	26.95 ± 1.85	29.15 ± 1.15	27.25 ± 1.25	28.10 ± 1.19	26.15 ± 0.92	27.75 ± 1.28
5	38.72 ± 1.45	40.59 ± 0.58	36.39 ± 0.87	39.27 ± 1.27	37.10 ± 1.27	38.16 ±1.73
6	51.96 ± 1.75	53.15 ± 1.26	50.26 ± 1.90	52.06 ± 1.51	51.37 ± 1.30	50.98 ± 1.09
7	63.16 ± 1.71	64.83 ± 1.75	62.60 ± 1.27	61.66 ± 1.30	62.12 ± 1.36	61.50 ± 1.26
8	73.25 ± 1.46	73.83 ± 1.90	72.83 ± 1.21	70.85 ± 1.13	72.37 ± 1.64	72.70 ± 1.92

The mean of different treatment groups at different ages do not differ significantly

Table 4.9.2 Average monthly gain (kg) of Large White Yorkshire pigs

Age (Months)	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
4	9.67 ± 0.06	10.88 ± 0.24	9.64± 0.62	11.03 ± 0.82	8.75 ± 0.43	10.09 ± 0.92
5	11.65 ± 1.48	11.37 ± 1.61	9.16 ±10.39	11.74 ± 0.91	10.88 ± 0.84	10.38 ± 0.89
6	13.17 ± 0.89	12.24 ± 0.62	14.14 ± 1.13	12.63 ± 0.94	13.97 ± 1.12	12.74 ± 1.73
7	11.18 ± 1.15	11.29 ± 0.86	12.26 ± 1.32	9.63 ± 1.27	10.98 ± 1.22	10.65 ± 1.82
8	9.95± 0.83	9.66 ± 0.33	10.48± 0.71	9.15± 0.45	9.52± 0.20	10.87 ± 0.24

The mean of different treatment groups at different ages do not differ significantly

Fig. 5 Mean Body Weights of LWY Pigs

Fig. 6 Average Monthly Gain of LWY Pigs

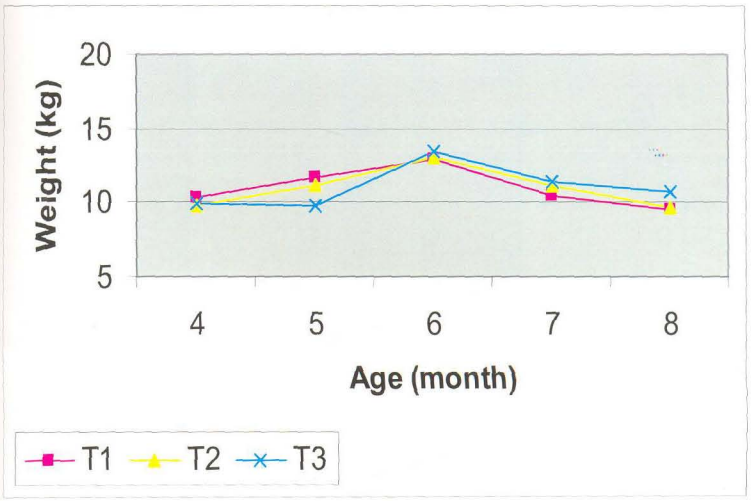


Table 4.9.3 Average daily gain (gm) of Large White Yorkshire pigs

Age (Months)	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
4	319± 32.2	357± 28.22	320± 17.6	365± 24.3	288± 12.8	334± 13.2
5	387± 28.22	375±18.64	300± 18.2	366± 24.7	358± 11.2	341± 28.4
6	433± 24.68	413± 30.2	454.± 22.4	419± 20.2	468± 19.1	420± 32.6
7	366± 29.94	372± 26.1	394± 16.8	316± 18.3	360± 26.4	346± 34.2
8	329± 36.1	319± 18.9	341± 17.3	301± 24.2	310± 17.5	367± 20.2

The mean of different treatment groups at different ages do not differ significantly

Table 4.9.4 Average daily feed intake of Large White Yorkshire pigs (kg)

Age (Months)	*Kaiparambu* Panchayath						*Kuzhoor* Panchayath					
	T_1		T_2		T_3		T_1		T_2		T_3	
	FW	DM	FW	DM	FW	DM	FW	DM	FW	DM	FW	DM
3	1.20± 0.13	0.36± 0.03	1.18± 0.72	0.32± 0.06	1.00± 0.33	0.31± 0.07	1.15± 0.42	0.37± 0.04	1.30± 0.21	0.36± 0.04	1.20± 0.33	0.38± 0.08
4	3.22± 0.92	0.87± 0.06	3.50± 0.22	0.78± 0.04	3.30± 0.84	0.82± 0.18	3.15± 0.62	0.97± 0.22	3.30± 0.62	1.00± 0.32	3.25± 0.38	0.90± 0.18
5	4.15± 0.74	1.12± 0.26	4.27± 0.31	1.14± 0.08	4.50± 1.02	1.54± 0.39	4.24± 0.88	1.26± 0.51	4.28± 0.17	1.11± 0.53	4.15± 0.96	1.16± 0.28
6	6.50± 0.62	1.68± 0.13	6.20± 0.42	1.73± 0.16	6.41± 0.31	1.82± 0.63	6.25± 0.22	1.61± 0.31	6.55± 0.93	1.64± 0.81	6.35± 0.62	1.73± 0.24
7	7.00± 0.63	1.83± 0.37	6.80± 0.33	1.79± 0.19	6.55± 0.17	1.96± 0.46	6.14± 0.26	1.85± 0.42	6.85± 0.13	1.94± 0.76	7.15± 0.13	1.82± 0.31
8	8.10± 0.36	2.04± 0.26	7.80± 0.88	2.11± 0.28	7.91± 0.28	2.16± 0.82	8.10± 0.60	2.10± 0.71	8.05± 0.28	2.13± 0.37	7.85± 0.42	2.16± 0.33

The mean of different treatment groups at different ages do not differ significantly

Table 4.9.5 Feed conversion efficiency on dry matter basis

Age (Months)	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
4	2.70±0.21	2.18±0.13	2.55±0.20	2.65±0.18	3.45±0.21	2.72±0.14
5	2.88±0.14	3.02±0.22	5.13±.0.41	3.42±0.34	3.06±0.37	3.48±0.24
6	3.86±0.42	4.21±0.42	4.08±0.64	3.83±0.37	3.51±0.63	4.12±0.51
7	4.96±.0.45	4.78±0.61	5.14±0.44	5.85±0.66	5.47±0.48	5.27±0.62
8	6.20±0.51	6.57±0.51	6.22±0.51	6.81±0.61	6.81±0.50	5.92±0.80
Overall	4.11±0.62	4.24±0.56	4.53±0.62	4.44±0.54	4.51±0.57	4.25±0.52

The mean of different treatment groups at different ages do not differ significantly

Fig. 7 Feed Conversion Efficiency of LWY Pigs

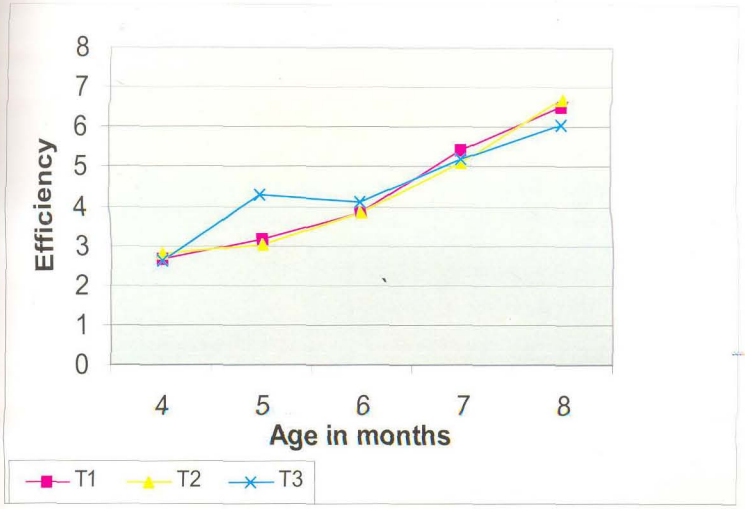


Fig. 8 Proximate Composition of Feed Sample
(DM basis)

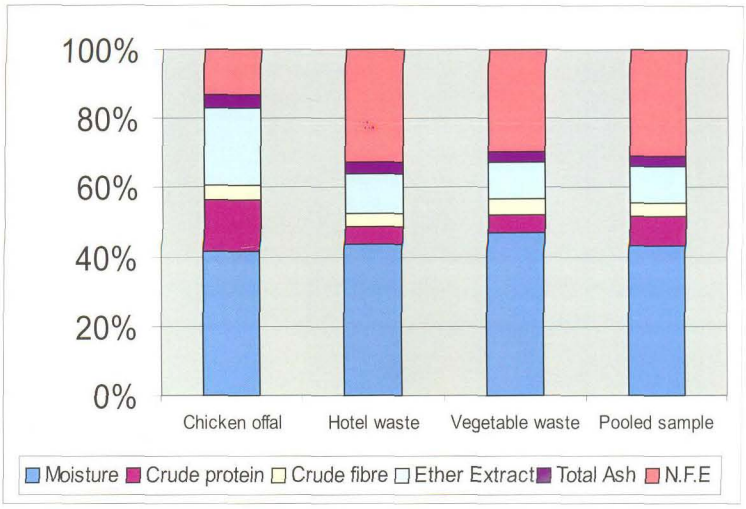


Table 4.10.1 Mean body length of Large White Yorkshire pigs (cm)

Age (Months)	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
3	41.15 ± 1.15	39.81 ± 1.62	40.28 ± 1.24	39.23 ± 0.82	41.53 ± 1.31	40.58 ± 0.91
4	52.16 ± 1.48	51.58 ± 1.71	51.93 ± 1.82	52.77 ±1.40	51.68 ± 1.48	51.32 ± 1.81
5	58.68 ± 1.34	56.74 ± 1.08	57.23 ± 1.73	56.91 ± 1.64	55.62 ± 1.52	56.82 ± 1.64
6	65.50 ± 1.33	66.13 ± 1.30	65.14 ± 1.68	64.89 ± 1.79	65.81 ± 1.81	65.44 ± 1.85
7	70.48 ± 1.71	71.00 ± 1.84	71.08 ± 1.46	69.73 ± 1.66	70.32 ± 1.22	70.17 ± 1.54
8	75.15 ± 1.62	74.67 ± 1.29	76.13 ± 1.33	75.21 ± 1.42	75.43 ± 1.73	74.63 ± 1.49

The mean of different treatment groups at different ages do not differ significantly

Table 4.10.2 Mean body girth of Large White Yorkshire pigs (cm)

Age (Months)	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
3	55.55 ± 1.28	54.48 ± 1.22	55.23 ± 1.45	54.63 ± 1.61	54.82 ± 1.16	54.75 ± 1.01
4	64.83 ± 1.64	65.13 ± 1.76	65.65 ± 1.72	64.65 ± 1.90	64.76 ± 1.48	65.25 ± 1.26
5	74.16 ± 1.91	73.85 ± 1.48	73.96 ± 1.68	74.56 ± 1.81	74.68 ± 1.77	73.83 ± 1.71
6	81.31 ± 2.07	81.62 ± 2.06	80.84 ± 2.32	81.16 ± 1.62	81.55 ± 1.68	81.00 ± 2.00
7	87.56 ± 2.41	88.15 ± 1.94	88.27 ± 2.27	87.76 ± 1.84	87.78 ± 2.13	88.33 ± 1.83
8	93.12 ± 1.88	92.98 ± 2.01	92.77 ± 2.11	92.63 ± 2.21	92.68 ± 2.04	93.35 ± 1.91

The mean of different treatment groups at different ages do not differ significantly

Table 4.10.3 Mean body height of Large White Yorkshire pigs (cm)

Age (Months)	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
3	37.68 ± 0.91	36.92 ± 1.22	37.15 ± 1.45	36.54 ± 0.82	37.33 ± 1.69	37.75 ± 1.62
4	45.13 ± 1.24	44.85 ± 1.77	44.93 ± 1.16	44.73 ± 1.11	45.50 ± 0.94	45.10 ± 1.61
5	51.08 ± 1.62	50.93 ± 1.75	51.15 ± 1.78	50.85 ± 1.27	50.10 ± 1.38	51.82 ± 1.77
6	55.16 ± 1.37	54.85 ± 1.67	55.65 ± 1.89	54.91 ± 1.72	55.23 ± 1.70	55.73 ± 1.84
7	57.22 ± 1.51	56.65 ± 2.21	56.92 ± 1.64	56.83 ± 2.13	56.85 ± 1.96	56.91 ± 2.26
8	58.77 ± 2.04	57.83 ± 2.10	58.17 ± 1.91	57.55 ± 1.83	57.81 ± 2.16	58.74 ± 1.94

The mean of different treatment groups at different ages do not differ significantly

Table 4.11 Proximate composition of feed samples (on DM basis)

Proximate Principle	Chicken offal	Hotel waste	Vegetable waste	Pooled sample
Moisture	71.4±1.33	76.8±1.57	88.2±0.88	76.82±1.62
Crude protein	25.26±2.84	9.6±0.91	9.76±1.02	14.8±1.42
Crude fibre	7.02±0.86	6.4±0.76	9.13±0.62	6.33±0.64
Ether Extract	38.7±2.21	20.21±1.38	19.5±1.57	18.65±1.18
Total Ash	6.30±0.41	6.4±0.22	5.9±0.52	5.8±0.16
N.F.E	22.7±1.77	57.41±1.61	55.75±1.24	54.51±1.62
Acid insoluble ash	2.1±0.28	0.43±0.13	0.91±0.09	1.04±006

Table 4.12.1 Carcass characteristics of Large White Yorkshire pigs

Characters	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
Slaughter weight (kg.)	72.43 ± 2.78	72.51 ± 2.81	71.65 ± 2.33	69.85 ± 2.18	70.64 ± 1.76	71.79 ± 1.61
Carcass length (cm.)	63.54 ± 1.24	65.42 ± 1.07	64.37±1.82	62.84 ± 1.76	65.48 ± 0.98	63.55 ± 1.44
Back Fat Thickness (mm.)	36.81 ± 0.42	33.42 ± 0.73	35.71 ± 1.06	32.46 ± 0.84	34.82 ± 1.34	36.44 ± 1.22
Loin Eye Area (cm^2)	15.82 ± 0.84	17.21 ± 0.67	16.84 ± 0.71	17.67 ± 0.81	16.72 ± 0.62	16.88 ± 0.73
Hot Carcass Weight (kg.)	52.17 ± 1.22	49.54 ± 1.44	54.08 ± 1.02	48.46 ± 0.98	52.85 ± 1.73	51.64 ± 1.51
Dressing Percentage	73.52 ± 2.11	75.16 ± 2.06	74.62 ± 1.88	73.46 ± 1.67	74.28 ± 2.24	72.88 ± 1.63
Deboned Meat (%)	61.85 ± 1.23	59.37 ± 1.18	63.78 ± 1.64	62.45 ± 0.93	63.14 ± 1.07	61.84 ± 1.41
Meat Bone Ratio	4.28 ± 0.76	4.41 ± 0.64	4.31 ± 0.44	4.04 ± 0.62	4.18 ± 0.38	4.27 ± 0.61

The mean of different treatment groups for carcass traits do not differ significantly

Table 4.12.2 Weight of Offals (%Body Wt)

Organs	*Kaiparambu* Panchayath			*Kuzhoor* Panchayath		
	T_1	T_2	T_3	T_1	T_2	T_3
Kidney	0.27±0.15	0.29±0.19	0.31±0.0.01	0.22± 0.01	0.24± 0.02	0.26± 0.12
Spleen	0.22±0.04	0.16±0.07	0.26± 0.01	0.24± 0.11	0.21± 0.18	0.22± 0.03
Lungs	1.23±0.02	1.28±0.03	1.18± 0.0.2	1.21± 0.16	1.22± 0.12	1.18± 0.22
Stomach & Intestine	13.7±0.45	13.2±0.52	128± 0.81	11.89± 0.54	13.13± 1.02	12.87± 0.82
Liver	1.61±0.07	1.58±0.04	1.61± 0.07	1.48± 0.2	1.51± 0.16	1.52± 0.18
Bone	9.1±0.17	8.8±0.02	9.21± 0.03	8.76± 0.18	9.1± 0.2	8.78± 0.21

Table 4.13 Average yield of crop / vegetables (kg/ 10 m^2)

Crop	*Kaiparambu* Panchayath		*Kuzhoor* Panchayath	
	T_2	T_3	T_2	T_3
Banana	24.50 ± 1.82	25.24 ± 2.34	25.36 ± 1.87	23.58 ± 2.33
Amaranthus	18.73 ± 1.58	21.53 ± 1.34	20.48 ± 1.72	19.68 ± 1.64
Brinjal	24.61 ± 1.67	23.83 ± 2.08	22.79 ± 1.82	25.13 ± 1.51
Bindi	09.82 ± 0.86	10.24 ± 0.71	09.76 ± 0.74	10.08 ± 0.62
Chilli	11.64 ± 0.63	12.37 ± 0.57	10.84 ± 0.74	12.17 ± 0.83

The mean of different treatment groups do not differ significantly

Fig. 10. Pig - Vegetable Integration

Fig. 11. Pig - Banana Integration

Table 4.14 Biomass production of crop / vegetables (kg/10 m^2)

Crop	*Kaiparambu* Panchayath				*Kuzhoor* Panchayath			
	T_2		T_3		T_2		T_3	
	Wet basis	Dry basis	Wet basis	Dry basis	Wet basis	Dry basis	Wet basis	Dry basis
Banana	134.82±13.25	16.73±1.22	136.52±12.42	17.21±1.43	133.52±13.46	16.64±1.23	135.21±14.2	16.82±1.48
Amaranthus	07.42±0.13	0.94±0.01	6.80±0.14	1.02±0.01	7.22±0.21	0.97±0.06	6.75±0.03	0.92±0.07
Brinjal	18.72±1.02	3.08±0.05	19.42±1.33	3.24±0.02	18.62±0.96	3.22±0.04	20.04±1.20	3.31±0.02
Bindi	18.46±1.13	3.36±0.08	19.22±1.41	3.41±0.06	17.66±1.02	3.27±0.02	19.14±1.16	3.38±0.04
Chilli	12.64v0.89	2.26±0.06	13.47±1.21	2.18±0.04	13.82±1.11	2.31±0.03	14.04±1.08	2.36±0.01

The mean of different treatment groups do not differ significantly

Fig. 12. Pig - Vegetable - Broiler - Fish Integration

Fig. 13. Pig - Banana - Broiler - Fish Integration

Table 4.15.1 Yield of fish (Kg/30 m^3)

Panchayath	Fish type	Total yield	Average yield	Survival rate (%)
Kaiparambu	Indian cat fish *Clarias batrachus*	132.26 ± 3.62^a	1.87 ± 0.37^a	92
	Assam vazha *Pangasius pangasius*	87.64 ± 2.13^b	1.34 ± 0.08^b	88
Kuzhoor	Indian cat fish *Clarias batrachus*	130.74 ± 2.77^a	1.92 ± 0.06^a	93
	Assam vazha *Pangasius pangasius*	90.25 ± 1.84^b	1.28 ± 0.08^b	87

Figures having different superscript within column are significantly different ($P<0.05$)

Table 4.15.2 Mean body weights (kg) of fish at 12 weeks interval

Panchayat	Fish type	Body Weight		
		12^{th} week	24^{th} week	36^{th} week
Kaiparambu	Indian cat fish *Clarias batrachus*	0.294 ± 0.08^a	0.765 ± 0.06^a	1.342 ± 0.08^a
	Assam vazha *Pangasius pangasius*	0.185 ± 0.03^b	0.484 ± 0.07^b	0.827 ± 0.06^b
Kuzhoor	Indian cat fish *Clarias batrachus*	0.302 ± 0.06^a	0.727 ± 0.05^a	1.478 ± 0.09^a
	Assam vazha *Pangasius pangasius*	0.200 ± 0.04^b	0.520 ± 0.06^b	0.931 ± 0.06^b

Figures having different superscript within column are significantly different ($P<0.05$)

Table 4.16 Mean body weight of broilers (kg)

Panchayath	Total yield/ batch	Average body weight	Livability (%)
Kaiparambu	852 ± 13.42	1.74 ± 0.09	95.0
Kuzhoor	844 ± 16.26	1.68 ± 0.06	94.6

Fig. 14. Pig - Banana - Broiler - Fish Integration

Fig. 15. Pig - Banana - Broiler - Fish Integration

Table 4.17.1 Average total income from different integrated units

Component	Unit size	Total income (Rs)
Pig	Two crops of 8 nos.	10527±440.81
Crop (Banana)	5 cent	6188±227.49
Vegetable	5 cent	1772±61.77
Fish	30 m^3	6582±89.64
Broiler	3 batches of 500 nos.	8241±396.69

Table 4.17.2 Economics of production from different models of integrated pig farming

Model	Total income (Rs)
Pig alone	10527.38±440.81 [e]
Pig + Banana	16715.88±432.46 [c]
Pig + Vegetable	12306.38±432.34 [d]
Pig + Banana + Fish + Chicken	31476.87±751.60 [a]
Pig + Vegetable + Fish + Chicken	27129.88±640.99 [b]

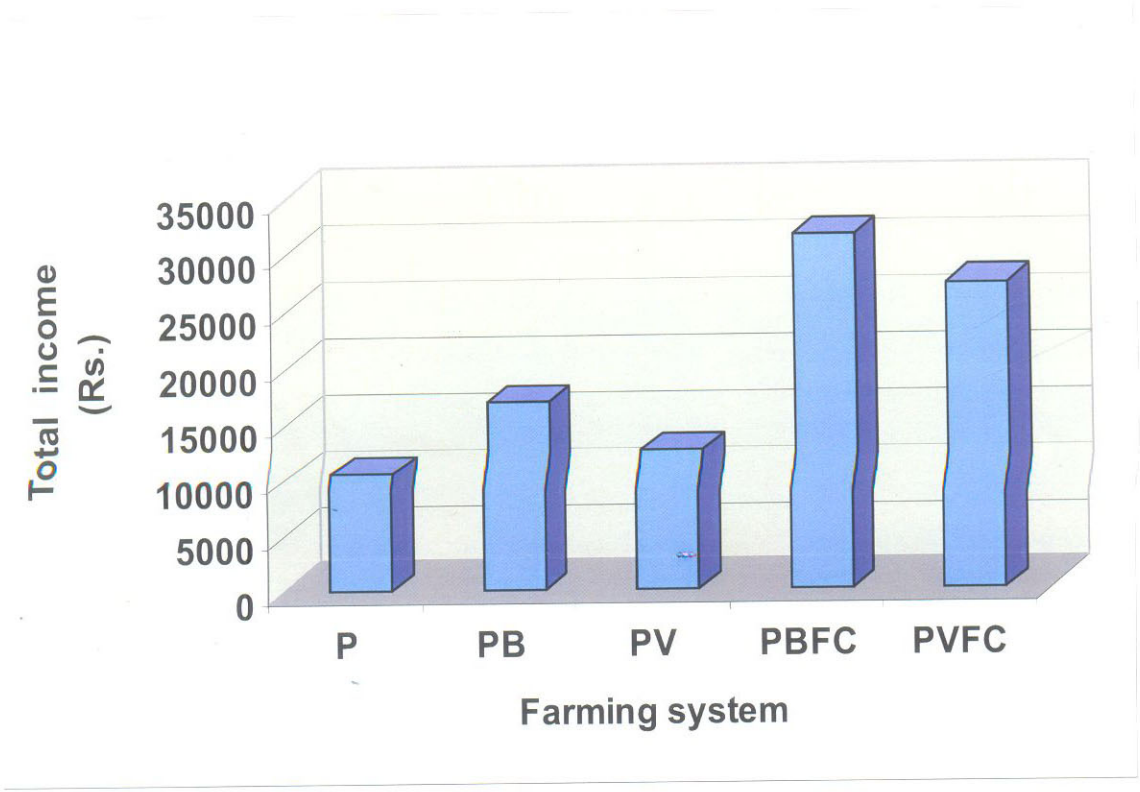
Figures having different superscript in upper case in a row are significantly different ($P<0.05$)

Table 4.17.3 ANOVA for total income grouped over different combination

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	4	2732655629.60	683163907.40	286.28*
Within	35	83521206.38	2386320.18	

* Significant at 5% level ($P < 0.05$)

Fig. 16 Economics of Integrated Pig Farming



P- Pig, B- Banana, V- Vegetable, F- Fish & C- Chicken

Table 4.17.4 Economic feasibility for different models of integrated pig farming

Model	Double log Regression Equation	R^2
Pig alone	$\ln \Pi = 2617 + 0.01 \ln(R)$	0.564
Pig + Banana	$\ln \Pi = 8617 + 0.24 \ln(R)$	0.831
Pig + Vegetable	$\ln \Pi = 2317 + 0.13 \ln(R)$	0.423
Pig + Banana + Fish + Chicken	$\ln \Pi = 1813 + 0.006 \ln(R)$	0.217
Pig + Vegetable + Fish + Chicken	$\ln \Pi = 910 + 0.08 \ln(R)$	0.378

$\Pi = \mathbf{f(R)}$
Where Π = Profit; R = Revenue
Critical Value = 2.18

Discussion

5. DISCUSSION

5.1 EXISTING PIG FARMING SYSTEMS IN KERALA

5.1.1 Socio Economic Status of Pig Farmers in Different Zones

The socio economic status of pig farmers in different agroclimatic zones of Kerala (Table 4.1.1) revealed that the farmers belonging to the age group of 31 to 50 years readily took up pig farming. Farmers below the age of 30 years rarely engaged in pig rearing in all the regions studied and this might be due to lack of interest among youngsters due to the prevailing socio-cultural attitude and high literacy rate of the state. This is in agreement with report of Harikumar (2001).

Among religious sects studied, Christians took up pig rearing in all the zones surveyed followed by Hindus while none of the Muslims took up pig farming. This observation is akin to Duru *et al.* (1999) and Harikumar (2001).

The farmers with average monthly income between Rs.4001 to 6000 were more involved in pig farming, and the percentage ranged from 37 in South zone to 53 in North zone. With respect to land holding, farmers having land area of above 100 cents were relatively more involved with pig farming. In this group of farmers, the percentage was highest (55%) in High range zone and lowest (26%) in North zone. This finding is in close agreement with Pandey and Ramkumar (1999). The result also revealed that education and family income of pig owners had positive effect in imbibing improved pig rearing practices.

5.1.2 Type of Agriculture and Animal Husbandry Activities

Farmers engaged in pig farming (Table 4.1.2) were largely involved in Coconut, Banana, Vegetables and Arecanut cultivation. The waste from the piggery unit was utilised as manure. Majority of the farmers maintained cattle besides pigs except in coastal regions where fish farming was the main subsidiary

animal husbandry activity. In the coastal zones the wastes and washing from the piggery units were very well utilized for fish production.

5.1.3 Rationale behind Rearing of Pigs

Rationale of rearing of pigs (Table 4.1.3) revealed that it was a source of additional income to the farmers. Survey at north zone showed that the pig rearing is source of security on crop failure and complement to their earnings. This finding is in agreement with the reports of Taneja (1998).

Among all the experienced groups, the percentage of farmers having the experience of nine to 12 years was more in all the zones with a minimum of 47% in High range zone to a maximum of 62% in North zone which shows that the awareness in pig rearing started only during the last decade and shows positive trend.

5.1.4 Details of Type, Source and Strength of Herd

Exotic crosses were chiefly preferred to the Desi crosses due to their advantage in feed conversion, better growth and carcass characteristics. They are economically viable compared to the Desi pigs. This is in accordance with the Quinquennial report on Livestock Census (1997). Pigs were obtained equally from both the government and private farms, which shows that the private sector has better breeding stocks catering the needs of the pig farmers. A high percentage of pig farmers had a herd strength of more than 50 animals followed by 10 to 50 animals indicating that the herd size of more than 50 is found to be economically viable (Table 4.1.4).

5.1.5 Needs and Type of Farming

Farmers maintained the stock for fattening and breeding and none were involved in breeding alone (Table 4.1.5) showing that both fattening and breeding is essential for a sustainable pig farming. The batch system of rearing was favoured over the all-in-all-out system for fattening of the stock, which

contributes regular income to the pig farmer and also favours effective, continuous utilization of the swill.

5.1.6 Litter Traits

Among the pig farming systems surveyed, the litter size at birth and litter size at weaning ranged from nine to 12 and seven to nine respectively (Table 4.1.6). This shows that the litter trait performances are optimum, which may be due to the availability of better breeding stock and efficient management practices. This was endorsed by the results of Rajiv and Pandey (1998) who also reported an average litter size of 6.5 to 7.0 in small and 6.6 to 8.5 in medium and in large farms.

5.1.7 Feeding Strategies

In pig farming, the feed cost constitutes nearly 80% of the production cost when raised on concentrate alone. Since the pigs are efficient converters of edible protein the importance of Swill in pig feeding is chiefly recognised by the farmers as a low cost feedstuff in pig rearing. The study revealed that swill feeding is found to be the major feeding method (74 to 85 %) followed by a combination with concentrate feed ingredients (15 to 26 %) and none were found to practice concentrate feeding alone. This finding is in accordance with the results obtained by Thomas and Xavier (1980), Ravindran *et al.* (1995), Sharma *et al.* (1997) and Harikumar (2001). Viswanathan *et al.* (2001) also reported that the pigs could be raised with swill alone and the economy and productivity of backyard pig production system based on hostel/hotel/domestic waste is suited for ordinary small-scale farmers. This holds true in the present study also.

The pigs were fed twice daily. The availability of waste and the leisure time of the family labour play a major role in the frequency of feeding. Since most of the farms are located in peri-urban areas, the distance of carrying feed materials from the chief sources of feed materials *viz.* Restaurants, Vegetable/fish market, hostel and slaughter house was ranging between 6 and 10 km and three

wheelers were the major mode of transportation, which was found to be convenient, cheap and economical. However in coastal regions, two wheelers were found to be the chief mode of feed transportation because of the affordability of the two wheeler, short distance between the source of feed and the lesser quantity of waste available, which reduces the total investment.

5.2 HOUSING OF PIGS

The study on the housing pattern of the pigs under different zones showed that the farmers generally raise the pigs under permanent type of houses (72 to 79%) with concrete floor (53 to 68 %) and thatched roof (72 to 81 %) that were fully covered (50 to 61%). Since the pig farmers of Kerala took up this farming as a permanent additional source of income they readily invest on housing the pigs, which resulted in higher permanent type of housing in the surveyed area. The rooting behavior of the pigs might have forced the farmers to built concrete floors. The easy availability of coconut leaves, and its cheaper cost may be the reason for thatched roof. To protect the animals from adversities of the environment the houses were fully covered.

5.3 DISPOSAL OF ANIMALS

The study revealed that the stock was disposed mainly based on the live weight basis (47 to 65 %) because of the less labour involvement when compared to the sale by other means. The disposal as hot carcass weight formed the second preferential mode of disposal (9 to 40 %). The unavailability of skilled labour for slaughter of the pigs is the major reason for the sale of pigs on live weight basis even though the sale as hot carcass is comparatively profitable. The above results are in agreement with the study of Harikumar (2001).

5.4 TYPES OF LABOUR

The study on the type of labour in the surveyed area revealed that family labour is (53% to 73 %) utilised in pig rearing. In order to reduce the expenditure

on hiring labour, effective utilisation of the free time, to get an additional income, to make the farming easy and profitable, the family members are readily involved in pig rearing. Those farmers who cannot afford the family labour; regularly depend on the hired labourers there by both family and hired labourers are involved in pig rearing (27% to 47%). None of the farmers reared pigs mainly on hired labourers. The above findings are in close agreement with Harikumar (2001) who reported that engaging family members in farming activities reduces the labour cost and suitable for rural sector.

5.5 HEALTH MANAGEMENT PRACTICES

The health management practices of pig farmers in different agroclimatic zones (Table 4.5) revealed that digestive disorder is the major problem in pigs and piglet mortality was mainly due to 'Mastitis Metritis Agalactia' (MMA) of the dam, Scour, Crushing and Deficiency. The findings of the study were in agreement with the reports of Srinongkote *et al.* (1992), Wagner and Polly (1997) and Duru *et al.* (1999). The digestive disorders might be due to the poor quality of the swill at the time of feeding. The skin and respiratory problem encountered in this study may be due to unhygienic practices. In addition, the deficiency diseases may be due to the unbalanced nutrients of the swill feed. 60 to 80 per cent of the farmers were seeking veterinary help for treatment and this reflects the literacy and awareness of the farmers with respect to health management practices.

5.6 TRAINING REQUIREMENTS

The training requirements of pig farmers (Table 4.6) showed that the prime requirement of training in pig rearing was on breeding management rather than on health, feeding and meat processing. Agwu (1999) also indicated that poor know-how on breeding and management was one of the major problems associated with pig production. The demand for quality piglets, its impact on the

production performance and the profit through sale of piglet as a breeding stock forces the pig farmers of Kerala to get trained on breeding management.

5.7 CONSTRAINTS

The study on the constraints in pig production systems showed that the financial problem is the major constraint (56 to 68 %) followed by the unavailability of stock (18 to 29 %) and social risk factor (14 to 17 %). This is in accordance with the findings of Harikumar (2001) who reported that the constraints of the pig farmers were financial, social and meagre availability of piglets. Duru *et al.* (1999) also reported that lack of capital investment was one among the major constraints in pig production. Since most of the pig farmers are marginal farmers they cannot afford higher capital investment. The need for *pucca* construction of pig housing, warrants outside financial support. The unavailability of stock and social factor were less important constraints in Kerala, probably due to adequate supply of quality piglets from private/ organised sectors and high proportion of pork consumers respectively.

5.8 SCIENTIFIC MANAGEMENT PRACTICES

The study on scientific management practices adapted by the pig farmers showed that the awareness (Table 4.8) is lacking in vaccination and control of ectoparasites. But deworming, iron injection, sanitation, waste disposal and castration were scientifically followed in higher proportion among the respondents. This was in close agreement with the results of Harikumar (2001). The results of this study reflect that the scientific practices *viz.* deworming, iron injection, sanitation, waste disposal and castration are receiving more attention than the preventive measures *viz.*, vaccination and spraying ectoparasiticide. This might be due to the awareness of the pig farmers on the importance of hygiene on economic production. Moreover the pigs are mainly reared as fatteners and are disposed nearly at eight to ten months of age the farmers are less concerned on the preventive measures.

Apart from the pig farming, farmers showed interest in allied activities like integrated farming, biogas production, expansion of farm and management through cooperative societies and their assistance. As early as 1977, FAO recommended that integration of livestock and fish raising with crop production should be revitalised and reoriented to meet the changing needs of small farmers in Asia. Santhakumar (2000) reported that integrated farming in India was proved to be efficient by adopting simple and easy technology involving meagre input. The main purpose of integrated farming approach was to enhance the income and to recycle the resources for pig production.

5.9 EVALUATION OF INTEGRATED PIG FARMING

5.9.1 Mean Body Weight of Large White Yorkshire Pigs

The mean body weights of Large White Yorkshire pigs under integrated farming system (Table 4.9.1) showed that there is no significant difference between treatments from three months to eight months of rearing. The mean body weight of Large White Yorkshire pigs at eight months of age ranged from 70.85 to 73.83 kg. This is in agreement with the results obtained by Harikumar (2001) and Anil (2005). In contrast to this Prabhakar (1994) and Singh *et al.* (1997) reported higher body weight at this age. A higher body weight of 90.17±0.99 kg at eight months of age was also reported by Singh *et al.* (1998). The difference in the body weight might be due to the type and quality of the unconventional feed used in the rearing and the breed difference.

It can be concluded that rearing of pigs with out integration is equally effective in promoting the growth of the pigs when compared to the integration with other combinations since the feeding of swill alone is sufficient for better growth. The by-products obtained from other components can only increase the economy rather than increasing the body weight.

5.9.2 Average Monthly Weight Gain of Large White Yorkshire Pigs

The results on average monthly weight gains (Table 4.9.2) revealed that there were no significant differences between treatments in both the Panchayaths. The positive weight gain was observed in all the treatment groups in both the Panchayats from fourth month to the end of the study. The average weight gain from fourth month of age (8.75 to11.03 kg) was increasing with advance in age reaching a peak at sixth month (12.24 to 14.14 kg) followed by a decline towards the end (9.15 to 10.87). This trend in monthly weight gain was similar to all the treatment groups in both the Panchayats. The results were similar to the findings of Harikumar (2001) and Anil (2005).

5.9.3 Average Daily Weight Gain of Large White Yorkshire Pigs

The average daily weight gain in gm (Table 4.9.3) did not differ significantly between treatments in both the Panchayaths. The pigs from different treatment groups in both the Panchayats showed gain in body weight from fourth month through eighth month. The average daily weight gain from fourth month of age (288 to 357 gm) increased with advance in age reaching a peak at sixth month (413 to 468 gm) followed by a decline towards the end (301 to 367). This trend in daily weight gain was similar to all the treatment groups in both the Panchayats. Similarly Harikumar (2001) and Anil (2005) recorded average daily gain of 318.98 ± 11.09 and of 341 ±14.24 gm respectively for LWY pigs.

The average daily gain obtained for pigs fed on swill was higher than the values reported by Bhar *et al.* (2000) (294 ± 28.68 g) for wheat bran based diet, Yadav *et al.* (2001) (275.19 ± 10.22) for rice bran based diet and Ranjan (2003) (248.42 g) for hotel waste based diet. The high mean daily gain in the field may be due to high CP percentage and the fat available in the swill especially from chicken offal. However, at eight months of age, the average daily weight gain in pig with fish, broiler chicken and vegetable/crops integration was numerically higher than integration of pigs with vegetable/crops and pigs without integration.

This may probably due to the feeding of left over from broiler unit and dead chicken carcasses in T_3.

5.9.4 Average Daily Feed Intake of Large White Yorkshire Pigs

The average daily feed intake (kg) of Large White Yorkshire pigs (Table 4.9.4) had no significant difference between treatment groups. The daily feed intake in terms of fresh weight and dry matter had linear increase from three months of age (1.00 to 1.30 and 0.31 to 0.38 respectively) to eight months of age (7.8 to 8.1 and 2.04 to 2.16 respectively).This increase trend in average daily feed intake for fresh and dry matter was similar in all the treatments of both Panchayath. Similar trend was also reported by earlier workers (Harikumar, 2001 and Anil, 2005). Due to the higher moisture content of the swill the pigs fed with swill alone consumed higher quantity of feed when compared with the feeding of concentrate alone. This might be due to the less dry matter content of the swill and in order to meet the dry matter requirement it consumed more.

5.9.5 Feed Conversion Efficiency

The pigs are better converters of swill into edible meat. The feed conversion efficiency on dry matter basis under different treatments in two Panchayaths showed that integration had no significant effect on feed conversion efficiency. The feed conversion efficiency was at its best at fourth month of age in all the three treatments (2.18 to 3.45). The efficiency of feed conversion reduced as the age advanced, and at eight months of age the value ranged between 5.92 and 6.81 with an overall average of 4.11 to 4.53. Srinivas and Sagar (1991) reported similar trend in feed conversion efficiency (4.2). However the present findings are contradictory to the reports of Ravi and Reddy (1997) who observed an efficiency of 5.49. The optimum feed conversion efficiency in this study may probably be due to the composition of swill which consisted of cooked chicken offal and restaurant waste and had higher crude protein, ether extract and NFE content.

5.10 LINEAR BODY MEASUREMENTS

The study on linear body measurements *viz.*, body length, chest girth and height (cm) of pigs revealed that the integration had no significant effect. The linear body measurements of pigs showed an increasing trend as the age advances. The body length of Large White Yorkshire pigs at three months of age ranged between 39.23 and 41.53 and at eight months of age ranged between 74.63 and 76.13. The chest girth of pigs at three months of age ranged between 54.48 and 55.55 and at eight months of age ranged between 92.63 and 93.35. The height at withers at three months of age ranged between 36.54 and 37.75 and at eight months of age ranged between 57.55 and 58.77. The present findings are in accordance with the reports of Sinha *et al.* (1993), Sinthiya (1998), and Anil (2005) who observed a correlation between body weight and body measurements. The linear body measurements were very important for predicting the body weight in pigs (Singh *et al.*, 2001).

5.11 PROXIMATE COMPOSITION OF FEED SAMPLES

The proximate composition of different feed samples (DM basis) *viz.*, chicken offal, hotel waste, vegetable waste and pooled samples were analysed. The Moisture content of vegetable waste was found to be the highest (88.20) followed by hotel waste (76.80), chicken offal (71.40) and pooled samples (76.82). The crude protein content of chicken offal was the highest (25.26). Vegetable waste had a slightly higher CP of 9.76 than hotel waste (9.60). The pooled sample had a CP of 14.80. Fanime and Tewe (1996) reported lower moisture for chicken waste than the present study but the crude protein per cent was 60, which was almost thrice of the observation in this study. Harikumar (2001) observed similar moisture percentage for chicken offal (70.79) but the crude protein per cent was higher (35.63) when compared to this study (25.26). Ranjan (2003) observed 35 per cent dry matter and 26.3 per cent crude protein in the hotel waste whereas Harikumar (2001) observed a crude protein per cent of 10.25 for hotel waste which is in agreement with the present study. Low CP per

cent of hotel waste may be due to presence of cooked rice as the major ingredient of hotel waste in this study. Rivas *et al.* (1996) also reported a high CP of 22.4 per cent for dehydrated edible restaurant waste.

The crude fibre content in this study was 7.02 for chicken offal and 6.40, 9.13 and 6.33 for hotel waste, vegetable waste and pooled samples respectively. The values are in agreement with observations of (Farimo and Tewe, 1996; Harikumar, 2001, Ranjan, 2003 and Anil, 2005). However Rivas *et al.* (1996) has reported a much lower per cent (2.3) crude fibre for dehydrated restaurant waste.

The ether extract value for the present study was highest for chicken offal 38.7 followed by hotel waste (20.21), vegetable waste (19.50) and 18.65 for pooled sample. Harikumar (2001) has reported EE of 30.9 per cent for chicken offal and 18.34 per cent in hotel waste. But Farimo and Tewe (1996) recorded a very low 8.46 per cent of EE for chicken offal and Ranjan (2003) 7.63 per cent of EE for hotel waste. Chicken offals in the present study included the alimentary tract and the subcutaneous fat of the skin and this might be the reason for a higher ether extract.

NFE for all the feedstuffs were more than 50 per cent except for chicken offal 22.70. Acid insoluble ash was highest 2.10 for the chicken offal and lowest for hotel waste 0.43.These values were with in the normal limits given by various authors (Michael *et al.*, 1973; Cunha,1977; Gloridoss and Das 1983; Ravi and Reddy, 1997 and Chinnamani, 2003).

Even though the proximate the composition of the different feed components varies, the pigs are finally fed with the combination of different sources of feed, which provides the required nutrients and hence the swill feed is sufficient for better growth of the pigs.

5.12 CARCASS TRAITS

5.12.1 Carcass Characteristics of Pigs

The study on carcass characteristics *viz.*, slaughter weight (kg), carcass length (cm), back fat thickness (mm), loin eye area (cm^2), hot carcass weight (kg), dressing percentage, deboned meat (percentage), meat bone ratio of pigs showed that there was no significant difference between treatments in all the carcass traits studied. This in accordance with findings of Anil (2005) who reported that carcass characteristics did not vary significantly between treatment with respect to the carcass length, loin eye area, hot deboned meat and meat bone ratio. Swill fed animals had a significantly higher back fat thickness (36.0) than the concentrate (24.7) fed animals (Anil, 2005). Similar findings are also reported by Jha *et al.* (1999), Harikumar (2001) and Chinnamani (2003).

5.12.2 Weight of Offals

The weight of offals (% body wt) did not differ significantly between treatments (Table 4.12.2) and might be due to the fact that the breed of the pigs and the system of feeding is similar in all the treatment groups. These results coincided with the findings of Harikumar (2001), who reported weight of kidney, spleen, lungs, stomach and intestine, liver and bone did not vary considerably between treatments.

5.13 AVERAGE YIELD OF CROP/ VEGETABLES

The average yield of crop/ vegetables (kg/10 m^2) *viz.*, Amaranthus, Brinjal, Bindi and Chilli recorded were not statistically significant (Table 4.13). The yield of banana crop was between 23.58 and 25.36. The yields of vegetables like Amaranthus, Brinjal, Bindi and Chilli were 18.73 to 21.53, 22.79 to 25.13, 9.76 to 10.24 and 10.84 to 12.37 respectively. The yields of banana crop and vegetables were within the optimum yield prescribed in Package of Practices and Recommendations of KAU- Crops (2002). The result showed that the pig manure

is alone sufficient to get better yield of crop/vegetables without any supplementation. However, Suraj (2000) reported lower yield for all vegetables on pigs centred integrated farming system compared to the present study. The difference in the yield may be attributed to the type of vegetable and the nature of fertilizer used.

5.14 BIOMASS YIELD OF CROP/ VEGETABLES

The biomass production (kg/10 m^2) of Banana crop and vegetables like Amaranthus, Brinjal, Bindi and Chilli on wet and dry basis were studied The wet basis biomass production of banana, Amaranthus, Brinjal, Bindi and Chilli were between 133.52 and136.52, 6.75 and7.42, 18.62 and 20.04, 17.66 and 19.22 & 12.64 and 14.04 respectively. On dry matter basis, the biomass production was 16.64 and 17.21, 0.92 and 1.02, 3.08 and 3.31, 3.27 and 3.41 & 2.18 and 2.36 respectively for banana, Amaranthus, Brinjal, Bindi and Chilli. Suraj (200) also reported similar trends in biomass production of vegetable crops in a study on pigs centred integrated farming system. However, the biomass production of Amaranthus was higher (41.05) than the production in present study (6.75 to 7.42). The difference in the production may be due to the type of vegetable and the fertilizers used.

Sherief (2005) stated that the integration of livestock into a farming system ensures a regular supply of organic matter, which facilitates effective recycling of biomass which in turn enhances soil fertility and yield and is therefore considered a vital component for organic farming.

5.15 FISH PRODUCTION

5.15.1 Yield of Fish

The study on the yield of fish (kg/30m^3) under integrated farming revealed that for Indian catfish, the total yield, average yield and survival rate were 130.74 to132.26, 1.87 to 1.92 and 92 to 93 respectively, whereas for Assam

vazha the values were 87.64 to 90.25, 1.28 to 1.34 and 87 to 88 respectively. Based on the better survival rate observed in this study, it may be concluded that these two varieties can be integrated with the pig farming and they can be raised only on wash water from pigsty without any supplementary feed.

However, within treatment the total and average yields were significantly different. In general, interms of the average yield and survivability the Indian cat fish performed better than the Assam Vazha and it is recommended that Indian cat fish is the most suitable fish variety to integrate with pig farming. This finding is supported by the results obtained by Sinha and Ramachandran (2002) and Antony (2002) who recommended cat fish as a better variety for integrated system.

5.15.2 Mean Body Weight of Fish at 12 Weeks Interval

The mean body weights of fish at 12 weeks (Table 4.15.2) had no significant difference between treatments for both the varieties. However, the body weight of both the varieties were significantly different within different age groups. The mean body weight of fish varieties showed linear increase from 12^{th} to 36^{th} week of age. Indian catfish performed better in terms of mean body weight than the Assam Vazha so that the Indian catfish can be recommended for profitable integrated pig farming.

5.16 MEAN BODY WEIGHT OF BROILER CHICKEN

The study on mean body weights (kg) of broiler chicken showed no significant difference between Panchayaths. However, the performance in terms of total yield, average body weight and livability were numerically superior in *Kaiparambu* compared to *Kuzhoor* Panchayath, which this may be due to better management practices adopted by them.

5.17 ECONOMICS OF INTEGRATED PIG FARMING

5.17.1 Average Total Income from Different Integrated Units

The average total income (Rs) from different integrated units showed that integration of pigs with two crops of eight numbers, banana in five cents, vegetables in five cents, fish reared in 30 m^3 and broiler in three batches of 500 numbers had total income of Rs. 10527, 6188, 1772, 6582 and 8241 respectively. The study on the different integrated systems revealed that the expenditure is mainly on piggery and chicken units and all other units are raised only on the by products of these tow units and hence the income raised through other units viz. banana/vegetables and fish are considered as additional sources of income.

5.17.2 Economics of Production from Different Models of Integrated Pig Farming

The economics of production from different models showed that there is significantly higher income between different integrated systems compared to pigs without integration. The percentage increase in the income of the different integrated systems *viz.* pigs and banana crop; pigs and vegetables; pigs and banana, fish and chicken and pigs and vegetables, fish and broiler chicken were Rs. 58.78, 16.90, 199.0 and 157.71 respectively. Among the different integrated pig farming the pigs with banana, fish and chicken and pigs with vegetables, fish and broiler chicken gave relatively higher income.

5.17.3 Economic Feasibility for Different Models of Integrated Pig Farming Systems

Considering the investment and income obtained from different integrated farming systems the economic feasibility of different models were studied. And it showed that the combination of pig with banana had relatively higher profit than pig without integration; pig with vegetable; pig with banana, fish and broiler chicken and pig with vegetables, fish and broiler chicken.

Even though a relatively higher income was obtained in two integrated systems viz. pig with banana, fish and chicken and pig with vegetables, fish and broiler chicken, they require higher input which cannot be easily born by the marginal pig farmers. It is therefore concluded that the integration of pig with banana is economically viable since it gave higher return with limited input, and hence recommended for the marginal farmers of Kerala.

Summary

6. SUMMARY

The research work was conducted to study the influence of various resources like land, agriculture, animal, man power etc in overall productivity of the pig production systems in the rural sector and economic viability of integrated pig-crop/vegetable-fish farming system. This study encompasses two phases; the first one was to study the existing pig farm systems in different agroclimatic zones of Kerala by survey. In second phase, the production performance and the economic efficiency of different models of integrated pig farming and the feasibility of integrating pig farming with crop/vegetables, fish/ broiler chicken farming in the field condition was assessed.

In the first phase, by employing stratified random sampling, 200 samples from five different agroclimatic zones viz., South, Central, North, High range and Costal zones were selected. A well-designed questionnaire and personal interview supplemented the survey. The socio-economic and educational levels of pig farmers and management practices including feeding, housing, breeding, marketing were analysed The problems and constraints in pig production were also evaluated.

In the second phase, to evaluate the productivity of the integrated pig farming models, twelve progressive farmers of each from *Kaiparambu* and *Kuzhoor* Panchayat Thrissur district of Kerala were supplied with eight Large White Yorkshire grower pigs which were reared under different combination as Pig farming alone as a control group (T1), Pig rearing and Crop/vegetables cultivation (T2) and Broiler chicken, Pig and Fish farming along with crop/vegetables cultivation (T3). The experimental animals in all the three groups were raised on swill and feeding the waste generated by the other components.

The other components of integration were a) crop (banana)/ vegetables (Amaranthus, Brinjal, Bindi and Chilli), b) fish (Indian catfish and Assam Vazha) and c) Broiler chicken (Vencob).

The parameters studied in pigs were monthly body weights, linear body measurements like body length, chest girth and height at wither, average daily weight gain, average daily feed intake, feed conversion efficiency, proximate analysis of feed sample and carcass characteristics viz., slaughter weight, dressing percentage, carcass length, loin eye area, back fat thickness, meat bone ratio and weight of offals. The parameters studied in other components were yield, biomass and survival rate. The economics and the feasibility of pig production under different integrated farming systems were analysed

The survey on socio-economic status of the pig farmers revealed that that the majority of the farmers belonged to the age group of 31 to 50 years with average monthly income between Rs.4001 to 6000 and among community status, Christians followed by Hindus but no Muslim took up pig farming. Farmers engaged in pig farming were largely involved in coconut, banana, vegetables and arecanut cultivation with the subsidiary animal husbandry activity of cattle rearing and fish farming in costal areas. The rationale behind rearing of pigs was mainly found to be a source of additional income and majority of the pig farmers had nine to 12 years of experience in pig rearing. Exotic crosses were chiefly preferred to the Desi crosses. Drove was obtained equally from both the government and private farms. A high percentage of pig farmers had herd strength of more than 50 animals followed by 10 to 50 animals. Farmers maintained the stock for both fattening and breeding and none were involved in breeding alone. A batch system of rearing was favoured over the all-in-all-out system for fattening of the stock. The surveyed farms had a litter size at birth of nine to 12 and litter size at weaning of seven to nine.

Swill feeding was the major feeding method, however, none practiced concentrate feeding alone. The common feeding frequency was twice daily. The

distance between the farm premises and the source of swill ranged from six to 10 km and three wheelers were the chief mode of swill transportation.

The animals were kept commonly under permanent houses with concrete floor and fully covered thatched roof. The most preferred disposal method was based on live weight. The chief manpower was from family labour and none hired labours for this purpose. Digestive disorder and 'Mastitis Metritis Agalactia' (MMA) was the major problem in adult pigs and Scour, Crushing and Deficiency in piglets. The prime concern of farmers regarding training was on breeding management rather than on health, feeding and meat processing. The main constraint in pig rearing was found to be financial. The farmers lacked awareness on vaccination and control of ectoparasites. Interestingly majority of the farmers have adopted integrated farming in all the agroclimatic zones. The farmers showed the interest on biogas production, expansion of farm and management through cooperative societies assistance.

The parameters like body weight, average monthly and daily weight gains, average daily feed intake, feed conversion efficiency, linear body measurements and carcass traits of pigs on swill feed showed no significant difference and all the combinations of integration were equally effective with respect to all the above parameters

The proximate composition of swill materials like chicken waste, hotel waste and vegetable waste were 25.26, 9.60 and 9.76 per cent respectively. The pooled sample had a crude protein value of 14.80 per cent.

The average yield and Biomass production of crop/vegetables, and total yield and average body weight of broiler in different treatments were not statistically significant. However, different varieties of fish within the treatments showed significant difference in their yield and mean body weight.

It was observed that integration of pigs with two crops of eight numbers, banana in five cents, vegetables in five cents, fish reared in 30 m^3 and broiler in

three batches of 500 numbers had total income of Rs. 10527, 6188, 1772, 6582 and 8241 respectively. There was a significantly higher total income between different integrated systems compared to pigs without integration. The total income for pigs without integration; pigs with banana crop; pigs with vegetables; pigs with banana, fish and chicken and pigs with vegetables, fish and broiler chicken were Rs. 10527.38, 16715.88, 12306.38, 31476.87 and 27129.88 respectively.

The combination of pig with banana crop had relatively higher return than pig without integration; pig with vegetable; pig with banana crop, fish and broiler chicken and pig with vegetables, fish and broiler chicken.

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Appendix

ANNEXURE I

Questionnaire

1. Name :

2. Age :

3.Religion :

4.Address :

5. Family details :

Sl.No.	Name of members	Age	M/F	Educational qualification	Occupation

6. Average monthly family income (Please tick)
Below Rs. 2000/-, 2001-4000, 4001-6000, above 6000

7. Land holding (please tick)
Above 100 cents/51 to 100 cents/21 to 50 cents/below 20 cents

8. Details of animals reared
A. Pigs (Please tick)
a. Breed : Exotic breeds/indigenous /cross breeds
b. Herd strength : Below 10/11 to 50/above 50
c. Sources of pigs : Government /private /both
B. Details of other domestic animals
C. Details of other Agricultural crops

9. Reasons for pig farm (please tick)
Main source of income/for extra income
To utilize organic wastes/for employment

10 Feeding (please tick)
a. Type of feeding concentrate/swill/both
b. Distance to feed source Above 10 km/5 to 10km/ below 5 km
c. Feeding frequency per day Once/twice/others
d. Transportation of feed Two/three/four wheeler

11.Housing (please tick) Permanent/temporary
a. Type of floor concrete/stone pavement/mud/others
b. Type of roof Thatched/tiled/asbestos/tin sheet/others

12.Purpose of rearing (please tick)	Breeding/fattening/both If breeding --litter performance of birth & weaning. If fattening-- batch /all in all out system
13. Health probems(please tick)	Common/Occasional/frequent
14.Common diseases (please rank)	Digestive disorders/skin problems/respiratory/deficiency/others
15. Mortality in piglets	MMA/Scour/Crushing/Deficiency
16.Distance to veterinary aid centre (please tick)	Above 10 km/5 to 10km/below 5km
17. Marketing of pigs (please tick)	Based on live weight/as meat/sale of piglets/carcass weight
18. Labour utilization (please tick)	Family/hired labour/both
19. Experience in pig farming (please tick)	>12 years/8-12 years/4-8years/< 4years.
20. Training (please tick)	Attended/not attended
21.Training requirement (please tick)	Selection of pigs/feeding/breeding Diseases control/meat processing/others
22.Adoption of scientific management practices (please rank)	Regular Deworming/vaccination/proper cleaning/ proper waste disposal/iron injection/castration/integration
23. Constraints in pig farming (please tick)	Financial/social/availability of piglets/marketing.
24.Interest in developmental activities (please rank)	Integrated farming/co-operative set up/ Meat processing/biogas installation/expansion of existing unit/others.

EVALUATION AND IMPROVEMENT OF INTEGRATED PIG FARMING SYSTEMS IN KERALA

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

Doctor of Philosophy

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ABSTRACT

The Evaluation of existing pig farming systems of Kerala and the productivity and economic viability of integrated pig-crop/vegetable-fish farming system were studied. A total of 200 pig farmers from five different agroclimatic zones were selected and surveyed using a questionnaire and personal interview. The socio-economic and educational levels of pig farmers and the management practices adapted were analysed. The problems and constraints in pig production were also evaluated.

The pig farmers in Kerala belonged to the age group of 31 to 50 years with average monthly income between Rs.4001 to 6000. Christians followed by Hindus but no Muslim took up pig farming. The other agricultural cultivations were coconut, banana, vegetables and arecanut cultivation with the subsidiary animal husbandry activity of cattle rearing and fish farming in costal areas. The rationale behind rearing of pigs was as a source of additional income and majority of the pig farmers had nine to 12 years of experience. Exotic crosses were chiefly preferred to the Desi crosses. Drove was obtained equally from both the government and private farms. A high percentage of pig farmers had herd strength of more than 50 animals with a litter size at birth of nine to 12 and litter size at weaning of seven to nine. Farmers maintained the stock for both fattening and breeding and batch system of fattening was favoured. Swill feeding was the major feeding method and the common feeding frequency was twice daily. The distance between the farm premises and the source of swill ranged from six to10 km and three wheelers were the chief mode of swill transportation. The animals were kept commonly under permanent houses with concrete floor and fully covered thatched roof. The most preferred disposal method was based on live weight. The chief manpower was from family labour. Digestive disorder and 'Mastitis Metritis Agalactia' (MMA) were the major problem in adult pigs. The breeding management was the prime concern regarding training need and finance was the main constraint. The farmers were in lack of awareness for vaccination and control of ectoparasites. The farmers have adopted integrated farming in all

the agroclimatic zones and showed interest on biogas production, expansion of farm and management through cooperative societies assistance.

Twelve progressive farmers of each from *Kaiparambu* and *Kuzhoor* Panchayat, Thrissur district of Kerala were supplied with eight Large White Yorkshire grower pigs which were reared under different combination as Pig farming alone as a control group (T1), Pig rearing and Crop/vegetables cultivation (T2) and Broiler chicken, Pig and Fish farming along with crop/vegetables cultivation (T3). The experimental animals in all the three groups were raised on swill and feeding the waste generated by the other components. The other components of integration were a) crop (banana)/ vegetables (Amaranthus, Brinjal, Bindi and Chilli), b) fish (Indian catfish and Assam Vazha) and c) Broiler chicken (Vencob). The parameters like body weight, average monthly and daily weight gains, average daily feed intake, feed conversion efficiency, linear body measurements and carcass traits of pigs on swill feed showed no significant difference and all the combinations of integration were equally effective with respect to all the above parameters. The chicken waste had higher CP content. The average yield and Biomass production of crop/ vegetables, and total yield and average body weight of broiler in different treatments were not statistically significant. However, different varieties of fish within the treatments showed significant difference in their yield and mean body weight.

In integrated farming, the net income (Rs) for pigs without integration (10527 .38) was significantly lower than pigs with banana crop (16715.88), pigs with vegetables (12306.38), pigs with banana, fish and chicken (31476.87) and pigs with vegetables, fish and broiler chicken (27129.88).

The combination of pig with banana crop had relatively higher return than pig without integration; pig with vegetable; pig with banana crop, fish and broiler chicken and pig with vegetables, fish and broiler chicken and hence the combination of pig and banana is recommended for the marginal farmers of Kerala.