EVALUATION OF RICE MILLING BY-PRODUCTS FROM MWEA IRRIGATION SCHEME IN LAYER CHICKEN DIETS

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE DEGREE OF MASTER OF SCIENCE IN ANIMAL PRODUCTION IN THE FACULTY OF AGRICULTURE

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DECLARATION

This Thesis is my original work and has not been presented for a degree in any other University.

Signature.. Date: 22nd/ July/2008

Njuguna Kamau Waweru

This Thesis has been submitted for examination with our approval as University Supervisors.

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ACKNOWLEDGEMENT

I wish to express my most sincere thanks and deep gratitude to all members of the Animal Production Department. Efforts by individuals not enumerated here are also highly appreciated.

I am greatly indebted to my first supervisor, Dr. Lucy W. Kabuage (Mrs.) who offered me invaluable assistance during my research work and writing of this Thesis. I was overwhelmed by her kind gesture in facilitating my work with AICAD (African Institute for Capacity Development) project. She so ably articulated the project leading to the yield of an enormous amount of literature on Mwea rice-by products. May the Good Lord bless her in a mighty way. I wish to record my satisfaction and appreciation with the AICAD Board of Management for supporting the study. Many thanks go to Dr. Joyce G. Maina (Mrs.), my second supervisor who played a pivotal role at all stages in my work. I wish to acknowledge all the efforts offered by Joyce W. Mugwe and the poultry unit staff in supporting me in performing the routine project duties as well as Mr. D. Ambale, who guided my laboratory work. It is with a deep sense of gratitude that I recall the encouragement I received from my colleague, Gladys Situma (my only course mate). Finally in this category, I feel privlleged as I note the cooperation offered to me by farmers in Mbui Njeru village (led by Mr. Martin Njigoya), in the on-farm trial.

I wish to profoundly thank the University of Nairobi's Board of Post graduate studies for sponsoring my MSc studies. I note with satisfaction the efforts by my then immediate supervisor, Mr. A Sang, the Provincial Director of Livestock Production, (PDLP) Nairobi who helped me secure my study leave. Last but not least, I wish to express my utmost gratitude and special thanks to my immediate family members, led by non-other than my dear wife, Anne Wanjugu Njuguna. I was impressed by the spirited tempo she maintained all through. She and the children had to endure long periods of my absence, as I battled it out with this task.

DEDICATION

This work is dedicated to my dear wife, Wanjugu and children, Muthoni, Wanjiru and Kamau

In memory of:

My departed parents Mr.Hezron Kamau Waweru, Mrs. Marion Muthoni Kamau and my deceased daughter, Nyaguthii Njuguna

May God rest their souls in eternal peace.

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ABSTRACT

Lack of affordable high quality feeds is one of the major constraints to the development of a vibrant poultry sub-sector in Kenya. Maize and its by-products have traditionally been used as the main energy sources in poultry feeds. Maize, however, is expensive because it is also staple food in diets of most Kenyan communities. It is therefore necessary to investigate new sources of energy as replacement for maize in poultry diets.

Two experiments were done to determine the feeding value of rice milling by-products found at the Mwea Irrigation Scheme (MIS) in Kirinyaga district. The by-products evaluated were special coarse bran (SCB), fine bran (FB) and broken rice (BR). Specific objectives were to determine the nutrient composition of the by-products, assess the effect of feeding graded levels of the by-products on layer chicken performance, and determine the optimal level of inclusion.

A total of three hundred and eighty Isa-brown layer chicks were used for the two experiments: one hundred and sity eight for the first and two hundred and twelve for the second. They were housed in battery cages located at the Poultry Unit in the University of Nairobi from the onset of lay to the end of the experimental period.

In the first experiment, five diets containing graded levels of special coarse bran (SCB) (0 – 20% of diet) were formulated, while fine bran was fixed at 20 %. They were fed for sixteen weeks (21^{st} to 36^{th} weeks of age) during which performance data was collected and evaluated.

Results of proximate analysis of the by-products showed that fine bran had higher levels of ether extract and crude protein than those of maize grain. Special coarse bran had high levels of crude fibre, while broken rice had a composition similar to that of maize.

Over the sixteen- week experimental period, layer performance data showed that birds fed on diet containing 20% SCB had the highest feed intake (14.18 kg per bird) while those fed on the diet with no SCB, had the lowest (9.12 kg per bird). Feed intake hence increased with increasing levels of SCB in the diet. Trends in egg mass production closely followed those of feed consumption. Layers fed on the diet containing 20 % SCB produced 3.85 Kg egg mass per bird, which was significantly (P<0.05) higher than those produced by birds on maize soya bean meal control and diets with 15, 10, 5 and 0 % SCB (3.74, 3.75, 3.47, 3.19 and 3.18 Kg egg mass per bird respectively).

The best feed conversion ratio (feed: egg mass) was observed in the layers fed on the maize soya bean meal control diet (2.81) while those on the diet containing 20% SCB had the poorest (3.68). Feed conversion ratio declined with increase in the level of SCB (2.86, 3.20, 3.46 and 3.57 for diets with 0, 5, 10 and 15 % SCB respectively)

In Experiment 2, all three by-products were evaluated in an on-station and on-farm experiment. They were compared to a commercial layers mash diet and a formulated maize-soya bean control diet.

Results showed that overall feed intake values for birds fed on diets containing 5 and 10% SCB (7.12 and 7.20 Kg/ bird respectively) were significantly (P < 0.05) higher than those of birds on the commercial layers mash and maize-soya bean diets. The higher feed intake for layers on rice-based diets positively influenced all the performance parameters up to 5 % SCB inclusion level, in the same manner explained in experiment 1.

The economic analysis of the study showed that birds on the 20 % FB and 20 % SCB diet had a gross margin per bird that was higher by Ksh. 2 / bird than for those on the control diet. Gross margins for 5 and 10 % SCB diets were similar, but higher by more than Ksh. 39/ bird compared to the control diets.

Overall, the rice based diets were well utilized and gave higher gross margins than the maize based control diets demonstrating good potential and affordability. The MIS rice by-products could therefore substitute for maize and its by- products in layer chicken diets up to 40 % when using FB and SCB and up to 65 % if additionally including BR

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Poultry plays an important role in the nutrition and provision of income of the rural people in Kenya. Chicken in particular are a major source of protein in the form of eggs and meat and form the largest portion of the poultry industry in Kenya; indigenous birds being the majority (GoK 1999). The indigenous birds however, have a low genetic potential, are raised under subsistence conditions and characterized by low productivity (GoK 1994).

Commercialization of the poultry sub-sector has a high potential of generating income and employment opportunities. Feed costs are by far the largest input in commercial poultry production, accounting for between 60-80% of the total production costs (GoK, 1984). Capacity building at all levels especially on intensification of research on least-cost feed formulation and production using locally available materials would spur growth in the industry (GoK, 2006). Inadequate information on ingredient composition and lack of adequate and reliable laboratory facilities for analysis are a major constraint in the industry (GoK, 2006). Attention to feed quality is essential for high productivity and desirable profit margins. Research has shown that feed quality is directly related to productivity (GoK, 2006). Availability of affordable quality feed has been a limiting factor in the development of the Kenyan poultry industry (GoK, 2004).

Maize and its by products constitute the principal energy source in most poultry diets in developing countries, but the same is also a staple food for local communities (Rama *et al.*, 2000). There is therefore high competition between man and animals over the same food and feed resource. This underscores the need for research on suitable non-conventional energy feedstuffs that are both inexpensive and locally available. Generally, availability of such feedstuffs locally would be influenced by the crop production patterns in different regions.

Mwea Irrigation Scheme (MIS) situated approximately 100 km north east of Nairobi on the foothills of Mount Kenya (Kirinyaga District, Central province) is the major rice-producing scheme in Kenya, with plentiful supply of inexpensive rice milling by-products. The by-products from different types of mills in the scheme that could be used for feeding poultry include special coarse bran (SCB), broken rice (BR) and fine bran (FB) all of which were evaluated in this study. These by-products are abundant within MIS and its vicinity. In recent years, there has been a mushrooming of small private mills in MIS competing with the large Mwea rice Mills (MRM) owned by the national irrigation board (NIB) and a similar one owned by the local cooperative society. A study by Kiarie (2003) showed that there was no documented information on the nutritional value of the by-product produced by small millers, which is a single-combined product (referred to as Special Coarse Bran in this study). This therefore provided scope for further research and development of appropriate technology for utilisation of the by-product. This would be done by analyzing the chemical composition of the by-product and conducting feeding trials with diets containing graded levels of the by-product. Currently, local farmers are hardly using the by-products to feed commercial and indigenous poultry. The extent to which the same by products can be incorporated in commercial poultry feeds without compromising performance has not been determined locally.

The yield of paddy rice in MIS in the period 1988/89 was 27,555 tonnes (CBS, 1990). Conventional rice milling has a recovery of approximately 65 % polished rice, the rest being by-products. The yield would therefore be associated with about 9,644.25 tonnes of the by-products. The survey by Kiarie (2003) showed that there was limited use of rice milling by-products as livestock feed. An enormous quantity of nutrients and energy embodied in the mass of these by-products produced each season in the MIS largely goes to waste. A sixty kilo gramme bag of either broken rice or fine bran retails at five hundred Kenya shillings while similar quantity of special coarse bran retails at one hundred Kenya shillings. For this low cost source of nutrients to be used efficiently, it is critical that constraints to its effective utilization be addressed. These by-products have not been evaluated through poultry feeding trials to establish the appropriate levels of inclusion or suitable formulations for different classes of poultry.

The study by Kiarie (2003) on livestock production systems in Mwea Irrigation Scheme concluded that there was great potential of producing rice based livestock feeds in the scheme. The common by-products previously mentioned are expected to be potentially useful for poultry feeding. Rice bran is reported to have a high fibre content, which could negatively affect feed intake and efficiency of utilization in non-ruminant animals. There is however a wide variation in the quality of brans from different sources caused by- rice variety and location, mill type, milling equipment type and degree and depth of milling (Primo *et al.*, 1970; Barber and Benedito, 1980). Rice polishings, which basically consist of aleuronic layer and some fine powder from the kernel, are generally high in crude protein, low in crude fibre and high in vitamin B complex, oil content and residual carbohydrates (FAO, 1999). This makes the by-product a potential source of energy and protein in commercial layer rations. Broken rice (feed grade) consists of fragmented rice particles that are undesirable in the human diet. Its high-energy value and low fibre content could make it valuable in rations for poultry. Polished rice generally used as human food is seldom used as animal feed because of its high cost but it can be fed in the same way as broken rice. Special coarse bran (specific to this study) refers to the single combined by-product generated in enormous amounts by the many and widespread small-scale mills in Mwea, the study area. These privately owned maize mills have been improvised to mill rice in a one- stage (single pass) process; they are, however, generally inefficient and with a low yield of polished rice. This by-product combines the desirable nutritional characteristics exhibited by fine bran (high residual carbohydrates and high crude protein content), coarse rice bran (high content of calcium and phosphorous), broken rice (high energy) and the undesirable characteristics exhibited by special coarse bran (high crude fibre content). The feeding value of this by-product has not been previously determined. For recommendations to be made on the level of inclusion of Mwea generated by-products in poultry diets, a thorough evaluation of their nutritional and feeding quality remains pertinent.

1.2 Statement of the Problem

Lack of research data on the nutritional value of by-products from Mwea rice mills for poultry feeding has discouraged their widespread use in the poultry feed industry. Availability of such data would enhance efficient, knowledge-based utilisation of the by-products by farmers and feed manufacturers nationally and in the study area. This research was therefore designed to determine the feeding value and appropriate levels of inclusion of special coarse bran and other by-products in diets for commercial layer chicken. Results of the study were expected to promote not only production of affordable layer chicken feed but also spur commercial layer production particularly in Mwea and its environs.

Justification

Literature cited earlier indicates that the annual yield of of rice milling by-products at the Mwea irrigation scheme stands at 9,644.25 tonnes. Following an upsurge of improvised small-scale mills, the yield of special coarse bran at MIS has increased significantly in recent years. The mills attract farmers due to their even distribution hence ease of access, relatively low milling cost and ability to handle small quantities of paddy. Commercial layer chicken production is largely absent not only in the area, but also in many others in Kenya, mainly due to lack of affordable commercial feed amongst other factors.

A study by Mutero *et al.*, (2001) showed that poverty is prevalent in Mwea. Cash income is considerably lower in the non-irrigated villages where 60% of Kagio households and 91% of Murinduko households earn less than Ksh. 108.5 (US $ 1.75) per day. Commercial layer chicken production has the potential to improve the people's livelihood by: - improving their nutritional and health status through provision of proteins, vitamins and minerals in the diet; increase their cash income through sale of eggs and culls. Promotion of layer chicken production in Mwea (based on rice by-products diets) would enhance sustainable utilization of locally available resources, in line with the national goal of poverty alleviation.

1.3 Objectives of the Study

Broad objective

To evaluate rice milling by-products from Mwea Irrigation Scheme as feed ingredients for commercial poultry.

Specific objectives

- To determine the nutrient composition of Mwea rice milling by-products (special coarse bran, fine bran and broken rice).
- To assess the effects of incorporating graded levels of rice by-products (special coarse bran and broken rice) on performance of layer chicken.
- To determine and recommend optimal inclusion levels of rice by-products for layer chicken diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of livestock and Animal Feed industries in Kenya

2.1.1 Livestock Industry

The overall goal of the Government is to eradicate poverty, illiteracy and diseases. Livestock being the mainstay of most rural households contributes significantly to the livelihoods of the population. Kenyan communities traditionally kept livestock for subsistence, prestige and as a source of insurance against drought. Among the main livestock breeds kept were East African zebu, the boran cattle, East African goats, Galla goats, Red Maasai sheep, the one hump camel and indigenous poultry (GOK, 2006). The livestock sector currently contributes 10% of the Gross Domestic Product (GDP) and accounts for 30% of the total value of agricultural commodities (GOK, 2001). Livestock farming is therefore, a major economic and social activity for most communities in Kenya, especially those living in the Arid and Semi-Arid areas. The population of the major livestock species is estimated at 9 million zebu cattle, 3.5million exotic and grade cattle, 9.9 million sheep, 11.9 million goats, 890,000 camels, 415,000 pigs and over 25 million chicken (GoK, 2003).

Dairy and grade cattle are found in the North Rift Valley and central Highlands of Kenya, while beef cattle, sheep and goats are mainly found in the arid and semi-arid areas (ASALs). Indigenous chicken are spread all over the country except in the very arid areas, while commercial poultry and pigs are found in the periphery of major towns such as Nairobi, Mombasa, Kisumu, Eldoret, Nakuru among others. The major challenges experienced by the industry are: - disease control, inadequate credit facilities, poor infrastructure, poor marketing structure and unavailability of good quality feeds at favourable prices (GOK, 1999).

2.1.2 Poultry Industry

Poultry keeping is the most popular enterprise in Kenya because: it requires low capital and minimum space, has a wide selection of feeds and the market outlets are available and within reach. This has led to improved production of pure breeds, hybrid and crossbred layers and broilers (GOK, 2003). A large indigenous chicken population and a smaller but more productive exotic flock characterize the Kenyan poultry population (GOK, 1994). Majority of the birds are chicken with very few of the other species such as turkeys, geese, quails, guinea fowl, pigeons and ducks (GOK, 2005). Current poultry population figures are estimated at 2,266,162, 4,731,399, 21,492,850 and 700,994 for layers, broilers, indigenous chicken and the others respectively (GOK, 2005). Layers and broilers are classified as commercial birds and constitute 26.3% of the total chicken population. Indigenous chicken is approximately 68.3% while the other species (combined) are estimated at 5.4% (GOK, 2002).

Commercial birds are kept in peri-urban areas for ease of procuring inputs and sale of products while the indigenous birds are reared in the rural areas (GOK, 1999). Commercial farmers typically keep from 100-1000 birds per batch. About two million farmers were reported to have been contracted by Kenchic, a company dealing mainly in day-old chick production (GOK, 1998). Farmers contracted by this company keep from 3000-12000 broilers per batch as the market is guaranteed. Production of meat and eggs was estimated at 20,785 tonnes valued at 144,447 Kenyan pounds and 1,254,678,000 eggs valued at 286,409,436 Kenyan pounds, respectively (GOK, 2003).

The majority of rural households in Kenya keep indigenous chicken, which are not classified as layers or broilers but serve as dual-purpose birds. Meat and eggs from these birds are sold in rural markets to supplement family income. Indigenous chickens are managed on a free-range production system with little or no supplementation. Production from these birds requires little or no financial inputs but the level of production is low. Local varieties of chickens have not been classified into breeds but there are many different ecotypes. Hens usually lay up to three clutches of twelve to eighteen eggs each year (Payne, 1990).

Layer Chicken Production

Commercial farmers mainly carry out layer production in Kenya. The size of commercial layer flocks varies considerably. A majority of farmers keep between 100 and 1000 birds per batch and in most cases less than 500 birds (GOK, 1998). The birds start laying at 20-22 weeks of age depending on the hybrid (Scott, *et al.*, 1982). The layer strains imported to Kenya include Isa brown, Shaver, Hisex and Harco. The Kenyan ministry of Livestock Development gives the following average production data for layer flocks in Kenya, based on a 52-week production cycle; 10% mortality during the rearing period and a similar rate for the laying phase, 240 saleable eggs per hen per year and a mean 0.13 Kg of feed per hen per day (GOK, 1989).

Ambient temperature may partly account for the difference in performance between layers in the temperate regions and those in the tropics. The thermal neutral zone of the adult fowl is from 12.8-26.0 °C. Within this range layer performance is not adversely affected by temperature. Egg production is adversely affected when ambient temperatures are higher than 32 °C. At higher temperatures egg production and egg size decrease while egg shells become thinner (Smith, 1974). The mean ambient temperature in the tropics is 27°C. Practical experience has however shown that, with proper management and feeding, exotic breeds can be economical layers in the tropics (Payne, 1990). Most of the layer houses in Kenya as in most countries in the tropics are open- sided and the layers receive only natural sunlight. The amount of light per day remains relatively constant at twelve hours. Laying hens require a minimum of fourteen hours of light per day for maximum egg production (North, 1984). Light intensity and day-length has some effect on voluntary food intake, longer days stimulate egg production and therefore encourage hens to consume more feed (Smith, 1990). When an open sided house is used, artificial light should be supplemented to increase the amount of light per day. Since light also encourages feeding, the additional light should be given in the morning and again in the evening to encourage the layers to eat during the cooler periods. However, very few egg producers in Kenya use supplemental light and this could partially account for lower egg production. Layer production in Kenya is predominantly on deep litter, though cage (battery) and slatted floor systems are becoming increasingly common (GOK, 2000).

The main factors that affect the poultry industry are: diseases, supply of day old chicks, high cost of quality feeds, lack of organized markets and lack of credit facilities and management of birds at the farm level (GOK, 2002). There is competition for raw materials for chicken feed and human food. This makes the feed cost quite high, which in turn makes the price of poultry products high and therefore reduces the market demand. Another major problem with the feeds is its quality, which is quite variable. In recent years, there has been a drastic rise in the number of feed millers. However some do not have the technical capacity to make quality feeds (GOK, 2003). The use of rice by products as ingredients for poultry feeds would greatly reduce competition between man and poultry for similar resources.

2.1.3 Animal feed industry

The main livestock feeds consist of roughages, concentrates, minerals and vitamins. Non-ruminants (pigs and poultry) are fed on concentrates mixed to meet their nutrient requirements (GOK, 2006). A survey by Gichohi *et al.,* (1988) found that farmers did not mix poultry rations on their farms because they lacked the knowledge required for feed formulation. They relied instead on feed manufacturers to provide them with good quality feeds. Kenya's animal feed industry started with the sale of 'cereal balancers' for pigs and dairy cattle (Said and Mbugua 1985). These 'balancers' were composed of proteins, vitamins and minerals which, when combined with cereals, supplied the animals' nutritional requirements. The 'cereal balancers' were developed to meet the needs of white settlers who were developing large-scale farms in Kenya's highlands in the colonial days. They grew maize, wheat and barley and also raised beef and dairy cattle as well as pigs. Whole grain or grain-milling by-products were used as supplements for animals on pastures. By 1967 Kenya had a well-developed feed industry and a variety of different animal feeds were available (Said and Mbugua 1985).

Feed millers can be classified as large or small-scale. Unga, Sigma and Ideal feeds are some of the large scale feed millers with branches throughout the country (GOK, 1998). Mbugua, (1989) reported ten large scale feed manufacturers with installed capacities ranging between 5,000 and 150,000 tonnes per year and a number of small scale millers producing variable amounts of feed. More recently, Quinet, (2003) showed that Kenya had thirty-four feed millers. The two reports demonstrated rapid growth of the industry between the two periods. Currently, there are about 70-80 feed manufacturers with an annual turnover of about KSh. 7 billion. The biggest feed company produces about 90,000 tonnes per year (GoK, 2006). The total concentrate feed production, according to returns received from provender millers was 317,912 metric tonnes, compared to the installed capacity of approximately 600,000 and the highest percentage was represented by poultry feeds (56%), followed by cattle feeds, (32%), pigs (9%) and other types (3%) (GoK, 2004).

Competition for maize, the main energy source, between humans and livestock and inadequate research information on suitable feed ingredients for specific areas is a critical constraint to the industry (GoK, 2006). Alternative energy sources such as by-products from cereals have the potential of addressing this constraint.

Cereal Grains and their by-products

Cereal grains are essentially carbohydrate concentrates, the main component of the dry matter being starch, which is concentrated in the endosperm (McDonald, *et al.,* 1987). Some of the most important cereals in Kenya are maize, wheat and rice (GOK, 2002). Maize is the staple food in most farming areas and is grown under diverse conditions of climate, soils and altitude. Maize production in Kenya takes place on both large scale and small-scale farms, but the bulk of it is from the latter. It is also an important livestock feed both as silage and crop residue, grain, and is used industrially for starch (energy) and oil extraction (GOK, 2002). Maize milling by-products are germ, bran and gluten. The three by-products are frequently mixed together and sold as maize gluten feed (Said *et al.,* 1982).

Wheat has been grown in Kenya since the early 1900s and it currently occupies the second position after maize as an important cereal. Early development of the crop was confined to large-scale farms in the Rift valley and parts of Central and Eastern Provinces. This pattern, however, has changed with small-scale farmers moving into wheat farming on sub divided large farms (GOK, 2002). Wheat by-products are usually classified and named on the basis of decreasing fibre content as: - bran, middlings (pollard), mill-run, shorts, red dog and wheat germ meal. (Kellems, *et al.*, l).

Rice is grown from the equator to 50 °N and from sea level to 2500 M. The soils on which rice grows are as varied as the climatic regime to which the crop is exposed: texture ranges from sand to clay, PH from 3 to 10; organic matter from 1 to 50 %, salt content from almost 0 to 1 %, and nutrient availability from acute deficiencies to surplus (Wanjogu *et. al.*, 1995). Globally, rice is the staple food in southern India, Bangladesh, Sri Lanka, Burma, China and Japan (Indiadiets Foods, 2006). In Kenya rice is the staple food at the Mwea Irrigation Scheme (Wanjogu *et. al.*, 1995). The following are the conventional by-products recovered after rice milling: hulls, bran, polishing and broken rice (FAO, 1990). However, in recent years, maize mills at the MIS have been improvised to mill rice in a one-stage operation yielding a single combined by-product referred to as special coarse bran (SCB) in this study.

2.1.4 Nutrient composition of cereal grains and by-products

Maize is the most important energy source used in the Kenyan animal feed industry. Proximate composition of main parts of maize has shown that the germ has a high CP (crude protein) content, among other nutrients. The endosperm has high starch content while the pericarp is high in crude fibre (FAO, 1992). It is however low in protein contents (mostly prolamin / zein) and has low levels of the essential amino acids lysine and tryptophan (Mcdonald et. al., 1987). Maize also has the yellow pigments, usually containing around 5 ppm (parts per million) xanthophylls and 0.5 ppm carotenes (Leeson, 1997). Since this grain is also the staple diet of most Kenyans, the quantity available for use in animal feeds is limited and the cost is high (Bartilol *et al.,* 1988). There is therefore need to do more research on alternatve energy sources for the livestock feed industry.

Wheat in many countries is used as the major source of energy in poultry diets. The composition of wheat is usually more variable than that of other cereals. Enviromental temperature during growing has a major effect on wheat nitrogen content. Wheat is higher than maize in protein content but its energy level is slightly lower (Leeson, 1997). There are potential constraints in feeding much more than 30% wheat in a diet, especially for young birds. Wheat contains about 5-8% of pentosans, which can cause problems in digesta viscosity, leading to reduced overall diet digestibility and also wet manure (Leeson, 1997).

Rice is mainly grown for human consumption. However, periodically in rice growing areas, damaged grains, unfit for human consumption, are available for feeding animals. Kenya also produces a variety of cereal grain milling by-products such as, maize, rice and wheat milling by-products. Their availability, however, depends on the availability of the cereal grains (Bartilol *et al.,* 1988).

2.2 Rice Production

2.2.1 Rice crop

Rice is basically a semi-aquatic annual plant. The two cultivated species are *Oryza sativa* L. and *Oryza glaberrima stead.* Cultivars of these two species can grow in a wide range of water soil regimes, from a prolonged period of flooding in deep water to dry land on hilly slopes (FAO, 1990). Rice was first cultivated some 7000 years ago in East China and India (Lu and chang., 1980). It is the staple food of two -thirds of the world's population with 90% of the world's production of over 425 million tonnes grown in the Asian region (Saunders, 1986). World rice production is higher than that of any other crop (Carter *et al*., 1974). Brown rice is the whole grain rice taken from the field with the inedible husk removed (General FAQs, 2006). White rice is milled from brown rice as very little brown rice is consumed and milling removes the outer layer of the caryopsis producing white rice, which is almost entirely endosperm (Farrell, 1994).

Global, Regional and National paddy production

Global paddy output in 1999/2000 was 598 million tonnes, representing a 2.6 percent increase from the previous season. Rice production, consumption and trade are concentrated in Asia, so events in that region usually set the pace for the rest of the international rice market (FAO, 1999). Africa's paddy output for the 1999 season was estimated at 17.4 million tonnes which was a substantial improvement compared to the previous year. The increase was attributed to expansion of the area planted with rice and an increase in yields in some of the major rice producing countries, particularly Egypt (the largest rice producer in Africa), Cote d' Ivore and

Madagascar (FAO, 1999). In Kenya rice is grown in Nyanza, Western, Central and Coast provinces. The total national rice production is estimated at 70,000 tonnes per anum. Kenya has never been self-sufficient in rice production, and it imports about 170,000 tonnes of the grain (GoK, 2005).

2.2.2 Paddy production in Mwea Irrigation Scheme (MIS)

The scheme, which is the major rice producer in Kenya was started in the 1950s and gradually expanded to about 2,000 hectares at independence in 1963. It was then managed by a department in the Ministry of Agriculture. In 1966 the National Irrigation Board (NIB) was established through an act of parliament and was made responsible for the management of irrigation schemes in the country. Under NIB management, approximately 5,830 hectares were put under rice cultivation in 1973 (Wanjogu *et al.*, 1995). The mean annual paddy production at the MIS for the period from 1984/85 to 1988/89 was approximately 28,000 metric tones (CBS, 1990). The scheme supports 3,240 farm families (Wanjogu *et al.*, 1995).

Agronomic and marketing practices in Mwea

In the Mwea irrigation scheme, each tenant farmer has in his/her holding of between 1.2-2.0 Ha, a nursery area of 0.05 Ha. The nurseries are cultivated manually and insecticides and fertilisers applied as recommended. A seed rate of 75 kgs per nursery is used and the seed is pre germinated before sowing. Seedlings are transplanted when about four weeks old at a recommended spacing of 10 by 10 cm (Wanjogu *et al.*, 1995).

Land preparation involves flooding the fields to a depth of 10 cm and then ploughing using tractors mounted with rotavators followed by leveling with oxen drawn implements.

Transplanting in the flooded paddy plots is done manually. Seedlings are spaced according to the tillering ability of a variety, with Basmati having a wider spacing. During transplanting, triple super phosphate (TSP) fertiliser is applied at a rate of 125kgs/hectre. A split application of sulphate of ammonia (21%N) applied at transplanting and then 43 to 58 days after transplanting makes a total of 250 kgs to 500 kgs per hectre depending on variety of rice grown (Wanjogu *et al.*, 1995).

Weeding and weed control is done manually by pulling and by covering the soil surface with water at a depth of 2.6 to 5.0 cm deep. This controls most of the sedges and grasses, as their seeds would not germinate under water. Harvesting is usually done by hand after 90 days post transplanting. Timely harvesting ensures good quality, a high market value and improved consumer acceptance. Farmers judge their harvest time by examining the percentage of ripened grains in the panicles. The crop is ready for harvest when 80% of the panicles are straw dust coloured and the grains in the lower portions of the panicle are in the hard dough stage. Farmers in MIS usually harvest at maturity to minimize losses resulting from shattering of over ripe grains, unfavourable weather and pilferage. Spreading on canvass sheets enhances drying (Wanjogu *et al.*, 1995).

The National Irrigation Board's (NIB) regulations required that farmers deliver all their harvest to the board. Payments were not made on delivery, and sometimes these would not be made before the following harvest. The board would supply all inputs but costs were borne by farmers through deductions from their returns, where farmers had no say over the same. This led to dissatisfaction and farmers parted ways with the Board in 1999.

The farmers therefore stopped delivering their paddy to the NIB large-scale mill, specially made for rice milling. Currently most farmers are relying on small-scale single pass rice hullers. These cannot separate broken rice from the whole, which makes the rice less competitive in the market (Kenya Human Rights Commission, 2000). The dried paddy is packed in 75 kg bags for storage and marketing. Farmers sell to buyers in unmilled form while some take to small-scale millers at the shopping centres around MIS for processing. There are about fifty small-scale rice millers.

2.3 Rice Milling by-Products and Their Nutritional Value

Rice milling is a 2-stage process as shown in Figure 1. The first stage is the removal of the hull (husks) to obtain the brown rice grain. The grain has a bran layer consisting of the pericap, a seed coat, the aleurone layer and the germ. The grain also has an endosperm.

The second stage of milling is the removal of the brown layer to produce polished (white) rice. The main by-products of rice milling are hulls, rice bran, polishings and broken rice.

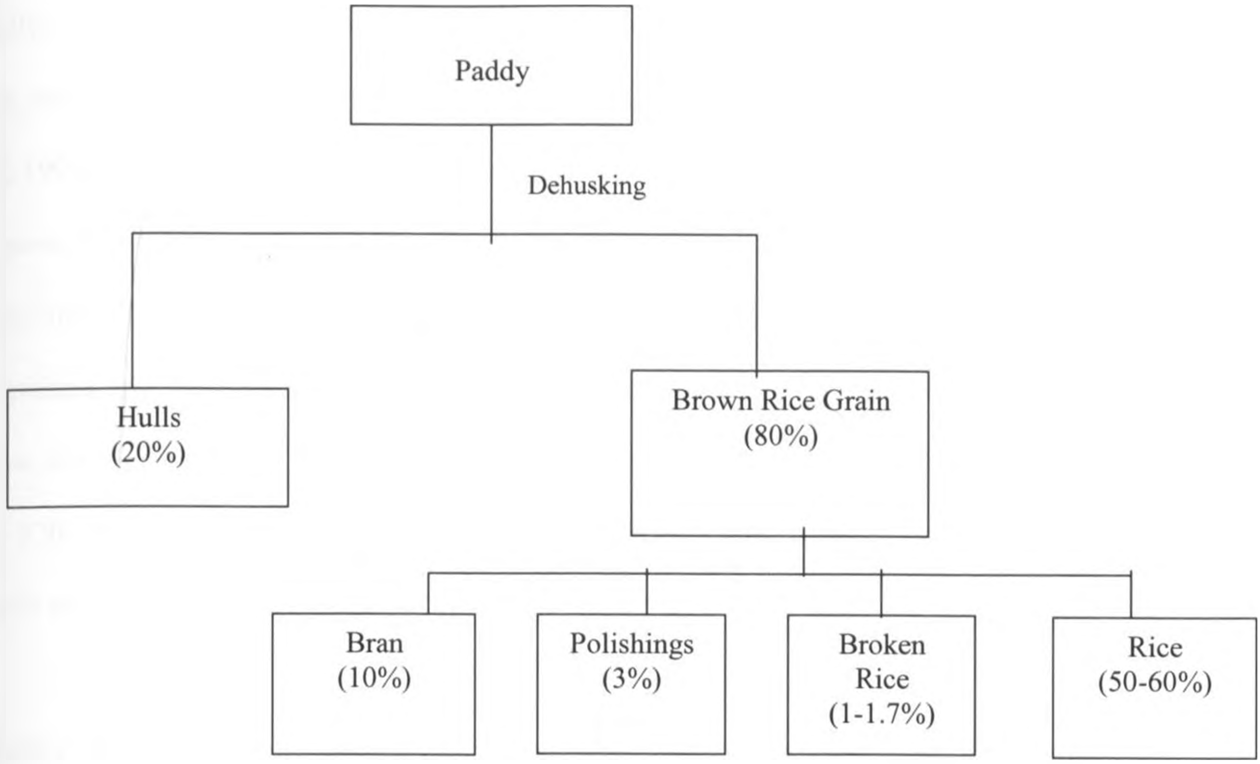

Figure 1: Multi-stage rice milling process

(FAO, 1990)

2.3.1 Rice by-products

The structure of rice is constituted by: -husk (hulls), bran, aleurone layer, embryo (germ) and endosperm. The hulls or husks make up approximately 20% of the paddy. They contain about 10% moisture and have high levels of ash, which mainly contains silica. The silica gives the hulls an abrasive surface. They have no nutritional value for non-ruminant animals. They are however used as bedding materials and as sources of energy for grain driers and electric power stations. At Mwea irrigation scheme, hulls are used to feed ruminant animals. Bran is the outer most coat of the grain containing nutrients and cellulose (Indiadiets foods, 2006). Rice bran is high in fibre content, which negatively affects feed intake and efficiency of utilization (Cherbut *et al.*, 1988). Aleurone layer is a thin layer found underneath the bran. Rice polishings, which basically consist of aleuronic layer and some fine powder from the kernel, are high in crude protein, low in crude fibre and high in vitamin B complex, oil content and residual carbohydrates (FAO, 1999). The embryo is the base of the grain and is rich in nutrients and vitamin E. The endosperm forms 75% of the grain. It consists mainly of starch, which is the principal source of calories (Indiadiets foods, 2006). Broken rice is nutritionally equivalent to polished rice. It has a crude protein level ranging from 7 (Ravendran *et al.*, 1991) to 9.4% (Crampton and Hams 1969) and low fibre level at 3.14% (Singh and Marrwaha, 1968). The metabolizable energy value is above 3200 ME Kcal/Kg (Wiseman, 1987). The by-product can therefore be considered as a potential energy source for chicken.

The nature of by-products from rice mills depends mainly on the type of milling operation. Multi-step operations undertake shelling, whitening and polishing separately. During each of these stages, certain by-products are recovered. The coarse bran recovered from the shelling stage mainly consists of hulls. The bran resulting from whiteners consist mainly of fragments of pericarp, aleurone and germ (Barber and Benedito de Barber, 1980). The rice polishing resulting from the polishing of white rice consists of fine grain particles and small proportions of adulterants carried over from previous stages. Broken rice is separated out after the polishing stage. The following figures give an approximate estimate of the proportions; hulls, 20%; bran, 10%; polishing, 3%; broken rice, 1 to 1.7%; polished rice, 50-60% (Figure1). The main by-products that are useful as animal feeds are rice bran, rice polishing and broken rice.

2.3.2 Chemical Composition and Nutritional Value

The main by-product of white rice milling in some countries eg Australia is referred to as pollard or rice bran and it includes true bran and polishings (Farrel, 1994). The chemical composition of rice bran varies over a wide range between different samples. Since the bran has little economic value, a high degree of milling is not practised in many countries unless the white rice is used to meet special needs, e.g. export market (Saunders, 1986). In Australia a report indicate that as little as 40% of the maximum yield of bran is frequently recovered (Saunders, 1986). The chemical composition of rice bran obtained after brown rice was milled through the first cone (milling 0-30 g/kg brown rice) was reported as: 13.2%; 20.2%; 10.8%; 7.9%; 22.2%; protein, fat, ash, cellulose and starch respectively. At the third cone milling, the same fractions were 16.7, 19.2, 10.0, 4.6 and 36.3%, respectively (Houston, 1972; Barber de Barber, 1980). Huller type mills produce bran that has low protein and oil content, higher fibre and ash than bran produced from cone type mills (Siriwardene, 1969). The friction type whitening machines produce bran of higher fat content than the abrasion type (Barber and Benedito de Barber, 1980). Rice bran is rich in linoleic acid (Belnave, 1982). In poultry the acid (18:2, n-6) is converted to a long- chain polyunsaturated fatty acid (PUFA) and is mainly found in the membrane phospholipids (Watkins, 1991). Insufficient deposition of the acid has an adverse effect on embryonic development. A 1% dietary inclusion level of the acid is sufficient for growing and adult birds, but higher levels are necessary for laying hens to achieve and maintain satisfactory egg weight.

Phosphorus is one of the major mineral constituents of bran. It occurs in phytic acid, nucleic acid, inorganic phosphate, carbohydrate and phosphatide, the major form being phytic acid (McCall et al, 1953). It is generally accepted that rice bran contains factors, which reduce feed intake and depress poultry performance (Saunders, 1986). The phytate content of rice bran is high and appears to be responsible for reducing availability of some minerals (Warren *et al.*, 1991). Trypsin inhibitors have been suggested as an important factor that could influence feed intake in rice bran (Kratzer *et al.*, 1974). However, the current study involved a general evaluation of rice bran with no specific tests on antinutritional factors. Rice bran is also rich in vitamins of the B group and tocopherols and has low contents of vitamins A, and C (Carangian and Sutaria, 1970). The same authors reported that though trace amounts of ascorbic acid were present in fresh bran, total loss of the same occurred after one-month storage at 27°C. There was however a total lack of vitamin D in rice bran. Due to wide variation in the chemical composition of rice by-products from different areas, it is important to subject the by-products from MIS to proximate analysis and actual feeding trials to establish their chemical composition and feeding value especially for poultry.

Bran is rich in various enzyme systems but lipase has merited the most attention since it affects the keeping quality and the industrial use of the material. The enzyme is dormant in the intact grain but it becomes markedly active as soon as the bran is removed from the rice grain (Barber and Benedito de Barber, 1980). The reason for this is that while lipase is localized in the testa cross layer of the rice grains, its substrate, the oil, is located in the aleurone, sub-aleurone layers, and the germ. The two are brought together when bran is scoured during milling. After milling, an immediate and rapid hydrolytic release of free fatty acids and a further breakdown by the action of lipooxygenase have been shown to occur in rice bran (Shaheen *et al.*, 1975). Storage temperature and humidity of rice bran are important factors in determining the rate of hydrolysis of the oil. Comparison of the content of free fatty acids between diets containing 600 g of rancid bran and another containing similar quantity of fresh bran was found to be 43 and 16% respectively (Hussein and Kratzer, 1982). The former was for bran stored for three weeks at 23.5° C. Inclusion of 250 ppm ethoxyquin has been shown to be effective in reducing rancidity development in rice bran for up to four weeks even when temperature and humidity are high (Cabel and Waldroup, 1989). This would indicate the importance of using antioxidants in feeds with high contents of rice bran to arrest deterioration associated with long storage.

In a report by Ambashankar and Chandrasekaran (1998), 21 samples of broken rice were analysed for proximate constituents and acid insoluble ash (AOAC, 1990), calcium (Talapatra *et al.*, 1940) and phosphorous (Fiske and Suubbarow, 1925) contents, as well as metabolisable energy (Carpenter *et al.*, 1956). Chemical composition was reported as: - 6.72-10.03% CP, 0.65-3.22% CF, 2.12-4.91% EE and 2.21-21.96% ash. The value of metabolisable energy was found to range between 2705-3478 Kcal ME / Kg while the true metabolisable energy was 3187 Kcal ME / Kg. The author concluded that broken rice could be considered as a potential high-energy feedstuff for chicken. Incorporating broken rice in poultry diets in the current study would help establish if this high energy by-product could fully replace the more expensive maize grain commonly used by feed manufacturers.

Rice by products in non-ruminant diets

Different rice milling by-products have been incorporated in diets for non-ruminants in a number of studies with varying results. Feed intake for growing-finishing pigs on diets containing 50-60% rice bran was found to increase with increasing amount of rice bran across dietary treatments while no significant effect on weight gain and other performance parameters (Karanja, 1994; Tuah and Boateng, 1982) was observed. It is generally agreed that feed conversion ratio gets poorer with increasing levels of rice bran in a diet, (E. Martin and D. J. Farrel, 1992) unpublished results. Studies by Lekule *et al* (1987) showed that cassava and rice polishings are excellent energy sources and can partially or even totally replace cereals in pig diets, provided that diets are formulated to meet the essential element requirements of the pigs. These research findings demonstrate the potential of rice bran in non-ruminant diets. Special coarse bran (SCB) from MIS, the focus of the current study might be considered as a non-conventional bran because it is obtained from a different type of milling process and hence the interest to investigate its usefulness in non-ruminant feeding.

Literature on the use of rice by-products in poultry diets demonstrates their potential as energy sources. Diets containing 20-45% of rice bran or rice polishings have been used to feed laying hens without compromising laying performance (Mahadevan *et al.*, 1957; Lodhi and Ichhponani, 1975). Sinha *et al.* (1980) showed that the ME content of rice polishings is lower than that of maize and wheat but was higher than that of pearl millet. The authors further demonstrated that rice bran or polishings might not completely replace maize as the major energy source in a layer's diet. However, there is need to evaluate the effect of partial replacement of maize with specific rice by-products from MIS. There is a scarcity of literature on the use of rice bran and broken rice from Mwea irrigation scheme in poultry diets.

Birds fed on diets containing 10% broken rice were reported to have a significantly ($P<0.05$) better feed conversion ratio than those on the control Ambashankar and Chandrasekaran (1998). In a study where broken rice replaced maize in diets for growing pullets, no significant ($P>0.05$) decline in weight gain was recorded up to a level of 50% broken rice (Nagra *et al.*, 1987). Diets containing 40% broken rice were compared to a maize soya bean control through a feeding trial and found not to differ significantly ($P>0.05$) in feed conversion ratio (Tyagi *et al.*, 1994).

Tangendjaja *et al.*, (1985) showed that Alabio ducklings could tolerate up to 750g/Kg rice bran without a depression in growth rate or feed conversion ratio.

2.3.3 The milling by-products of Mwea Irrigation Scheme

At the Mwea Irrigation Scheme, large and small-scale millers carry out rice milling. It is either in a multi-step or single step operation (single pass). In a multi-step operation, the by-products so far identified and recovered separately are rice hulls, coarse rice bran, fine rice bran, coarse broken rice and fine broken rice (locally known as "chicken feed"). With the exception of rice hulls, all the others are used as animal feeds. Fine rice bran (rice polishing) is the most widely used by-product. The single pass milling process yields a combined by- product, (the focus of this study) referred to as Special coarse bran (SCB). The nutritive value of SCB had hitherto not been studied or established and hence formed the basis of the current research work. The single-pass millers are less efficient and have a mean rice recovery of about 65%, 35% being milling by-product with an enormous turnover each season (Kiarie, 2003). The mills have a relatively low installation cost (Ksh. 170,000), are well distributed and offer better terms to small scale farmers.

2.4 Production and feeding requirements of layer chickens

Layer chicken are fed on concentrates compounded to meet their nutrient requirements. The concentrates used originate from cereals (maize, wheat, barley, oats, millet etc.), legume and oilseed cakes (soybeans, cotton seed cake, etc.) and animal by-products (fish meal, blood meal, meat and bone meal etc.) (GoK, 2006). Generally, concentrate feeds are readily available but the quality has been reported as fair to poor (GOK, 2000). The main energy sources are cereals, which are also staple food in the human diet, hence posing stiff competition between man and livestock especially during drought periods. In 1984, there was a severe drought, which caused a shortage of poultry feeds, due to reduced supply of maize for inclusion in livestock feeds. Nambi (1987) reported that due to that drought the poultry population in Kenya decreased from 19.6 million birds in 1983 to 15.3 million in 1984. A similar drought occurred in 1980, but changes in poultry populations were not recorded. Non-conventional feedstuffs could be very useful during such periods when competition between man and animals for similar feed resources is high. To cope with both short-term and long-term needs for poultry feeds, the government is currently promoting diversification of the feed resource base through use of alternative sources of energy (GOK, 2006).

2.4.1 Egg production cycle

The egg production cycle of a laying hen usually covers a span of twelve to fifteen months. Production commences at twenty two weeks of age, rises sharply, reaching a peak at about 28-32 weeks of age (Smith, 1990), and then gradually declines to a level of approximately 55% of lay when the hens are 82 weeks of age (Scott, 1969). There are three phases in the egg laying cycle. Phase 1 is designated as the time from commencement of egg production through maximum egg mass output. Phase 2 is the period between 36 and approximately 52 weeks and is marked by a high but declining egg production and increasing egg weight. Phase 3 runs from about 52 weeks to the end of the production cycle at about 80 weeks (NRC, 1994). During phase one a pullet is expected to increase egg production from 0% (at 22 week) to a peak of approximately 85% (Scott, *et al.*, 1982). At the onset of lay the size of an egg is about 40 grams. This increases gradually to approximately 60 grams at the peak production (Scott, 1969).

2.4.2 Nutrient and feeding requirememts

Layer chicken production follows three distinct feeding regimes namely: -Starter mash (0-8weeks); Grower mash (9-17weeks) and layer mash (18weeks to end of laying). Feeding requirements change as birds pass through the starting, growing, laying, and molt phases (NRC, 1994). The eggs produced by a pullet during a laying year weigh eight times as much as she weighs. During this period, she also increases her body size by 25%. To do this she has to eat nearly 20 times her body weight in feed (North, 1972). The most important factors affecting voluntary feed intake are characteristics of the bird (body weight, rate of live weight gain and output of eggs), quality of feed and the environment. Heavy and fast growing birds consume more feed while a 1% increase in egg production is associated with a 2% increase in feed intake. The major factor which affects this parameter is energy concentration. A decline in energy concentration results in increased feed consumption (Smith, 1990). On low energy diets, birds adjust their feed intake upward to meet the energy deficit (Cunningham and Morrison, 1976; McNaughton *et al.*, 1977b). However, the mechanism is not accurate and usually overconsumption results (Morris, 1968).

In general, the larger the body weight at maturity, the larger the same throughout the laying cycle and hence the larger the potential energy reserve and the greater the feed intake (Leeson and Summers, 1997). Under normal enviromental and managerial conditions feed intake increases with increase in egg production and / or age of bird, and this must be taken into account when formulating diets.

Brown egg layer pullets given a diet made to provide 17% crude protein and 2850 Kcal ME /Kg have been shown to consume 89 grams of feed per day at the twentieth week of age. The same was shown to consume 118 grams during the thirtieth week. This enhances the attainment of ideal body weight and appetite at maturity (Leeson and Summers, 1997). Many problems associated with reduced nutrient intake for layer birds can be overcome by ensuring optimum body weight and appetite of young pullets. Layers have specific nutrient requirements that are all geared towards maximum egg production in terms of numbers, size and rate (Scott, 1969). To produce a good layer hen, the chick and growing pullet must be supplied with all the necessary nutrients in the correct proportions. Body weight is important in laying hens. At onset of lay an average pullet weighs 1450 grams and is expected to increase in body weight to approximately 1900 grams at 42 weeks during peak production. Small birds, at peak production, will not have the physical capacity to consume enough feed to provide adequate energy for egg production and will be forced to rely on body stores. This puts the bird in a negative energy balance, which results in weight loss during peak egg production (Scott, 1969).

Management practices, as well as nutritional regimes, can affect the maintenance requirements (NRC, 1994). In warmer houses, layers need less energy in maintaining body temperature. Hens eat less feed with increasing temperatures and decrease feed consumption drastically at temperatures above 30^{o} C (Davis *et al.*, 1973). Some research indicates that hens are able to make a good adjustment of feed intake to provide nearly identical daily energy intake with up to 6 percent dietary fat (Sell *et al.*, 1987). Most egg-type hens are given continous access to feed. However, feeding programmes may be modified after the maximum rate of egg mass has been attained (Cerniglia *et al.*, 1984; Cunningham, 1984).

2.5 Evaluation of Egg Production and Quality Parameters

2.5.1 Egg production

Egg production is the main factor used in layer evaluation. Production on a daily, weekly or overall basis can be reported as hen-housed or hen-day egg production. Hen day egg production (%) for any given day is calculated as:

$$\frac{\text{Number of eggs produced X100}}{\text{Number of Live Hens}}$$

Similarly, hen-housed egg production (%) on any given day is calculated as:

$$\frac{\text{Number of eggs produced X100}}{\text{Number of hens initially housed}}$$

Hen-day egg production is an indicator of how well the live hens are laying and is unaffected by the level of mortality. In theory a producer could lose all but 10 birds out of 100 housed, and if they laid 8 eggs on any given day, the hen-day egg production would be 80%. Both egg production and mortality affect hen-housed egg production. Percent egg production, whether on hen-housed or hen-day basis varies from day to day.

Egg production is therefore usually reported over specific time periods such as a week or 4 – week period. Hen-day egg production (%) over a specific number of days is calculated as:

Number of eggs produced in Period X100
Sum of number of live hens on each of the days*

(*Referred to as total hen days)

Hen-housed egg production (%) over a specific number of days is calculated as:

Number of eggs produced in period X100
Number of hens initially housed XNumber of days.

(Jacob, 1993).

2.5.2 Egg Weight and Egg Mass

Egg weight is correlated with weight of laying hens (Jull, 1924). The relative egg weight during a laying cycle parallels the relative body weight. Within a flock, heavier birds lay heavier eggs (Leeson and Summers, 1987). Nutritional means may be used to alter egg weight (NRC, 1994). Egg Mass is computed by taking the weight of eggs multiplied by the number of eggs for a given period. Maximum egg mass output is expected at peak production (NRC, 1994).

2.5.3 Shell strength

Calcium is the main factor affecting shell quality but vitamin D_3 and phosphorous also has influence (Leeson and Summers, 1997). Rice bran is associated with low calcium: phosphorous ratio of 1.3:6 (Rao and Reddy, 1986). The NRC (1994) requirements is given as 2:1 calcium to non-phytate phosphorous for most poultry diets, with the exception of diets for laying birds which is estimated at a ratio of 12: 1 for the elements (Rao and Reddy, 1986). The number of marketable eggs is reduced by incidences of cracked and broken eggs, which is a function of shell strength hence the importance of this parameter. Shell strength can be assessed using direct or indirect methods.

Direct methods

One of the direct methods of evaluating shell strength is measurement of shell thickness. A shell thickness of at least 0.33 mm is necessary to give the egg a greater than 50 % chance of passing through the normal marketing system without breaking (Stadelman and Cotteril, 1977). Shell thickness is measured using a paper thickness micrometer with a convex anvil on one leg to reduce the errors resulting from shell curvature.

Indirect methods

Measuring specific gravity of eggs:

The specific gravity of an egg (SG) is significantly correlated to the percent of shell (Olsson, 1934; Novikoff and Gutteridge, (1949). Salt solutions of different specific gravity are used for this immersion test. This measurement is accurate only if eggs have very small air cells, thus only with fresh eggs (Moreng and John, 1985). There are several sources of error in measuring egg SG by floatation in saline solutions. One is the temperature of the solutions. Most SG determinations are done with solutions stored at room temperature. Voisey and Hamilton (1977) showed that, with ambient temperature ranges of 22 to 32^{o}C the mean SG of 115 eggs increased linearly with increasing solution temperature at 0.00033 per ^{o}C. It is often customary to store eggs overnight in a cooler temperature / place and take the SG readings in the morning. The stored eggs will have a cooling effect on the warmer saline solutions. The effect will be greatest with the first solution used.

2.5.4 Yolk mottling

This refers to the discolouration of the yolk. There are a number of known causes of mottling including certain worming compounds, gossypol, Nicarbazin and storage at room temperature (Cunningham and Sanford, 1974). The incidence of mottling has also been shown to increase when layer rations are deficient in calcium (Roland *et al*, 1972). The phytate content of rice bran has been reported as high and it was suggested that this could be responsible for reducing availability of some minerals (Warren, *et al.,* 1991). Phytate binds minerals like calcium, making it unavailable, thereby causing mottling. This therefore makes the parameter important in this study. A scoring system where the absence of any mottling is denoted by zero, while scores between one and five are assigned to different degrees of mottling is used in assessing this parameter.

2.5.5 Yolk colour

Carotenoid pigments are responsible for yolk colour and they consist mainly of cryptoxanthine, alcohol -soluble xanthophylls, carotenes and vitamin A is also included in this group (Carmen and George, 1997). Xanthophylls, which are characterized by the presence of hydroxyl groups, are the most important carotenoids in poultry diets (NRC, 1994). Consumers are receptive to eggs with a fair degree of yolk pigmentation mainly for aesthetic reasons (Leeson and Summers, 1987). Synthetic carotenoids that have been approved by regulatory agencies are used in poultry diets, because levels of desired pigments in natural feedstuffs are not always constant and many of the carotenoid containing feedstuffs are relatively low in energy content (NRC, 1994). The Roche colour fan is used for the assessment of yolk colour.

2.5.6 Blood spots and Meat spots

A blood spot is basically a dot of blood formed in close conjunction to the egg yolk and can usually be detected in candling. Vitamin A or K deficiency has been known to increase the incidences of blood spots (Moreng and John, 1985). Rice bran has been reported to have low levels of vitamin A (Carangian and Sutaria, 1970). A blood spot can occur in the egg yolk since during ovulation a slightly irregular tear of the stigma into the more vascular area can cause the formation of a drop of blood on the yolk. According to the current grading standards in the USA, eggs with blood spots are not used for human food because of their unfavourable aesthetic value, not because they are not nutritious and wholesome as other eggs (Carmen and George, 1997).

Meat spots are degenerated bloodspots or loose pieces of oviduct tissue in the albumen. Blood spots and meat spots that are in the albumen appear to move more rapidly on candling than the chalazae, which may be mistaken for meat spots. They are most easily detected if the eggs are stored for at least 24 hours prior to candling. They will appear as rather distinct spots that more rapidly pass the candlelight (Moreng and John, 1985). A scoring system similar to the one used for the assessment of yolk mottling can be used for the assessment of this parameter.

CHAPTER THREE

3.0 EXPERIMENT ONE: DETERMINATION OF THE CHEMICAL COMPOSITION OF RICE BY-PRODUCTS FROM MIS AND STUDY OF THE EFFECT OF INCLUDING SPECIAL COARSE BRAN (SCB) AND FINE BRAN (FB) IN LAYER DIETS ON PERFORMANCE

3.1 INTRODUCTION

The practical part of the Master of Science degree work was embedded in a wider programme sponsored by the African Institute for Capacity Development (AICAD), whose objective was to help in poverty alleviation in Mwea and promote food and nutritional security. Further emphasis was laid on the optimal utilisation of locally available resources, such as Special coarse bran and broken rice among other rice milling by-products. Currently the by-products are mainly fed to ruminant animals. However, due to the small sizes of the land parcels per household (1.2-2 Ha) and the fact that most of the land is under rice production, most of the by-products either goes to waste or are sold out.

Maize is an excellent source of digestible energy (Mcdonald, *et al.,* 1987) and it supplies the bulk of the energy in a layer diet. However, being the staple grain for most Kenyan communities, it is expensive hence not economical for feed milling. Locally available non-conventional feedstuffs could play this role appropriately if their nutritional value is known. Rice by-products, which are produced at approximately 9,644.25 tonnes annually (as cited in earlier literature) at the Mwea Irrigation Scheme, could fulfil this requirement and hence the need to determine their feeding values. Although some work on the use of rice bran from other countries has been reported, there is no information on the nutritional value of specific rice by-products generated from this major rice-growing scheme in Kenya.

The objectives of this experiment were to:

i). Determine the chemical composition of the Mwea rice milling by-products

ii). Assess the levels of ash, calcium and phosphorous contents of the Mwea rice by-products, and

iii). Assess the effect of feeding diets containing graded levels of SCB on layer chicken performance.

3.2 Materials and Methods

3.2.1 Source and Chemical Composition of Rice By-products

The rice milling by-products used in this study were purchased from the MIS. Fine bran and broken rice (feed grade) were obtained from the Mwea Rice mill owned by the National Irrigation Board (NIB), while special coarse bran (SCB) was obtained from the privately owned small-scale mills.

Analysis of the chemical composition

Samples of the three by-products (fine bran, broken rice and special coarse bran) were subjected to proximate analysis in the laborotary to determine their nutrient content. They were also analysed for ash, calcium and phosphorous contents. Official methods of analysis (AOAC, 1984) were used.

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3.2.2 Experimental design and management of birds

The feeding trial in experiment one was conducted for a period of sixteen weeks, from 21st to 36th week of age within phase 1 of laying. It comprised a feeding trial to investigate the potential of two rice by-products (SCB and FB) as dietary energy sources for commercial layer chicken. A total of four hundred ISA brown layer chicks were obtained from a commercial hatchery and used for two experiments. They were housed in a battery brooder for the first four weeks and thereafter transferred to battery cages in a grower/ layer house up to twenty weeks of age. In the pre-experimental period, they received conventional layer chicken diets (chickmash, 0-8thweek, grower's mash, 9th-20thweek of age).

At the end of twenty weeks, a total of 380 birds were selected and randomly allocated to two experiments. One hundred and sixty eight (168) for Experiment 1, two hundred and twelve (212) for Experiment 2 (with 140 of these assigned to the on station and 72 to the on-farm trials respectively). The two experiments ran concurrently. The dimensions of the layer house were 12 m (length) by 6m width) and with long, wide corridors that served as working spaces. Natural lighting system, which was relatively constant at 12 hours per day, was used. This was provided through open sides fixed with chicken wire mesh. The open sides also provided adequate ventilation. The experimental birds were in cages made of metallic wire mesh and measuring 45 by 45 by 30 cm and fitted with feeding and drinking troughs. A set of four (4) cages constituted an experimental unit. The first three cages in each experimental unit housed two birds each, while one bird occupied the fourth. The birds were vaccinated twice against Gumboro at 10th and 21st day while the New Castle and Fowl pox vaccines were both given at twelve and a half weeks. Feed and water were provided throughout. Water troughs were cleaned daily to remove contamination from feed particles. The feed troughs were filled to three-quarter level to prevent spillage. Excreta collecting on the floor under the cages was removed twice weekly to prevent any excessive build-up.

3.2.3 Experimental diets

The rice by-products were obtained from Mwea (section 3.2.1). The other feed ingredients were purchased from a feed manufacturing firm while maize was bought at the local market. Six diets whose composition is shown in Table 1 were formulated. Five of these were test diets with zero, five, ten, fifteen and twenty per cent SCB. Fine bran was incorporated at a fixed level of 20% in all the test diets. This level has widely been used without any deleterious effect. These were compared to a maize- soyabean meal control (non-rice) diet (Diet 1). The six diets were fed to 168 pullets, with each diet randomly assigned to a group (treatment) of twenty eight birds. Each dietary treatment (28 birds) comprised of four replicates of seven birds each in a completely randomized design. The experimental diets were fed from the 21st to 36th week of age. The five test diets were formulated according to NRC (1994) requirements to provide 17% crude protein and 2850 Kcal of metabolisable energy (ME) per kilogram. For each diet, all the ingredients were weighed and mixed for 45 minutes using a small feed mixer (70-kg capacity)

Not much literature was accessed on the levels of carotenoids in rice by-products, yet the yolk colour is an important internal egg quality characteristic, especially with respect to aesthetic appeal, closely associated with deep yellow colour. To give an indication of how the by-products based diets would influence the yolk colour; synthetic carotenoids were incorporated or excluded in diets in two distinct periods. Carotenoids were excluded in diets in the period between the 20th and 28th week of age, while the same were incorporated in diets between 29th and 36th weeks of age.

3.2.4 Data collection

3.2.4.1 Layer chicken Performance

Data on feed intake, body weight gain, egg production and weight of eggs was taken weekly over the 16 weeks of the experiment. Data on the internal egg quality factors was recorded on a monthly basis. The various performance parameters were measured as follows: -

a) Feed intake

The difference between the amount of feed offered at the beginning of each week and the leftover at the end of the week for each replicate was used to compute weekly feed intake per replicate. This was further used to compute the mean feed intake per bird. Data was then pooled together for 4-week periods and for the overall 16-week period. Means for the four replicates were used to compute the treatment mean per bird.

b) Body weight gain

The total weight of birds in each replicate was taken every week from which the mean body weight per bird was computed. The mean weight per bird for each replicate at week 36 was used to compute the treatment mean. The difference between the mean weight per treatment at 20 and 36 weeks of age was used to compute the weight gain per treatment. The treatment means were computed as average for the four replicates.

Table 1: Composition of Layer diets used in Experiment 1 (21-36 weeks of age)

Ingredient, %	Diets					
	Control	1	2	3	4	5
Fine bran	0	20	20	20	20	20
Special coarse bran	0	0	5	10	15	20
Maize	57.04	40.93	36.31	32.36	28.36	24.31
Corn oil	2.98	2.94	2.83	2.76	2.70	2.63
Soya bean meal	19.38	17.66	17.09	16.57	16.08	15.61
Fish meal	9.93	9.80	9.43	9.20	8.97	8.76
Limestone	7.95	6.82	6.60	6.44	6.28	6.13
Dicalcium phosphate	1.86	0.98	1.89	1.84	1.79	1.75
Vitamin/Mineral Premix[2]	0.50	0.50	0.47	0.46	0.45	0.44
Methionine	0.05	0.049	0.08	0.07	0.07	0.07
Lysine	0.05	0.05	0.05	0.05	0.04	0.04
Carotenoids	0.02	0.02	0.02	0.02	0.02	0.02
Common salt	0.25	0.25	0.24	0.23	0.22	0.22
Determined Analysis, % (air dry basis)						
Dry matter	89.3	90.06	90.74	90.62	91.00	91.28
Crude Protein	17.46	17.11	17.32	17.29	17.32	17.08
Crude fibre	3.38	5.43	5.74	5.95	6.05	6.18
Ether extract	5.92	7.48	8.54	8.59	8.73	7.98
Ash	9.3	9.5	9.7	9.9	10.1	10.3
Phosphorous	1.27	1.20	1.24	1.52	1.40	1.45
Calcium	3.96	4.06	4.09	3.76	4.00	4.09

[1]Vitamin mineral premix composition: Vitamin A-4, 500,000 IU/kg; vitamin D_3-900, 000 IU/kg; Vitamin E-12000mg/kg; vitamin K-1000mg/kg; vitamin B_1-700mg/kg; vitamin B_2-1750mg/kg; Vitamin B_6-1500mg/kg; vitaminB_{12}-0.024mg; Nicotinic acid-32mg; Pantothenic acid-4000mg/kg;

Vitamin C-40, 000mg/kg; Cholinechloride-350mg/kg; Folicacid-400mg/kg; Fe-12800mg/kg; Mn-4800mg/kg; Cu-1600mg/kg; Zn-14, 400mg/kg; I-448mg/kg; Co-72mg/kg; Se-40mg/kg; Antioxidant-1600mg/kg;

c) **Egg production and quality**

Mean egg production (number per bird) in each replicate was computed every week. Data was pooled together on per replicate basis for the 16 weeks. Thereafter, the totals were divided by the number of birds in the replicate to give the data per bird. The treatment means were calculated as the average of the four replicates. Eggs were collected three times a day: -early in the morning, midday and in the evenings. Egg mass and quality parameters were assessed as shown below.

i). **Egg weight and mass**

The weekly total weight of eggs produced per replicate was divided by the number of birds (in the replicate) to give the egg mass per bird. This represented the mean egg mass per bird per replicate for the week. The egg mass per bird divided by number of eggs per bird gave the mean weight per egg for the week. Egg mass data was computed for 4-week periods and for the overall 16-week period.

ii). **Egg shell strength**

The specific gravity method was used to determine the shell strength on monthly basis. Nine salt solutions were prepared with specific gravity ranging from 1.060 to 1.100 increasing at intervals of 0.005. This range has been used successifully in other trials. To three litres of water, the following amounts of salt were added: 276g for 1.060 specific gravity, 298g for 1.065, 320g for 1.070, 342g for 1.075, 365 for 1.08, 390 g for 1.085, 414g for 1.090, 438g for 1.095 and 462g for 1.100 specific gravity. Two eggs were chosen at random from each replicate and labeled appropriately. The salt solutions were placed in 500ml beakers. The two eggs from each replicate were immersed in each of the solutions separately. The strength of the solution in which each egg floated first was recorded. The mean specific gravity of an egg was estimated to be equivalent to the specific gravity of the saline solution in which it first floated. The mean specific gravity of eggs from each of the replicates was computed as the average strength of the two solutions where each of the eggs floated. Treatment mean was calculated as the average of the four replicates.

iii) Yolk colour

One of the two eggs used for the assessment of shell strength was further used for yolk colour assessment. It was broken into a Petri dish and the colour was identified using the Roche Colour Fan. Treatment means were calculated as mean colour scores for the replicates.

iv). Yolk mottling

The same egg used for the estimation of yolk colour for each replicate was used to assess the yolk mottling. The following scoring system was used:

0 – No visible mottling spot.

1 – Very slightly spotted (usually a small oval blemish of = 0.15cm in diameter).

2 – Slightly spotted; (Usually 2 - 4 small oval blemish of = 0.15cm in diameter or 1 blemish of = 0.30cm).

3 – Moderate spots (easily detectable, often appear as swirls or undulated shape covering 5 -15% of exposed yolk surface).

4 – Severely spotted; (usually covers up to 33% of exposed yolk surface).

5 - Very severely spotted; (usually covering up to 60% of exposed yolk surface).

Treatment means were computed as the means for the replicates v). **Blood and meat spots**

The same egg used for the estimation of yolk mottling was used to assess the presence of blood and meat spots on the yolk and albumen. The scoring system used was similar to that of yolk mottling (above) but visually assessing the incidence of blood spot and meat spot blemishes. (Jacob, 1993)

3.2.5 Statistical analysis

Treatment means were calculated using Microsoft excel program while analysis of variance of the same was computed using Genstat Discovery Edition, a statistical program. Significant treatment means were separated using the Duncan's multiple range tests.

3.2.6 Economic evaluation

The market prices of ingredients in March 2004 (when this work was done) were used to compute the break-even prices of the formulated diets. The mean feed intake per bird for each treatment over the experimental period multiplied by the unit cost of the corresponding experimental diet was used as the basis of computing the cost of feeding one bird. The selling price per dozen of eggs (weighing 0.5 kg) was fifty shillings. Therefore 1 kg egg mass would retail at one hundred Kenya shillings. The total eggmass per treatment per bird multiplied by one hundred was the basis of computing the income. Net income per bird was calculated as the difference between the total income per bird and cost of feeding per bird per treatment. This was just a simple economic assessment to serve as an indicator on performance of diets and their costs and not a full gross margin computation.

3.3 Results and Discussion

3.3.1 Chemical composition of the Mwea rice by-products (as determined by the researcher at the University of Nairobi, department of animal production, animal nutrition laborotary).

Table 2: Chemical composition of Mwea rice by-products (Air-dry basis).

Proximate constituents, ash, phosphorous and calcium (%)	Broken rice	Fine bran	Special coarse bran
Dry Matter	88.61	91.33	91.90
Crude Protein	8.67	10.83	5.69
Crude Fibre	2.66	8.32	31.88
Ether Extract	1.36	16.09	3.90
Ash	1.19	10.15	11.64
Phosphorous	0.33	0.83	0.38
Calcium	0.16	0.045	0.076
Nitrogen Free Extract	74.73	45.94	37.95

Fine bran contained higher levels of oil (ether extract) compared to broken rice and special coarse bran (Table 2). It also had high ash and protein contents. Fine bran is a mixture of pericap, seed coats and some aleurone layer. The latter component is relatively rich in protein, which explains the high protein content of fine bran compared to broken rice. Broken rice had average levels of protein (compared to fine bran and special coarse bran), low crude fibre and high levels of Nitrogen Free Extract and calcium. The crude protein, ether extract and crude fibre contents were 8.75, 1.4 and 2.55% respectively, making it a good potential feed for non-ruminant animals. The analysed nutrient content of rice grain (broken rice) was similar to that of maize grain, which has an average of 8% crude protein, 3 % crude fibre and 1-2 % ether extract. The two cereal grains would therefore be expected to have similar levels of metabolisable energy and can presumably substitute each other in poultry diets. According to literature, the ME values for the two grains are 3300 ME Kcal/kg for maize and 3187-3475 ME Kcal/kg for rice (NRC, 1994; Ambashankar and Chandrasekaran, 1998). The rice grain is however reported to have low levels of of some antinutritional factors such as oxalates and trypsin inhibitor (Leeson and Summers, 1997), which could affect its utilisation if included at very high levels in poultry diets. The by-products of the two cereal grains however show considerable differences, although they are products of different milling procedures. Conventionally, rice is milled in a multi-stage operation (Figure 1) while maize is usually milled in a single stage operation. In addition, these by-products consist of different fractions of the two types of whole (unmilled) grain and hence expected to be of different nutrient composition. The common maize bran is therefore a different kind of by-product from rice bran especially where the latter comprises of two (or more) types of by-products as found in this study. The crude fibre level of rice bran is variable depending on the amount of husks mixed in it during the milling process. Rice husks have high levels of crude fibre and ash. Special coarse bran (SCB) is produced by a single milling process. The results showed its chemical composition was poorer than that of fine bran, with higher levels of crude fibre showing it contained more husks than the fine bran. However, it had higher levels of ash, especially Calcium which could be useful for egg production depending on bioavailability.

The rice by-products analysed in the current study had striking differences, well demonstrated by the levels of crude protein, crude fibre and ether extract. With a high fat content (ether extract) and low crude fibre, fine bran would apparently have a higher level of ME than SCB and therefore be well utilised at higher inclusion levels in poultry diets. The high level of crude fibre in SCB was further expected to contribute to high fibre levels in diets containing this by-product which is associated with low energy values. The presence of high crude fibre levels in poultry diets could lower digestibility and hence overall utilization of such feeds. However, birds have an ability to adjust their feed intake upwards to meet their energy demand from low energy diets. The level of substitution of maize as an energy ingredient with specific rice by-products would apparently depend on the metabolisable energy content of the latter feedstuffs and the capacity of the layer to adjust its feed intake upwards to meet any energy deficit in the feed.

3.3.2 Layer Performance

Results of feed intake, body weight and weight gain at 36 weeks of age, egg production (egg number and egg mass) and the feed conversion efficiency (feed: eggs) during the experimental period (21^{st}-36^{th} weeks of age) are summarized in Table 3. The trends observed in the mean monthly feed intake (4-week periods) are shown in Table 4 and Figure 2, while trends observed in the mean monthly egg mass production (4-week periods) are shown in Table 5 and Figure 3. The mean scores for the egg quality factors are summarized in Table 6.

The mean feed intake per bird for the diet containing 20% SCB was 14.18 kg which was significantly ($P>0.05$) higher than that of the control (10.54 kg) and other diets (9.12, 10.22, 12.00 and 13.41 kg for birds on diets with 0, 5, 10 and 15 % SCB respectively). Birds on diets containing 10, 15 and 20% SCB had significantly ($P<0.05$) higher feed intakes than those on the control and other test diets during the experimental period. Birds on the control diet had significantly ($P<0.05$) higher feed intake than those on diets containing 0 and 5% SCB. Feed intake increased with increase in age of birds and level of SCB among rice based diets.

Birds' attempt to maintain a given energy intake each day, and therefore, while on a low energy diet, feed consumption increases as the bird attempts to meet the energy deficit (Scott 1969). While pullets appear to have a fairly precise inherent ability to regulate their energy intake regardless of dietary energy level (Cunningham and Morrison; McNaughton et al., 1977b), the mechanism is not perfect and as energy level in a diet declines, the adjustments in feed intake are not accurate and usually overconsumption of energy results (Morris, 1968). In the current study, feed intake increased with increase in the level of SCB in the rice based diets. The SCB had high levels of crude fibre (Table 2) and increase in its content in rice based diets was attributed to increased dietary fibre level. This was evident from the determined composition of diets presented in Table 1. High levels of dietary fibre are associated with poor digestibility hence low ME value of diets. Although the ME values of the diets were not assayed, it was expected that the increase in the level of SCB corresponded with a decline in ME.

The observations on feed intake made in this study were similar to those by Piliang *et al.,* (1982). These researchers found that birds fed on diets containing 81.5% rice bran with an ME value of 2320kcal/kg consumed more feed than layers fed on a maize-soya bean control diet. The latter diets had an ME value of 2750 kcal/kg. Similar observations were made by Din *et al.,* (1979), where layer birds were fed diets containing 68% rice bran. In the study by Din *et al.,* (1979), it was noted that feed intake was higher for birds fed on the diets based on rice bran than those fed on the maize soya bean meal control diet. Studies to evaluate the potential use of rice by-products have also been done with other non-ruminant animals. In Alabio ducklings, Tangendjaja *et al.,* (1985) found that rice by- products could be incorporated upto 75% of the diet without compromising performance of the birds. They also noted that feed intake was higher for birds fed on diets containing 75% rice bran than for those fed on the maize-soya bean meal control diet. In pigs, Karanja (1994) and Tuah and Boatang, (1982) observed that rice bran could replace upto 60% of maize in the diets of pigs weighing between 45-66 Kg. Feed intake of pigs increased with increasing levels of rice bran in the diets in the two studies

Feed consumption in the current study generally increased towards the peak laying period, with a correspondingly enhanced laying performance. However, data analysis for all parameters compared the different treatments across periods. It may be reasonably deduced that with increase in age, the bird's adaptation capacity was enhanced and high fibre diets were utilized more efficiently. At the onset of lay, most layer chicken are reported to consume about 70 grams of feed per day rising to about 100 grams during the peak production period (Scott *et al.*, 1982). The trends on feed intake reported by the cited author are consistent with the results of the current study.

Table 3: Overall Layer Performance (21st-36th weeks of age)

	Diets						
Parameters assessed	Control	1	2	3	4	5	LSD[1]
Feed intake (kg/bird)	10.54[c]	9.12[a]	10.22[b]	12.00[d]	13.41[e]	14.18[f]	0.18
Body weight (g/bird) at 36 weeks of age	1841.9[c]	1810.5[a]	1812.0[a]	1831.1[b]	1845.5[c]	1860.0[d]	3.90
Weight gain (g/bird)	291.5[d]	253.2[a]	266.6[b]	285.7[c]	301.8[e]	319.9[f]	4.50
Egg production (number/bird)	66.7[e]	53.6[a]	59.6[b]	60.1[c]	64.7[d]	67.2[f]	0.26
Egg production (Hen day %)	59.6[e]	51.5[a]	53.3[b]	54.6[c]	57.9[d]	60.6[f]	0.26
Egg mass (kg/bird)	3.74[c]	3.18[a]	3.19[a]	3.47[b]	3.75[c]	3.85[d]	0.01
Feed conversion ratio (kg feed:kg eggs)	2.81[a]	2.86[a]	3.20[b]	3.46[c]	3.57[d]	3.68[e]	0.05

[ab]Means followed by the same superscript per row are not significantly ($P>0.05$) different
[1]LSD-Least significant differenc

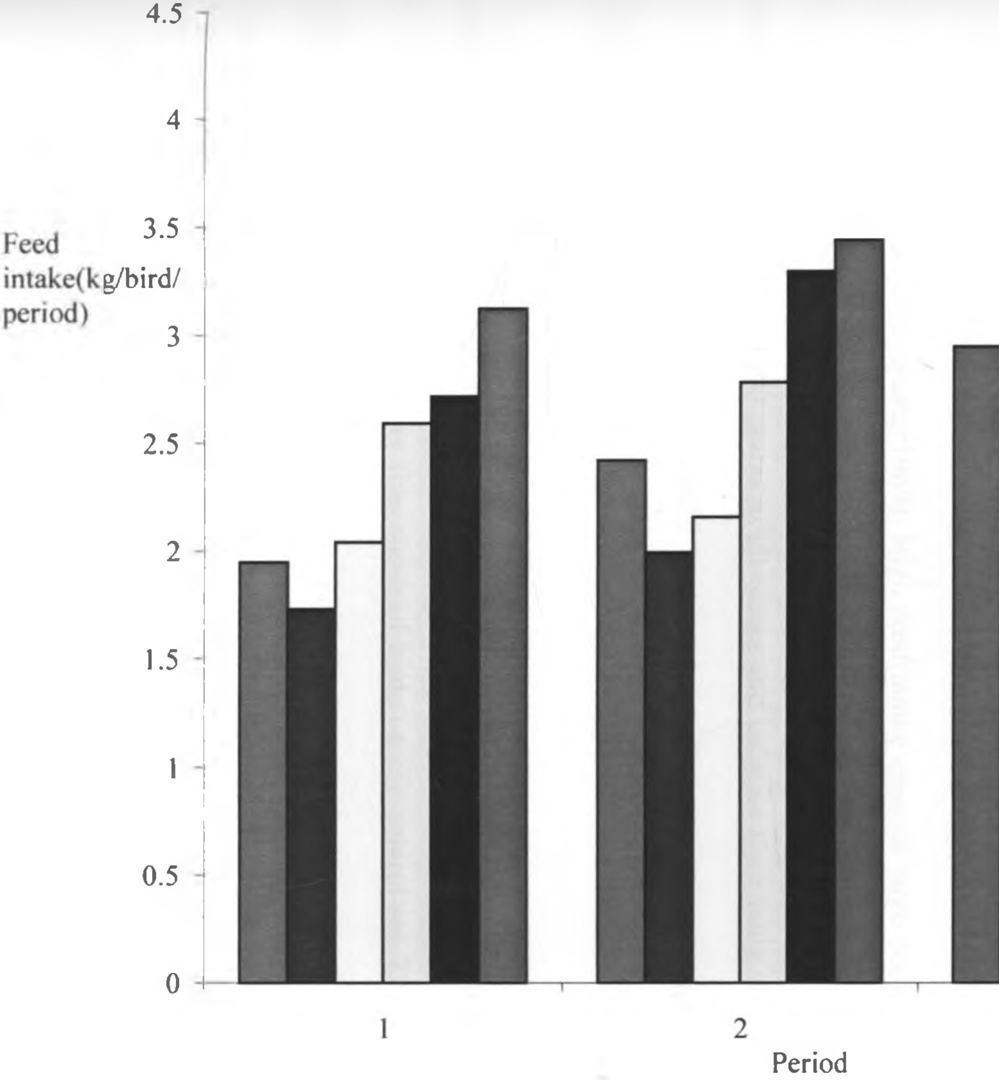
Table 4: Feed Consumption over 4- week periods, (kg/bird/period)

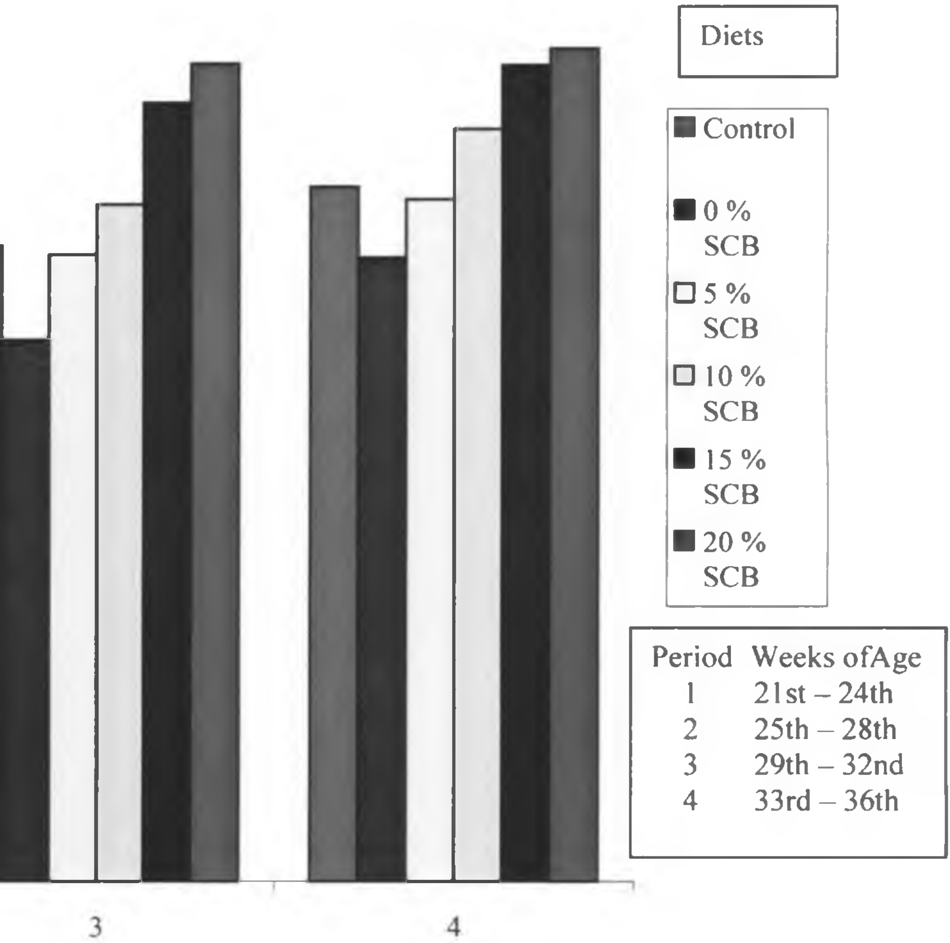
Weeks of age	Diets						
	Control	1	2	3	4	5	LSD[1]
21st-24th	1.95[b]	1.73[a]	2.04[c]	2.59[d]	2.72[e]	3.13[f]	0.06
25th-28th	2.42[c]	1.99[a]	2.16[b]	2.78[d]	3.30[e]	3.44[f]	0.07
29th-32nd	2.95[c]	2.51[a]	2.87[b]	3.14[d]	3.61[e]	3.77[f]	0.10
33rd-36th	3.22[c]	2.89[b]	3.16[b]	3.49[d]	3.78[e]	3.85[f]	0.05

[ab]Means followed by the same superscript per row are not significantly (P>0.05) different

[1]LSD-Least significant difference

Figure 2: Trends in feed intake over 4-week periods in Experiment I





Diets
Control
0 % SCB
5 % SCB
10 % SCB
15 % SCB
20 % SCB
Period Weeks ofAge
1 21st – 24th
2 25th – 28th
3 29th – 32nd
4 33rd – 36th
3
4

Birds on 20% SCB diets weighed 1860.00 g per bird which was significantly ($P<0.05$) higher than those on the control (1841.90g) and other test diets (1810.50, 1812.00, 1831.10 and 1845.50 g for birds on diets with 0, 5, 10, and 15 % SCB respectively) at 36 weeks of age (Table 3). The body weights of birds on the control diet and the diet containing 15% SCB were not significantly ($P>0.05$) different. The two groups of birds were however significantly ($P<0.05$) heavier than those on diets containing 0, 5 and 10% SCB. Body weight of birds increased with increase in the level of SCB in the diets and age of birds.

Earlier discussion indicated that feed intake increases when layers are subjected to low energy density diets, probably in an attempt to meet the energy deficit. However, this has also been shown to lead to overconsumption of energy. This phenomenon by birds on diets with high levels of SCB might have contributed to the significant ($P<0.05$) increase in weight. Feed intake and body weight are correlated (Scott, 1969). High feed intake ensures large body weight and energy reserve in the body (Leeson and Summers, 1997). The normal growth curve for layers shows that pullets weigh about 1500 grams at 20 weeks and increase their body weight to1900 grams at 42 weeks of age (Scott *et al.*, 1982). In the present study, the body weights of birds followed similar trends.

The mean number of eggs (per bird) produced by birds on the diet containing 20% SCB was 67.2 which was significantly ($P>0.05$) higher than those of birds on the control (66.7) and birds on other test diets (53.6, 59.6, 60.1 and 64.7 for birds on 0, 5, 10 and 15 % SCB diets respectively) over the experimental period (Table 3). Birds on the diet with 20 % SCB and those on the control diet laid significantly ($P<0.05$) more eggs than those on other diets. Similarly, the highest egg mass was recorded from birds on diets with 20% SCB (3.85 kg) which was significantly (P<0.05) higher than that of birds on the control and diet with 15 % SCB (3.74 and 3.75 kg respectively), which were not significantly (P>0.05) different. Birds on the two diets produced significantly (P<0.05) higher egg mass than birds on other test diets (3.18, 3.19 and 3.47 kg for birds on 0, 5 and 10 % SCB diets respectively) Apart from the control treatment, egg production and egg mass apparently increased with dietary inclusion levels of SCB up to 20% (Table 3). Trends in egg mass production are shown in Table 5 and Figure 3.

The body weight gain demonstrated trends similar to those observed on the parameters discussed. However, this trend was not consistent with feed conversion ratio values. Birds on the control diet were significantly (P<0.05) more efficient in converting feed into eggs compared to those on rice by-product diets (Table 3). The productivity parameters from the 15 and 20% rice by-product inclusion diets were apparently better or similar to that of the control diet but the utilization efficiency was lower. These results mainly reflected the differences in diet composition, feed intake and utilization as explained below.

Firstly the higher inclusion rice by-product diets had higher crude fibre content and correspondingly, a lower metabolisable energy was expected. The latter is presumed to have prompted the birds to continue feeding in an attempt to fulfil their energy requirements (compensatory feeding) a common phenomenon in poultry. Birds are however not able to accurately adjust their feed intake upwards and this usually leads to excess consumption, subject to the bulk of the diet and the capacity of the gastro intestinal tract. The excess intake could partly be associated with the higher productivity from the rice based treatments.

Table 5: Eggmass production over 4- week periods, (kg/bird/period)

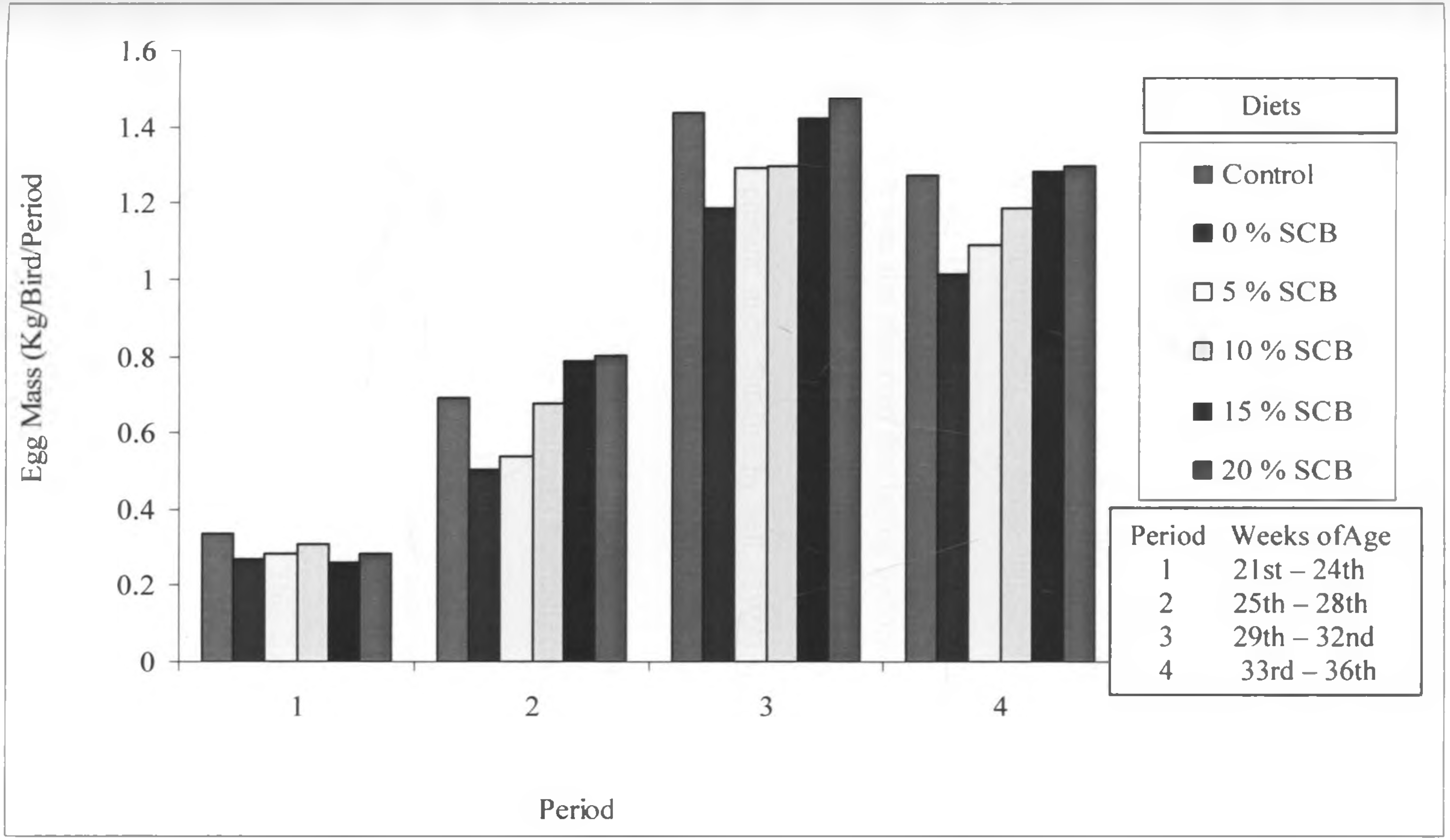
Weeks of age	Diets						
	Control	1	2	3	4	5	LSD[1]
21st-24th	0.340[c]	0.268[a]	0.283[a]	0.307[b]	0.258[a]	0.280[a]	0.10
25th-28th	0.690[c]	0.505[a]	0.538[b]	0.680[c]	0.790[d]	0.803[d]	0.01
29th-32nd	1.44[c]	1.18[a]	1.29[b]	1.30[b]	1.43[c]	1.48[d]	0.01
33rd-36th	1.27[d]	1.01[a]	1.09[b]	1.19[c]	1.28[d]	3.851.30[e]	0.01

[ab]Means followed by the same superscript per row are not significantly P>0.05) different
[1]LSD-Least significant difference

The higher crude fibre content of such diets however limits their utilization efficiency especially owing to reduced digestibity. This further explains the lower feed conversion ratio values indicated for the same diets (Table 3).

Other dietary factors that could have played a role revolve around composition of rice by-products in relation to that of maize. The basal amount of maize in the control diet was largely substituted for in the rice based diets. Rice by-products are richer in linoleic acid, thiamin and niacin, and contain higher quality protein than maize grain (Morrison, 1984). Linoleic acid contributes to egg size and weight and therefore birds on rice bran diets lay heavier eggs (Belnave, 1982). Protein composition also affects egg weight and the higher quality protein of the rice by products might have positively influenced this parameter. Furthermore, if the diets were slightlydeficient in vitamins, the rice based diets had an advantage in supplying extra

Figure 3: Trends in egg mass production over 4-week periods in Experiment 1



thiamin and niacin, both essential for energy utilization. Maize grain is not only poor in niacin content but also in the amino acid tryptophan which acts as a precussor for the vitamin niacin. An additional factor contributing to the higher egg mass from the higher inclusion rice based diets was the bigger size of birds in these dietary treatments. The heavier the bird, the heavier the egg laid (Leeson and Summers, 1987). The phenomenon of higher body weights for the indicated treatments could largely be explained in the same manner as that of egg productivity above.

Several studies have shown that egg production did not differ significantly ($P<0.05$) between birds fed on diets based on maize and soya beans and those fed on diets containing 45 % rice bran (Mahedevan et al.; 1957, Panda and Gupte 1965; Cuca and Avila 1974; Lodhi and Ichhponnani, 1975). It was also observed that laying performance continued normally when rice bran was incorporated in a layer diet at a level of 450g/Kg (Farrel, 1994). Similar trends were demonstrated in the present study. Studies by Jull, (1924) showed that egg weight and body weight have a positive correlation. In this study, birds on high levels of rice by-products were heavier than those on lower levels of the same, and had correspondingly heavier eggs. Results in the current study concur with these findings. Normally maximum egg mass production is expected at peak production period (NRC, 1994) and the trend of this parameter was consistent with this principle. It is generally agreed that feed conversion ratio declines with increasing levels of rice bran in a diet (E. Martin and D. J. Farrel, 1992). Birds increase their feed intake, to meet energy deficits in diets with low ME values. This correlates with reduced efficiency at which feeds are converted into eggs. In the present study, significant ($P<0.05$) decline in feed conversion ratio with increasing amounts of SCB was evident at an inclusion rate of 10% SCB. The study therefore concurs with the findings by other researchers.

The yolk mottling score ranged from 0.5 to 1.25 for eggs laid by birds on the control and the rice by product diets (Table 6). A score of zero indicated the absolute absence of yolk mottling while a score of one indicated the presence of very slight mottling. Calcium deficiency is reported as one of the causes of yolk mottling (Roland et al; 1972). Rice milling by- products have high content of phytate which might be responsible for reducing availability of some minerals (Waren and Farrel, 1991).

Phytate has the potential of binding calcium thereby making it unavailable. Effects of calcium deficiency associated with pytate in rice by-product diets and manifesting in form of yolk mottling were therefore assessed in this study. The visual scores however indicated the absence or presence of very slight mottling.

Table 6: Mean Score for Egg Quality Factors

	Diets						
Parameters assessed	Control	1	2	3	4	5	SEM[1]
Yolk mottling	1.250	0.875	1.125	1.250	1.00	0.500	0.2320
Meatspots	0.50	0.88	1.25	1.00	1.00	1.12	0.378
Bloodspots	0.25	0.00	0.67	0.00	0.25	0.25	0.320
Specific gravity	1.098	1.097	1.098	1.097	1.098	1.096	0.001062

[1]S E M-Standard Eror of the Mean

The experimental diets had calcium levels ranging from 3.76 to 4.09 %, which apparently were above the recommended levels of 3.6% (NRC, 1994). The effect of phytate was therefore not significant with respect to inclusion of rice by-products in layer diets.

The mean score for the presence of meat spots (Table 6) ranged from 0.5 to 1.25, while those of blood spots ranged from 0.0 to 0.5 for eggs from the different dietary treatments. There were no significant differences (P>0.05) between the treatments. A score of zero indicated the absolute absence of any meat or blood spot while that of 1 indicated presence of very slight traces of either. Vitamins A and K deficiencies are associated with the presence of blood spots in eggs (Moreng and John, 1985), which degenerate into meat spots. Rice bran has low contents of vitamin A (Carangian and Sutaria, 1970) hence the need to study its influence on the presence of both meat spots and blood spots. With low vitamin A levels in rice bran, it was anticipated that deficiency of the vitamin might be exhibited in form of blood spots or meat spots in eggs from rice based dietary treatments. Although a vitamin mineral premix was incorporated in the rice based diets, study of these two parameters was expected to give an indication of the adequacy of the premix to supply the vitamin in rice by-products based diets. However, the scores for both parameters were insignificant. It was therefore concluded that the premix in the diets might have supplied the vitamins.

The specific gravity of eggs from birds on all the treatments did not differ significantly (P>0.05) (Table 6). All eggs collected from birds fed on the different diets had a mean specific gravity of at least 1.09. A specific gravity of at least 1.075 or more represents good shell quality (Moreng and John, 1985). Rice milling by-products have been reported to contain high content of phytate, which may be responsible for reducing availability of some minerals e.g calcium (Waren and Farrel, 1991). Calcium is a major component of the egg shell having a bearing on the shell strength. The fact that all the eggs tested had a specific gravity of at least 1.09 demonstrated the good shell quality for all the treatments. This implies that the possible presence of phytate in rice based diets did not negatively affect the shell strength.

The mean score for the egg yolk colour was 3.65 in period one (diets without synthetic carotenoids) which was significantly (P<0.05) different from the mean score in period two (diets with carotenoids), which was 4.75 (LSD-0.499). Xanthophylls, which are characterized by the presence of hydroxyl groups, are the most important carotenoids in poultry diets (NRC, 1994). The pigments ensure that consumer's tastes, which are receptive to eggs with a fair degree of yolk pigmentation, mainly for aesthetic reasons are met (Leeson and Summers, 1987). Synthetic carotenoids that have been approved by regulatory agencies are used in poultry diets, because levels of desired pigments in natural feedstuffs are not always constant and many of the carotenoid containing feedstuffs are relatively low in energy content (NRC, 1994). Since the level of carotenoids in rice by-products was not assessed in this study, the general effect of including or excluding synthetic carotenoids in rice-based diets was visually assessed. Results demonstrated the need to incorporate synthetic carotenoids in rice-based diets where aesthetic appeal of deeper yellow yolks can improve marketing

A study of the economics of using fine bran and special coarse bran based diets for layers demonstrated a high gross margin for diets with 20% SCB (Table 7). Laying performance improved with increase in the level of SCB. SCB was the cheapest ingredient in these diets. Its incorporation at the 20% level minimized the feeding cost while no adverse effects on performance were observed

Table 7: Gross Margin per bird based on Feed consumption and Egg Sales (Experiment 1)

	Diets					
Parameters	Control	1	2	3	4	5
Feedcost/Kg	23.8	21.8	21.2	20.2	19.3	18.4
Feedintake/ (Kg)	10.54	9.12	10.22	12.00	13.41	14.18
Cost of feed (Ksh)	250.9	198.8	216.7	242.4	258.8	260.9
Egg mass (Kg)	3.74	3.18	3.19	3.47	3.75	3.85
Unit price/ kg of eggs (Ksh)	100	100	100	100	100	100
Gross income (Ksh)	374	318	319	347	375	385
Gross margin (Ksh)	123.1	119.2	102.3	104.6	116.2	125

1 kg egg mass is equivalent to 2 dozens of eggs sold at Ksh. 100

3.4. Conclusions

Results of this study demonstrated that FB and SCB from Mwea could effectively substitute for maize and its by-products in layer chicken diets up to 40% level.

Although data on the gross margin per bird over the experimental period was not statistically analysed, it was higher (by Ksh. 2) for the 20% SCB dietary treatment than for the control. This further cornfirmed that the economic and technical value of the cheap and readily available Mwea rice by-products was equivalent to that of conventional cereal by- products up to 40% inclusion in poultry diets.

CHAPTER FOUR

4.0 EXPERIMENT TWO: EFFECT OF INCLUDING SPECIAL COARSE BRAN (SCB) AND BROKEN RICE (BR) IN LAYER DIETS ON PERFORMANCE

4.1 INTRODUCTION AND OBJECTIVE

At the Mwea Irrigation Scheme (MIS), large quantities of broken rice (feed grade) are available for use as poultry feed, and indeed the by-product is locally called chicken feed. Maize and its milling by-products usually constitute about 60% of layers diets in Kenya. This was therefore considered as a basis for determining inclusion levels of broken rice in this experiment. Part of this study was conducted in the field where some of the diets were tested under farmer conditions. Involvement of farmers is considered important in participatory technology development and determination of appropriate interventions for local communities. It was imperative that different levels of broken rice from the MIS be tested in feeding trials to determine their feeding value in diets for layer chicken in combination with special coarse bran. The levels of fine bran and special coarse bran were kept constant across the dietary treatments.

The objective of this experiment was to assess the effect of feeding diets containing broken rice, fine bran and graded levels of special coarse bran on layer chicken performance under on- station and on -farm conditions.

4.2 Materials and methods

In the on-station trial layers were fed diets containing 60% broken rice (BR) during the first eight weeks (stage 1) and 40% over the subsequent eight week period (stage2). The diets also contained graded levels of special coarse bran (SCB) while fine bran was fixed at 20% in the basal diet as in experiment 1.

Two control diets comprising a commercial layers mash and a maize soya-bean meal based diet were also fed. Layers in the on-farm trial were fed on three experimental diets which were also fed to birds in the on-station trial during the first eight weeks.

4.2.1 Experimental design and Management of the birds

Experiment two involved an on-station sixteen- (16) week feeding trial and a parallel on-farm trial done for five weeks. The study investigated the potential of special coarse bran and broken rice as dietary energy sources for layer chicken. The on-station feeding trial was conducted in two distinct stages. The first stage covered a period of eight weeks from the 21st to 28th weeks of age. Birds on the 60 % BR diets performed sub-optimally on all the performance parameters during the first stage of the feeding trial. Due consideration of performance results of this phase necessitated a revision of the composition of the rice based experimental diets. Broken rice was therefore reduced from 60 to 40 % of the diets which were fed from 29th to 36th weeks of age (8 weeks) constituting the second stage of the experiment. Although a carry over effect was anticipated, this was considered to be uniform across the rice based diets. Analysis of data was therefore done for the overall period and then separately for stages one and two. This was done to cover the effect of including SCB (at the same levels) in the diets for the overall period and then separately to capture the effects of including BR at different levels during the two stages of the experiment.

Four hundred Isa brown layer chicks were obtained from a commercial hatchery and used for two experiments. They were fed on conventional layer chick diets for the first twenty weeks as described in experiment one (section 3.2.2). At the start of the 21st week of age, one hundred and forty (140) birds were randomly selected and used in the on -station trial. The birds were allocated to 5 dietary treatments in a completely randomized design (CRD). Each treatment was replicated 4 times with 7 birds per replicate hence 28 birds per dietary treatment. The on-station trial birds were managed as in experiment one (section 3.2.2).

For the field trial, seventy-two (72) birds were randomly selected and transported to Mbui-Njeru village in Mwea irrigation scheme. They were allocated to three dietary treatments. Each treatment was replicated 4 times with 6 birds per replicate, making a total of 12 experimental units. Each of the 12 participating households constituted an experimental unit. The design and size of the field trial was kept simple and manageable due to co-ordination and logistics involved and the fact that these farmers were handling commercial birds for the first time and had to be trained accordingly. The trial lasted for five weeks.The laying performance of experimental birds under prevailing on-farm conditions was assessed. Feed and water were offered continously using locally available feeding and watering equipments. Routine vaccinations were administered both in the on-station and on-farm trials.

4.2.2 Experimental diets

The rice by-products were purchased from MIS as explained in experiment one, section 3.2.1. Five diets comprising of a commercial layers mash control diet, a maize soya bean-meal control diet and three rice by-product diets were used for the on-station experiment. The composition of the maize soya bean meal control and the rice based diets is shown in Table 8. The determined analysis of the commercial layer mash control diet is shown on Table 8. However, the diet was purchased from a commercial firm and the constituent ingredients are not shown. The three rice-based diets were made from maize combined with 60 or 40% broken rice (BR) in stages one and two respectively, 20% fine bran and other ingredients (Table 8 and 9 respectively). Birds fed on diets containing 60% broken rice in stage one resulted in sub-optimal performamce, which necessitated the reduction of this ingredient to 40% of the diet in the second stage. Special coarse bran was incorporated in test diets at levels of 0, 5 and 10% to make diets 3, 4 and 5 respectively. All diets (except the commercial one) were mixed in a (70kg) laborotary mixer and stored in 70 kg bags at room temperature until they were used. The commercial layers mash was purchased from a commercial feed milling firm, while the second control diet was formulated on station from maize, soya- bean meal and other ingredients as shown in Tables 8 and 9. For the field trials, the three diets used were; Diets 3 and 4 in stage one of the on-station trial (i.e with 60% BR, 0 and 5% SCB) and the commercial layers mash. The rationale of formulating and testing high level rice based diets was to determine the highest level to which a feed manufacturer in Mwea could effectively incorporate the cheap rice by-products without compromising poultry performance. The results together with those of economic assessment would help address the question on the usefulness of the rice by-products especially for those wishing to utilise them within the local Mwea environment.

4.2.3 Data collection

This was done as described in experiment one section 3.2.4. Thereafter, the same data was analysed for the two stages respectively to indicate the successive performance trends. Egg production was assessed in the on-farm trial. Each household recorded the total egg production from which the treatment means were computed in terms of number of eggs per bird.

Statistical analysis and economic evaluation were done as described in experiment one, section 3.2.5 and 3.2.6 respectively.

Table 8:Composition of Layer diets in Experiment 2 Stage 1 (21st- 28th weeks of age)

	Diets				
Ingredients, %	Control 1[1]	Control 2	3	4	5
Fine bran		0.00	0.00	20.00	20.00
Special coarse bran		0.00	0.00	5.00	10.00
Broken rice		0.00	60.00	60.00	60.00
Maize		57.04	6.24	2.32	1.82
Corn oil		3.00	0.00	0.00	0.00
Soya bean meal		19.38	5.00	3.95	3.65
Fish meal		9.93	2.50	4.12	4.00
Limestone		7.94	5.91	5.35	4.30
Dicalciumphosphate		1.86	0.20	0.20	0.20
Vitamin/Mineral premix[3]		0.50	0.46	0.45	0.43
Methionine		0.05	0.02	0.02	0.02
Lysine		0.05	0.04	0.04	0.04
Common salt		0.25	0.23	0.22	0.22
Determined Analysis					
Dry matter %	91.9	90.50	89.5	90.2	90.9
Crude Protein %	16.40	17.88	14.60	14.33	14.1
Crude fibre %	3.561	3.47	4.81	4.92	5.37
Ether extract %	3.49	4.93	5.51	5.43	6.84
Ash %	13.300	9.49	9.83	9.94	10.13
Phosphorous %	0.386	1.30	1.34	1.37	1.39
Calcium %	3.504	4.18	3.71	3.50	3.81

[1]Control 1(Commercial layer mash; ingredients details not available)

[2]Vitamin mineral premix composition: Vitamin A-4, 500,000 IU/kg; vitamin D_3-900, 000 IU/kg; Vitamin E-12000mg/kg; vitamin K-1000mg/kg; vitamin B_1-700mg/kg; vitamin B_2-1750mg/kg; Vitamin B_6-1500mg/kg; vitaminB_{12}-4800micrograms/kg; Niacin-17500mg/kg;
Pantothenic acid-4000mg/kg; Vitamin C-40, 000mg/kg
Cholinechloride-140, 000mg/kg; Folic acid-400mg/kg; Fe-12800mg/kg; Mn-4800mg/kg; Cu-1600mg/kg;
Zn-14, 400mg/kg; I-448mg/kg; Co-72mg/kg; Se-40mg/kg; Antioxidant-1600mg/kg;

Table 9:Composition of Layerdiets in Experiment 2 Stage 2 (29th –36th weeks of age)

	Diets				
Ingredients, %	Control 1[1]	Control 2	3	4	5
Fine bran		0.00	20.00	20.00	20.00
Special coarse bran		0.00	0.00	5.00	10.00
Broken rice		0	40.00	40.00	40.00
Maize		57.04	7.20	3.12	1.76
Corn oil		3.00	0	0	0
Soya bean meal		19.38	14.63	14.19	12.76
Fish meal		9.93	10.05	9.80	9.57
Limestone		7.94	6.40	6.24	5.10
Dicalciumphosphate		1.86	0.91	0.89	0.57
Vitamin mineral premix[3]		0.50	0.46	0.45	0.43
Methionine		0.05	0.02	0.02	0.02
Lysine		0.05	0.04	0.04	0.04
Carotenoids		0.02	0.02	0.02	0.02
Common salt		0.25	0.23	0.22	0.22
Determined Analysis					
Dry matter %	91.9	90.50	89.40	90.10	90.40
Crude Protein %	16.40	17.88	17.19	17.17	17.20
Crude fibre %	3.561	3.47	4.78	5.25	5.81
Ether extract %	3.49	4.93	4.94	4.68	4.28
Ash %	13.300	9.49	9.63	9.90	10.35
Phosphorous %	0.386	1.30	1.34	1.32	1.33
Calcium %	3.504	4.18	3.61	3.85	3.58

[1]Control 1(Commercial layer mash; ingredients details not available)

[2]Vitamin mineral premix composition: Vitamin A-4, 500,000 IU/kg; vitamin D_3-900, 000 IU/kg; Vitamin E-12000mg/kg; vitamin K-1000mg/kg; vitamin B_1-700mg/kg; vitamin B_2-1750mg/kg; Vitamin B_6-1500mg/kg; vitaminB_{12}-4800micrograms/kg; Niacin-17500mg/kg; Pantothenic acid-4000mg/kg; Vitamin C-40, 000mg/kg Cholinechloride-140, 000mg/kg; Folic acid-400mg/kg; Fe-12800mg/kg; Mn-4800mg/kg; Cu-1600mg/kg; Zn-14, 400mg/kg; I-448mg/kg; Co-72mg/kg; Se-40mg/kg; Antioxidant-1600mg/kg

4.3 Results and Discussion

4.3.1 Overall layer performance

Results of feed intake, egg production, egg mass, body weight, weight gain and feed conversion (kg feed: kg eggs) are shown in 10. The overall results showed that birds on the diets containing 10 and 5% SCB had significantly ($P<0.05$) higher feed intakes (11.44 and 11.24 kg respectively) than those on the commercial and maize soya bean meal control diets (10.88 and 10.54 kg respectively) and the diet with 0% SCB (9.41 kg). Feed intake increased with increases in the level of SCB among the rice-based diets (Table 10). Similar trends were observed in experiment one (section 3.3.2).

At 36 weeks of age, birds on the commercial control diet and the diet with 5% SCB had significantly ($P<0.05$) higher body weight (1860.2 and 1849.4 g respectively) than those on the maize soya bean meal control (1841.9 g) and diets with 0 and 10% SCB (1830.6 and 1844.4 g respectively). Birds on the commercial and maize-soya bean meal control diets had significantly ($P<0.05$) higher weight gains (303.3 and 291.5 g respectively) than those on rice-based diets. Birds on 5 and 10% SCB diets were not significantly ($P>0.05$) different in their weight gains (288.6 and 284.1 g respectively). They had significantly ($P<0.05$) higher weight gains than those on 0% SCB diet (273.9 g). This was mainly attributed to the higher feed intake ($P<0.05$) by the former (11.24 and 11.44 kg). Weight gains increased with increases in the level of SCB among the rice-based diets up to the 5% inclusion level. It may be concluded that the 5 % SCB inclusion level was the optimum at which SCB would be included without compromising performance.

Table 10:Overall Layer Performance (21st-36th weeks of age)

Parameters	Diets					
	Control 1[1]	Control 2[2]	1	2	3	LSD
Feed intake (kg/bird)	10.88^{c}	10.54^{b}	9.41^{a}	11.24^{d}	11.44^{e}	0.14
Body weight (g), 36 weeks	1860.2^{bc}	1841.9^{ab}	1830.6^{a}	1849.4^{bc}	1844.4^{b}	11.82
Weight gain (g/bird)	303.3^{c}	291.5^{bc}	273.9^{a}	288.6^{b}	284.1^{ab}	11.94
Egg production (number/bird).	71.2^{e}	66.7^{d}	56.9^{a}	64.9^{c}	62.5^{b}	0.30
Egg production (Hen day %)	63.59	59.55	50.83	57.96	55.84	
Mean egg mass (kg/bird)	3.88^{e}	3.74^{d}	3.08^{a}	3.60^{c}	3.47^{b}	0.02
Feed conversion ratio (kg feed: kg eggs)	2.80^{a}	2.81^{b}	3.05^{c}	3.12^{d}	3.29^{e}	0.03

^{ab}Means followed by the same superscript per row are not significantly P>0.05) different

[1]Control 1-Commercial Layer Mash diet

[2]Control 2-Maize Soya Bean Meal diet

Birds fed on the commercial and maize soya bean meal control diets produced significantly (P>0.05) more eggs (71.2 and 66.7 respectively) than those on rice by-product diets. However, amongst the latter, birds on the 5 and 10% SCB diets produced significantly (P>0.05) more eggs (64.9 and 62.5 respectively) than those on 0% SCB diet (56.9). The same trend was observed for egg mass. For both parameters however, the diet containing 5% SCB performed better than that with 10%. Birds fed on the former diet also had better feed conversion ratio (3.12 compared to 3.29), which was correspondingly reflected by the superior performance. The decline in performance for birds fed diets containing more than 5% SCB demonstrated that this could be taken as the maximum level above which SCB caused adverse effects when fine bran and broken rice were also included at 20 and 40 % levels respectively. Even at this low inclusion, the 5% diet could not match the egg production performance and feed conversion ratio of the two control diets. This was partly due to the poor utilization of these higher crude fibre diets. The diet with 0% SCB but containing the other two rice by products was the poorest ($P<0.05$) in egg productivity but more efficient ($P<0.05$) than the 5 and 10% inclusion in its utilization. More notable however for the three diets used in stage 1 was their low crude protein content (14.60, 14.33 and 14.10 %) for diets with 0, 5 and 10 % SCB, which failed to meet the NRC (1984) requirement for layer chicken diets. This must have been the major factor that adversely influenced the performance of the three rice by-product diets. The situation was however rectified in stage II where diet composition was adjusted. The results for the overall period in this experiment indicated that the commercial control diet gave the highest ($P<0.05$) egg productivity (71.2) and was significantly ($P<0.05$) the most efficient (2.80) in feed conversion ratio. It was however imperative to consider the two stages of the experiment separately before making final conclusions on the best diet.

4.3.1.1 Layer Performance, Stage 1 (21st -28th week of age)

Results of feed intake, egg production, egg mass, body weight, weight gain and feed conversion (kg feed: kg eggs) are shown in Table11. Birds on the commercial and maize soya bean meal control diets had significantly ($P<0.05$) higher feed intakes (4.56 and 4.37 kg respectively) than those on rice-based diets during stage 1. Those on diets containing 10 and 5 % SCB had significantly ($P<0.05$) higher feed intakes (4.23 and 4.12 kg) than those on the 0% SCB diet (3.39 kg). Feed intake increased with increases in the level of SCB among the rice-based diets as observed in experiment one. In diets containing 60% BR, at least 80% of all the ingredients were made from rice by-products. This might have contributed to the lower feed intakes for birds on diets containing 60% BR. Studies by Piliang *et al.,* (1982) showed that birds fed on diets containing 81.5% rice bran had lower feed intakes ($P<0.05$) compared to others on a standard breeder diet. Results of the present study concur with these findings. Feed intakes of birds on all the treatments increased with age. As explained earlier, birds increase their feed intake to compensate for low dietary energy. This compensatory increase in feed intake is however limited by factors such as bulkiness of the diet, presence of antinutritional factors and the gut capacity. Diets based on rice by-products had higher crude fibre content, making them bulky. In addition, they might have contained relatively higher levels of antinutrional factors such as trypsin inhibitor (Leeson and Summers, 1997). These factors may have negatively affected energy intake, especially during peak egg production.

At 28 weeks of age, birds on the commercial and maize soya bean meal control diets had significantly ($P<0.05$) higher body weight (1751.96 and 1741.43 g respectively) than those on the other test diets. Birds on 5 and 10% SCB diets were not significantly ($P>0.05$) different in their body weights (1715.05 and 1709.05 g respectively). They were significantly (P<0.05) heavier than those on 0 % SCB diet (1703.95). Birds on the commercial and maize soya bean meal control diets were not significantly (P>0.05) different in their weight gains (195.1 and 191.0 g respectively). They had significantly (P>0.05) higher weight gains than than those on 5, 10 and 0 % SCB diets (154.3, 149.6 and 147.2 respectively) (Table 11).

Table 11: **Layer Performance in Stage 1 (Week 21st-28th weeks of age)**

	Diets					
Parameters	Control 1[1]	Control 2[2]	1	2	3	LSD
Feed intake (kg)	4.56[e]	4.37[d]	3.39[a]	4.12[b]	4.23[c]	0.07
Egg Production (number/bird)	24.3[e]	20.1[d]	15.4[a]	18.2[c]	16.9[b]	0.14
Egg Mass (Kg/bird)	1.17[e]	1.03[d]	0.72[a]	0.86[c]	0.80[b]	0.01
Feed Conversion ratio (Kg feed: Kg Eggs)	3.89[a]	4.24[b]	4.74[c]	4.77[c]	5.25[d]	0.09
Body weight	1751.96[d]	1741.43[c]	1703.95[a]	1715.05[b]	1709.05[ab]	6.60
Weight Gain	195.1[b]	191.0[b]	147.2[a]	154.3[a]	149.6[a]	8.08

[ab]Means followed by the same superscript per row are not significantly P>0.05) different
[1]Control 1-Commercial Layer Mash
[2]Control 2-Maize Soya Bean

Growth of a pullet is initially sensitive to dietary protein and amino acid levels, whereas energy intake becomes more critical as the bird approaches maturity (Leeson and Summers, 1989). The pullets in the present study had attained sexual maturity; hence energy was more critical in their diets. However, energy and protein levels in diets containing 60% BR were slightly lower than those recommended by NRC (1984) standards. As previously explained, dietary factors may have hampered compensatory feed intake by the birds. Literature reviewed earlier showed that feed intakes and body weights are correlated. The significantly (P<0.05) poorer feed intake for birds on the diets with 60% BR compared to those on the control diets might have largely contributed to their significantly (P<0.05) lower body weights.

Egg production was significantly (P<0.05) higher for birds on the commercial and maize soya bean meal control diets (24.3 and 20.1 respectively) than those on rice by-product diets (18.2, 16.9 and 15.4 for birds on 5, 10 and 0 % SCB diets respectively). Egg mass showed similar trends (Table 11). These results were consistent with the feed intake levels of the corresponding diets. Additonally, these results were in agreement with those of feed conversion ratio which indicated significantly (P<0.05) better utilization (3.89 and 4.24 respectively) for the control diets than those on 0, 5 and 10 % SCB diets (4.74, 4.77 and 5.25 rspectively) (Table 11). The main limitations of the rice-based diets that could have adversely affected performance have been discussed above. Some of the antinutritional factors associated with rice by-products include trypsin inhibitor, oxalates and phytate (Leeson and Summers; 1997; Warren and Farrel, 1991). It should be noted however that such antinutrional factors were not analysed for in this study as they were outside the scope of the study objectives. It may be reasonably deduced that the rice by-product inclusion levels in stage 1 were too high and this caused the poor performance of birds observed. In view of these results, it was found necessary to reduce the levels of rice by-products in the subsequent period (stage 2). Broken rice was therefore reduced from 60 to 40% of the diets in order to comply with the NRC (1984) nutrient requirements for layer birds. This dietary intervention was expected to enhance performance of the birds in stage 2 of the experiment.

4.3.1.2 Layer Performance, Stage 2 (29th -36th weeks of age)

Results of feed intake, egg production, egg mass, body weight, weight gain and feed conversion (kg feed: kg eggs) are shown in Table12. As noted earlier (section 4.2.1), after the first eight weeks of the on-station feeding trial, the level of broken rice was adjusted downwards to 40%. This was expected to have a carry-over effect. However, its effect was presumed to be uniform across the rice-based diets and hence data analysis was done as in stage one.

Birds on the diets containing 10 and 5 % SCB had significantly (P<0.05) higher feed intakes (7.21 and 7.12 kg respectively) than birds on the commercial and maize soya bean meal control diets (6.32 and 6.17 kg respectively) and those on diet containing 0% SCB (6.02 kg). The response to the reduction in the content of broken rice in the diets was dramatic and immediate. The overall response is well reflected on Table 12 showing improvement in all performance parameters. Feed intakes for the birds fed on rice-based diets were low in stage 1, but the same increased significantly in stage 2. This showed that the rice-based diets in stage 2 were of better quality and had higher nutrient densities and the limitations to adequate compensatory feed intake experienced in stage 1 had mostly been overcome. The higher feed intakes positively influenced all the performance parameters except for feed conversion efficieny, which was worse than that of birds fed on the control diets. Except for feed intake, all other performance indicators declined beyond the 5% SCB inclusion level. This was in agreement with the trend in stage 1 where the 5% SCB diet gave better (P<0.05) results in respect of egg production, egg mass and feed conversion efficiency compared to the 10% inclusion diet. Results from this experiment show that the highest level to which SCB could be added to layer diets was 5 %, when the same diets contained 60 % of other rice- bypoducts.

Table 12: Layer Performance in Stage 2 (29th-36th Weeks of age)

	Diets					
Parameters	Control 1[1]	Control 2[2]	1	2	3	LSD
Feed intake (kg)	6.32^{c}	6.17^{b}	6.02^{a}	7.12^{d}	7.21^{e}	0.08
Egg Production (number/bird)	46.9^{c}	46.6^{c}	41.5^{a}	46.8^{c}	45.7^{b}	0.08
Egg Mass (Kg/bird)	2.71^{c}	2.70^{c}	2.36^{a}	2.73^{c}	2.67^{b}	0.02
Feed Conversion Ratio (Kg feed: Kg Eggs)	2.33^{a}	2.32^{a}	2.54^{b}	2.60^{c}	2.70^{d}	0.02
Body Weight at 36 Weeks	1860.2^{bc}	1841.9^{ab}	1830.6^{a}	1849.4^{bc}	1844.4^{b}	11.82
Weight Gain	108.2^{a}	100.5^{a}	126.7^{b}	134.3^{b}	134.4^{b}	13.84

^{ab}Means followed by the same superscript per row are not significantly P>0.05) different
[1]Control 1-Commercial Layer Mash
[2]Control 2-Maize Soya Bean

The results of this study were largely in agreement with those of other researchers in this area of feeding rice-based diets to poultry; In a study where broken rice replaced maize in diets for starter pullets upto a level of 50%, there were no significant (P>0.05) difference in weight gain between those birds and pullets on a maize soya bean meal control (Nagra *et al.*, 1987) diet. In a feeding trial, Tyagi., *et al.*, (1994) found that birds fed on diets containing 40 % BR were not significantly (P<0.05) different from a group on a maize soya bean meal control control diet. Studies have shown that effects of low protein diets on muscle fibre size are transitory rather than long-term (Timson *et al.*, 1983). No long-term effects on growth performance were therefore expected following the feeding of diets with protein levels that fell below the NRC, (1984) requirements. This was manifested after the levels were adjusted upwards, leading to enhanced compensatory feeding and performance by birds on the rice based diets in stage two.

The trends observed in feed intake over 4-week periods are shown in Table 13 and Figure 4. Feed intake increased with increase in the age of birds and also with increase in the level of SCB among the rice based diets. The capacity to utilize high fibre diets appeared to have been more enhanced with increase in age of birds; hence the efficiency of converting feeds into eggs increased with age of birds up to the peak production period. Similarly, the trends in egg mass production (Table 15 and Figure 5) increased with increase in feed consumption and age of birds up to the peak production period. However, after the peak production, feed consumption continued to increase but the corresponding egg mass production declined. The normal egg production cycle shows that feed intake continues to increase even after the peak period, which corresponds to a declining egg production phase (Smith, 1990), consistent with this study

Table 13: Feed Consumption over 4-Week Periods in Experiment 2 (Kg/Period))

Weeks of age	Control 1[1]	Control2[2]	1	2	3	LSD
	Diets					
21^{st}-24^{th}	2.04^{c}	1.95^{b}	1.60^{a}	1.89^{b}	1.91^{b}	0.03
25^{th}–28^{th}	2.48^{e}	2.42^{d}	1.79^{a}	2.23^{b}	2.32^{c}	0.04
29^{th}–32^{nd}	2.93^{b}	2.95^{b}	2.77^{a}	3.39^{c}	3.48^{d}	0.05
33^{rd}–36^{th}	3.24^{a}	3.22^{a}	3.25^{a}	3.72^{b}	3.73^{b}	0.05

[ab]Means followed by the same superscript per row are not significantly P>0.05) different
[1]Control 1-Commercial Layer Mash
[2]Control 2-Maize Soya Bean

Figure 4: Trends in Feed intake over 4 week periods in Experiment 2

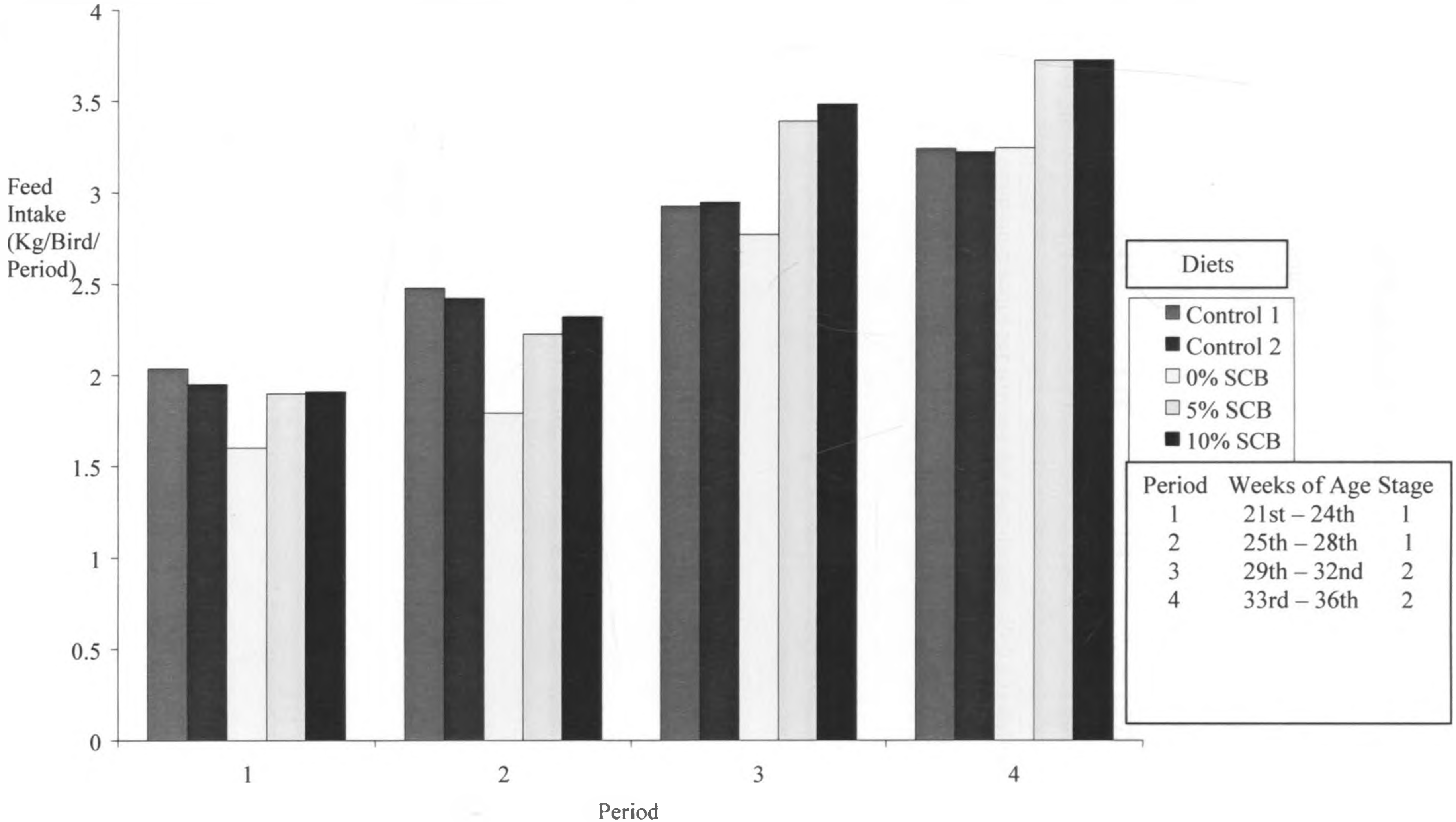
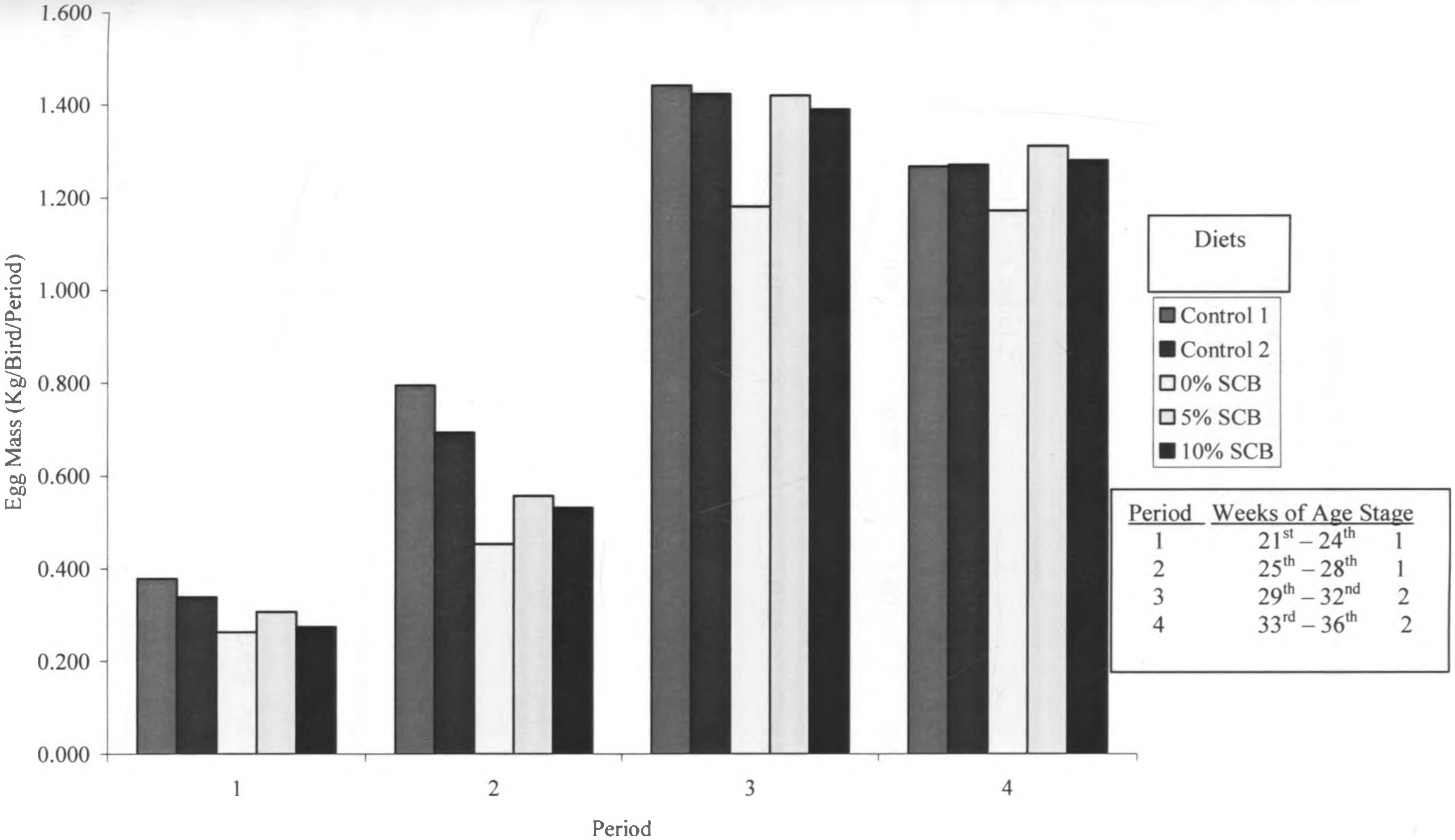


Table 14: Egg mass production (4-Week Period) (Kg/Period))

			Diet			
Weeks of age	Control 1[1]	Control2[2]	1	2	3	LSD
21st-24th	0.378[e]	0.338[d]	0.263[b]	0.307[c]	0.275[a]	0.01
25th-28th	0.795[e]	0.693[d]	0.452[a]	0.556[c]	0.530[b]	0.01
29th-32nd	1.44[d]	1.43[c]	1.18[a]	1.42[c]	1.39[b]	0.02
33rd-36th	1.26[d]	1.27[b]	1.17[a]	1.31[e]	1.28[c]	0.01

[ab]Means followed by the same superscript per row are not significantly P>0.05) different
[1]Control 1-Commercial Layers Mash diet
[2]Control 2-Maize Soya Bean meal diet

Figure 5: Trends in egg mass production over 4- week periods in Experiment 2



The yolk mottling score ranged from 0.75 to 1.75 for eggs laid by birds on the formulated diets and all were not significantly different (P>0.05) as shown on Table 15. Experimental diets had calcium levels ranging from 3.58 to 4.18 %, which fell within the levels recommended by NRC, (1984) i.e 3.6 %.

Table 15: Mean Score for Egg Quality Factors

			Diets			
Parameters	Conrol 1[1]	Control 2[2]	1	2	3	SEM[3]
Yolk mottling	0.75	1.25	0.75	0.88	1.75	0.294
Meat spots	0.5	0.5	0.75	1.00	0.50	0.250
Blood spots	0.00	0.31	0.75	0.50	0.50	0.301
Specific gravity	1.0955	1.0980	1.0945	1.0962	1.0950	0.0264

[ab]Means followed by the same superscript per row are not significantly P>0.05) different

[1]Control 1-Commercial Layers Mash diet

[2]Control 2-Maize Soya Bean Meal diet

[3]SEM Standard Eror of the Mean

The score for the presence of meat and blood spots ranged from 0.5 to 1.0 and 0.0 to 0.75 respectively, for eggs from birds fed on the different diets. There were no significant differences (P>0.05) between the treatments as shown in Table 15. The specific gravity of eggs from birds on all the treatments (Table 15) did not differ significantly (P>0.05). All eggs had a mean specific gravity of at least 1.09. The mean scores for the yolk colour were significantly (P<0.05) different between the first (3.68) eight weeks (Diets without synthetic carotenoids) and second (6.82) eight weeks (Diets with synthetic carotenoids) for the formulated diets. Those on the commercial control diet had a significantly (P<0.05) higher scores for this parameter.

Since the egg quality results were similar to those obtained in experiment one, the discussion of results followed the same trend as presented for experiment one.

The economics of using rice by-products based diets for layers at the MIS demonstrated a high gross margin for diets with 10 and 5 % SCB (Table 16) in stage 2. The gross margin per bird for diets with 5 and 10 % SCB was higher by more than Ksh. 48 and 39 than for the commercial and maize soya bean meal control diets respectively. Inclusion of SCB at 5 % level minimized the feeding cost while no adverse effects were observed.

Table 16: Gross Margins per bird based on Feed consumption and Egg Sales

			Diets		
arameters	Control 1	Control 2	1	2	3
eedcost/Kg	24	23.8	16.2	15.4	14.5
eedintake/ (Kg)	6.32	6.17	6.02	7.12	7.21
ost of feed (Ksh)	151.7	146.8	97.5	109.6	103.2
gg mass (Kg)	2.67	2.71	2.38	2.73	2.67
nit price/ kg of egg (Ksh)	100	100	100	100	100
ross income (Ksh)	267	271	238	273	267
ross margin (Ksh)	115.3	124.2	140.5	163.4	163.8

1 kg egg mass is equivalent to 2 dozens of eggs sold at Ksh. 100

4.3.2 Field Trial

The mean number of eggs per bird was significantly (P<0.05) higher for birds fed on the commercial layers mash (control) diet (Table 17). Birds fed on the 0 and 5% SCB diets did not differ significantly (P>0.05) in their egg production, although birds on the latter diet generally produced more eggs than those on the former. Although feed intake was not studied in the on-farm trial, it was considered that feed intake was different among diets, thereby contributing to the large difference in egg production. The trends observed agreed with those of the on-station trial. The differences observed between on-station and on farm-trials were mainly attributed to differences in housing and equipments used in different households, possible errors in data collection and other management issues at farm level. It should be noted that the field trial did not have the benefit of extending to the second stage where broken rice was reduced to 40%, enhancing performance in the on-station birds/treatments. This was mainly because funding of the project work was terminated earlier than anticipated among other logistical issues, especially the conduct of two trials concurrently. The field trial was therefore terminated early (after 5 weeks).

Table 17: Mean egg production (On-farm trial over 5 - week period).

		Diets		
Parameter	Control	1	2	LSD
Mean egg number/bird	10.36[b]	6.93[a]	8.12[a]	1.94

[ab]Means followed by the same superscript per row are not significantly P>0.05) different

4.4. Conclusions

The main objective of this experiment was to assess the effects of feeding all three rice by-products: fine bran, broken rice and special coarse bran on the performance of layer chicken. In addition, the highest level at which the by-products could be incorporated in the diets without affecting performance was evaluated.

Among birds fed on diets containing rice by-products, the best performance in terms of egg production, egg mass, and body weight gain was observed among birds fed on diet containing 5 % SCB. This diet also contained 60% of other rice by-products (20 % FB and 40 % BR). There were no differences in the performance of birds fed on the 5 % SCB diets and those fed on the commercial control diet, showing that this was the optimum level at which SCB could be added to the diets without affecting the productivity of the layers.

Feed costs account for approximately 60 % of the total cost of production in a poultry enterprise. Research that is beneficial to farmers is one that addresses both productivity per bird and economic returns to the farmer. Although birds fed on the two control diets produced more eggs than the ones fed on rice-based diets, the diets were expensive and gross margins were low. The best diets in terms of economic returns were diets based on rice by-products, especially the diet containing 20 % FB, 40 % BR and 5 % SCB

CHAPTER FIVE

5.0 GENERAL DISCUSSION

The aim of this section is to summarize and tie up the results of the two feeding trials, where the effect of including Mwea rice by-products in layer diets was studied.

Mwea irrigation scheme is located in Kirinyaga district, and covers an area of 5,830 hectares. Eighty percent of all the rice consumed in Kenya (approximately 28,000 tonnes annually) is grown in this irrigation scheme. The National Irrigation Board (NIB) regulated milling and marketing of rice until 1999 when the farmers demanded greater autonomy in the production and marketing processes.

Before 1999, two ultra-modern mills owned and operated by the NIB and the Mwea Savings and credit Cooperative Society (SACCO) did milling of rice in the scheme. These mills separated the by-products through various milling stages to produce hulls, fine bran, coarse bran, rice polishings and broken rice.

After 1999 farmers declined to deliver their rice to the NIB mill and relied on small-scale single pass rice hullers. These hullers produce a single milling product refered to as "Special coarse bran"in this study. The potential of this product as a feed ingredient for non-ruminant animals has not been evaluated or documented. With about 9,644.25 tonnes of by-products produced annually from processing of the rice crop, the area has a high potential for the production of commercial chicken on rice-based diets. The main constraint that prevents the development of a viable commercial poultry industry in the area is the lack of good quality and affordable feeds.

The main focus of the study was special coarse bran (SCB), a relatively new but plentiful by-product yielded at approximately 4,500 tonnes annually (Wanjogu, personal communication) by the small-scale rice milling in the scheme and its environs. The diferent by-products obtained from the large scale multi-stage milling process are reported to exhibit different nutritive characteristics. Combination of these into a single by-product (SCB) as generated by the small mills would render this a special by-product with unique qualities. However, high fibre content from inclusion of the hulls could apparently limit utilization and based on this premise, the by-product was incorporated at relatively low levels. It was envesiged that broken rice reported to be similar in energy content to maize energy levels would largely replace this cereal grain and its by-products normally included up to about 60 % in layer diets. However, BR is also associated with low levels of certain antinutrional factors such as trypsin inhibitors, oxalates and phytates, which could potentially reduce its utilization. This consideration was made in determining inclusion levels of BR. Inclusion of fine bran was fixed at a low level of 20% across the diets, to minimize its influence on performance of diets that contained more than one type of rice by-product. The overall objective was to not only determine the feeding value of the three by-products but to also assess maximum but acceptable inclusion levels that would take advantage of the low cost of these feedstuffs.

Two experiments were done in this study to evaluate the effect of including rice milling by-products in layer chicken diets. In experiment one, five different levels of SCB (0, 5, 10, 15 and 20 %) were included in layer diets while FB was fixed at 20 %. These were fed to layer birds from the 21st to 36th week of age. In the second experiment, broken rice was included as an additional energy source. Special coarse bran was incorporated at three levels (0, 5 and 10 %)

while FB was fixed at 20 % as in experiment one. Sixty and 40 % BR were incorporated in the diets during the first eight (stage one) and subsequent eight weeks (stage two) respectively.

Results of proximate analysis indicated that fine bran (FB) had higher levels of oil (ether extract) and crude protein (16.09, 10.83 % respectively) compared to broken rice and special coarse bran (3.90 and 5.69 and 1.36 and 8.67 % respectively). Its shortcomings would be considered as the low Calcium: Phosphorous ratio (approximately 1:20). The high oil content was also a potential deterrent that could lower the keeping quality. Special coarse bran (SCB) had the same chemical constituents as fine bran, however the levels were different and it had higher levels of crude fibre (31.88 %), mainly attributable to the high content of hulls. However, the by-product had a high level of ash (11.64 %). Broken rice (BR) was comparable to maize in crude protein, crude fibre and ether exctract (8.67, 2.66, and 1.36 % respectively) composition. Cited literature demonstrated high levels of metabolisable energy in BR (3187 ME kcal/kg). The by-product was however reported to have low levels of antinutritional factors such as oxalates, trypsin inhibitors and phytate.

Performance of layers on diets containing five levels of SCB was demonstrated in experiment one. Layers were found to have increased their feed intake as a response to low energy diets. The possible high levels of linoleic acid and other favourable nutritional factors like higher quality protein and presence of high amounts of vitamins niacin and thiamin in SCB improved performance. The diet with 20 % FB and 20 % SCB demonstrated better performance than the control and other rice based diets. The cost of feeding was generally reduced. The phenomenon was to a large extent consistent with the overall results of experiment two, where feed intake and corresponding performance increased with increase in the level of SCB up to 5 % inclusion level, during the second stage.

Inclusion of BR at 60 % level during the first eight weeks of experiment two resulted in significantly poorer performance of birds on the rice-based diets, which was attributed to low nutrient density especially proteins and energy. Similar findings were observed in the on farm trial. During the second eight weeks of the experiment, the positive effect of reducing the level of BR was clearly demonstrated. Birds on diets with 5 and 10 % SCB drastically improved feed intake with corresponding enhanced performance. The diets containing 60 % BR had a total content of about 80 % by- products. Results showed that birds could not perform well at this level. The diets cotaining 40 % BR had a total content of about 60 % by- products. Results showed that birds could perform optimally at this lower inclusion level of by- products.

The economic analysis of the study showed that birds on the 20 % FB and 20 % SCB diet (experiment 1) had a gross margin per bird that was higher by Ksh. 2 than for those on the control diet. Gross margins for 5 and 10 % SCB diets (experiment 2) were similar, but higher by more than Ksh. 39 / bird than for the control diets. High levels of poverty have been reported at the Mwea Irrigation Scheme and its environs (Mutero et. al., 2001), hence the need to spur economic activities. Small scale to medium scale poultry farmers in other parts of Kenya have been reported to raise flocks ranging from 100-500 birds on average (Gichohi et. al., 1988). The potential gross margin for 100 birds would be Ksh. 3900 while a flock of 500 birds would earn 19500 per production cycle, if the the same production trend would be replicated at the MIS using the diet with 20, 40 and 5 % FB, BR and SCB respectively.

The information generated from this study would be useful not only in promoting commercial poultry production in Mwea and its environs but also in establishing rice based feed mills, with a high potential of reducing poverty. The rice based diets had higher levels of fats in comparison to the control diets, which enhances digestion. High level fat feeding increases the intestinal retention time, which enhances more complete digestion and absorption of the non-lipid feed constituents (Mateos and Sell , 1981). However, rice based diets are prone to undergoing deteriorative changes with long storage due to high fat content. Rice bran contains oils that are predominantly esters of unsaturated fatty acids and is prone to oxidative rancidity (Sarkar and Bhattacharyya, 1989). The diets could however, be stabilized through addition of synthetic antioxidants such as ethoxyquin.

In conclusion, the studies demonstrated the potential of rice by-products as poultry feed ingredients at 40 % inclusion level with FB and SCB, and 65 % when BR is added. The rice-based diets had correspondingly higher gross margins than the control diets; hence the potential for promoting layer chicken production and establishment of small scale feed industries in Mwea and its environs.

6.0 GENERAL RECOMMENDATIONS

- Inclusion of 20% SCB and 20% FB in layer chicken diets is recommended for the promotion of commercial poultry.
- When using three rice by-products an optimal combination of 40% BR, 20% FB and 5% SCB inclusion levels is recommended. The diet with this formulation generally perfomed as well as the control diets.
- Rice-based diets were characterized by high fat content. This would make them prone to oxidative rancidity, which could interfere with the keeping quality of the diets. There might be need to stabilize the diets with an antioxidant additive. However, this anomaly was not experienced in these studies probably because diets were not kept for long
- The three rice by-products are abundant in Mwea but are currently underutilized. The study demonstrated their technical and economic capacity to substitute for maize in layer's diets. Establishment of small-scale feed mills in Mwea is therefore recommended to take advantage of these factors.

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APPENDICES

APPENDIX 1.0: DATA FOR LAYERS PERFORMANCE IN EXPERIMENT 1 (WEEK 20-36)

1.1 FEED INTAKE per bird (Kg/week)

				Diets		
Weeks of age	Control (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)	4 (15 %-SCB)	5 (20 %-SCB)
21	0.435	0.405	0.4832	0.616	0.6125	0.735
22	0.465	0.4175	0.4891	0.646	0.6825	0.7775
23	0.515	0.4375	0.4983	0.65975	0.7025	0.795
24	0.5325	0.4675	0.5077	0.66975	0.7175	0.8175
25	0.55725	0.48	0.5164	0.6785	0.7975	0.8325
26	0.5725	0.4925	0.5285	0.6885	0.815	0.845
27	0.595	0.505	0.534	0.6985	0.8275	0.8725
28	0.695	0.515	0.5462	0.7185	0.8625	0.8925
29	0.7075	0.575	0.653	0.727625	0.885	0.93
30	0.7175	0.625	0.685	0.782	0.8975	0.94
31	0.755	0.635	0.719	0.806	0.9075	0.9425
32	0.7675	0.675	0.737	0.823125	0.92	0.9525
33	0.7775	0.6925	0.7525	0.845	0.93	0.955
34	0.7925	0.7025	0.7665	0.865	0.9425	0.9575
35	0.815	0.7225	0.7845	0.8825	0.95	0.9675
36	0.835	0.775	0.803	0.895	0.96	0.97
Total	10.53475	9.1225	10.0039	12.00175	13.41	14.1825

1.2 BODY WEIGHT (g/bird/week)-commenced at the end of the 20th week

		Diets				
Weeks of age	Control (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)	4 (15 %-SCB)	5 (20 %-SCB)
20*	1550.40	1557.40	1545.40	1545.50	1543.70	1540.10
21	1587.50	1585.29	1565.95	1562.00	1586.93	1590.43
22	1653.57	1610.07	1591.43	1595.93	1634.28	1639.00
23	1683.93	1645.79	1621.71	1635.00	1665.07	1687.86
24	1702.38	1687.91	1664.67	1680.72	1695.14	1702.43
25	1707.00	1702.29	1706.85	1710.46	1715.57	1719.43
26	1717.50	1707.89	1712.92	1716.64	1722.57	1730.96
27	1724.96	1714.43	1718.20	1721.43	1729.86	1738.14
28	1730.00	1723.11	1723.80	1731.79	1736.07	1744.64
29	1741.43	1735.61	1730.22	1740.57	1745.11	1750.07
30	1755.57	1751.56	1736.63	1751.71	1764.29	1762.71
31	1760.36	1765.95	1742.73	1760.04	1776.50	1781.50
32	1768.64	1776.68	1750.87	1770.86	1787.86	1795.86
33	1795.00	1789.38	1759.94	1789.98	1799.15	1812.57
34	1803.06	1797.09	1770.77	1803.93	1810.00	1831.71
35	1814.86	1806.08	1788.60	1817.72	1828.43	1853.57
36	1841.92	1810.53	1812.00	1831.14	1845.47	1860.00

1.3 Mean egg number per bird

Weeks of age	Control (Non rice)	Diets 1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)	4 (15 %-SCB)	5 (20 %-SCB)
21	0.6025	0.2	0.21	0.2675	0.3075	0.245
22	1.7975	1.31	1.3925	1.445	1.1725	1.185
23	2.3325	2.03	2.045	2.146	1.79	2.0925
24	2.4775	2.15	2.16	2.26	1.915	2.295
25	2.6925	2.23	2.255	2.36	2.7775	3.2
26	3.29	2.35	2.56	2.7725	3.6075	3.3125
27	3.3575	2.32	2.5925	3.5725	3.9075	4.0525
28	3.54	2.71	2.7375	3.6	3.98	4.2275
29	5.94	4.64	5.1125	5.1275	5.6825	5.9225
30	6.06	5.03	5.37	5.26	5.7475	6.0475
31	6.1325	5.11	5.4375	5.495	5.90625	6.135
32	6.1625	5.21	5.62	5.5625	6.035	6.255
33	5.935	4.84	5.39	5.3675	5.845	5.9575
34	5.735	4.69	5.045	5.225	5.6375	5.635
35	5.4325	4.48	4.6375	4.94	5.335	5.445
36	5.21	4.32	4.2325	4.7425	5.1	5.165
Total	66.6975	53.62	59.69	60.1435	64.74625	67.1725

1.4 Mean egg weight (g/bird)

	Diets					
Weeks of age	Control (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)	4 (15 %-SCB)	5 (20 %-SCB)
21	42.20	42.32	42.60	45.19	45.63	45.13
22	44.86	45.32	45.19	48.01	47.03	45.68
23	46.61	46.91	48.23	50.45	49.60	47.47
24	49.84	48.34	52.15	52.05	52.48	51.05
25	52.27	50.34	52.25	53.82	53.49	52.80
26	53.43	51.57	52.85	54.90	54.58	53.56
27	54.28	52.14	53.24	55.49	55.66	54.28
28	54.76	53.39	53.46	56.01	56.34	55.93
29	58.61	54.26	55.23	59.56	60.67	59.92
30	58.74	55.35	56.24	60.28	60.87	60.33
31	59.65	55.65	56.90	60.91	60.99	60.66
32	59.76	56.81	58.05	61.22	61.24	61.01
33	56.18	58.30	59.23	57.47	57.62	57.47
34	57.07	59.31	60.03	58.42	58.53	58.33
35	57.53	59.64	60.12	58.92	58.78	58.58
36	57.75	60.54	60.32	59.15	59.18	59.28
Overall mean	53.97	53.14	54.13	55.74	55.79	55.09

1.5 Mean egg mass (kg/bird)

	Diets					
Weeks of age	Control (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)	4 (15 %-SCB)	5 (20 %-SCB)
21	0.025414	0.007732	0.008942	0.012087	0.01368	0.011058
22	0.080628	0.060048	0.062926	0.069362	0.055123	0.054127
23	0.108766	0.104144	0.09236	0.108254	0.089748	0.09933
24	0.123485	0.113226	0.135194	0.117619	0.101173	0.117158
25	0.140755	0.152655	0.141202	0.12702	0.148925	0.16895
26	0.175776	0.162433	0.149848	0.15221	0.194796	0.177408
27	0.182224	0.178449	0.189529	0.198219	0.218295	0.219967
28	0.19383	0.199275	0.194459	0.201644	0.224717	0.236456
29	0.348117	0.270656	0.302791	0.305373	0.345326	0.354877
30	0.355992	0.297287	0.322335	0.317057	0.348762	0.364816
31	0.365785	0.305046	0.326916	0.334669	0.358445	0.372149
32	0.368285	0.316029	0.338996	0.340524	0.369157	0.381633
33	0.333437	0.263563	0.297674	0.308435	0.341502	0.342352
34	0.327295	0.258204	0.283729	0.305215	0.328409	0.328677
35	0.312528	0.247082	0.263873	0.291077	0.313242	0.318941
36	0.300876	0.245571	0.245687	0.280494	0.302643	0.306192
Total	3.743194	3.181399	3.193302	3.46926	3.753943	3.85409

APPENDIX 2.0 Analysis of variance (Layer performance experiment 1)

2.1 Feed intake

***** Analysis of variance *****

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.19155	0.06385	4.72	
Replicate.*Units* stratum					
Treatment	5	77.07875	15.41575	1139.86	<.001
Residual	15	0.20286	0.01352		
Total	23	77.47317			

***** Tables of means *****

Variate: Feed intake_kg_week

Grand mean 11.579

Treatment	Control	1	2	3	4	5
	10.535	9.123	10.224	12.002	1 3.410	14.183

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.1753

2.2 Egg production
Variate: **Egg Production- number/Bird**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.08787	0.02929	1.01	
Replicate.*Units* stratum					
Treatment	5	544.77653	108.95531	3767.37	<.001
Residual	15	0.43381	0.02892		
Total	23	545.29822			

***** Tables of means *****

Variate: Egg Production number/Bird

Grand mean 61.947

Treatment	Control	1	2	3	4	5
	66.698	53.683	59.640	60.144	64.746	67.173

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.2563

2.3 Body_Weight
Variate: **Body Weight at Week 36 weeks**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	5	7646.342	1529.268	226.41	<.001
Residual	18	121.577	6.754		
Total	23	7767.919			

***** Tables of means *****

Variate: Body Weight at Week 36

Grand mean 1833.51

Treatment	Control	1	2	3	4	5
	1841.92	1810.53	1812.00	1831.14	1845.47	1860.00

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	18
l.s.d.	3.861

2.4 Weight gain

Variate: Weight gain

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	5	11546.056	2309.211	252.48	<.001
Residual	18	164.631	9.146		
Total	23	11710.686			

***** Tables of means *****

Variate: Weight gain

Grand mean 286.45

Treatment	Control	1	2	3	4	5
	291.52	253.15	266.61	285.66	301.82	319.94

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	18
l.s.d.	4.493

2.5 Egg_**Mass Kg/Bird**

Variate: **Egg_Mass (Kg/Bird)**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.00224311	0.00074770	7.69	
Replicate.*Units* stratum					
Treatment	5	1.75345501	0.35069100	3604.60	<.001
Residual	15	0.00145935	0.00009729		
Total	23	1.75715747			

***** Tables of means *****

Variate: Egg_Mass

Grand mean 3.5322

Treatment	Control	1	2	3	4	5
	3.7432	3.1814	3.1933	3.4693	3.7521	3.8541

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.01487

2.6 Feed Efficiency (Kg Feed: Kg Eggs)

Variate: Feed Efficiency Kg_Feed_Kg_Eggs

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.0073035	0.0024345	2.45	
Replicate.*Units* stratum					
Treatment	5	2.6814323	0.5362865	540.52	<.001
Residual	15	0.0148825	0.0009922		
Total	23	2.7036182			

***** Tables of means *****

Variate: Feed_Efficiency

Grand mean 3.2661

Treatment	Control	1	2	3	4	5
	2.8144	2.8675	3.2018	3.4593	3.5740	3.6798

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.04747

2.7 <u>Feed Consumption Over Four Week Period</u>
Feed_Consumption_Period 1_Week_21-24_
<u>Variate: Feed Consumption: Period_1</u>

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.015967	0.005322	3.03	
Replicate.*Units* stratum					
Treatment	5	5.747159	1.149432	654.29	<.001
Residual	15	0.026352	0.001757		
Total	23	5.789478			

***** Tables of means *****

Variate: Period_1

Grand mean 2.3579

Treatment	Control	1	2	3	4	5
	1.9475	1.7275	2.0410	2.5915	2.7150	3.1250

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.06317

Variate: **Feed Consumption Four Week Period: Period_2**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.010643	0.003548	1.54	
Replicate.*Units* stratum					
Treatment	5	7.169098	1.433820	624.14	<.001
Residual	15	0.034459	0.002297		
Total	23	7.214200			

***** Tables of means *****

Variate: Period_2

Grand mean	2.6832					
Treatment	Control	1	2	5	4	5
	2.4197	1.9925	2.1582	2.7840	3.3025	3.4425

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.07224

Variate: **Feed Consumption Four Week Period: Period_3**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.058473	0.019491	4.12	
Replicate.*Units* stratum					
Treatment	5	4.484422	0.896884	189.40	<.001

Residual	15	0.071032	0.004735
Total	23	4.613928	

***** Tables of means *****

Variate: Period_3

Grand mean 3.139

Treatment	Control	1	2	3	4	4
	2.947	2.510	2.865	3.139	3.610	3.765

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.1037

Variate: **Feed Consumption Four Week Period: Period_4**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.000646	0.000215	0.18	
Replicate.*Units* stratum					
Treatment	5	2.816037	0.563207	469.88	<.001
Residual	15	0.017979	0.001199		
Total	23	2.834662			

***** Tables of means *****

Variate: Period_4

Grand mean 3.3987

Treatment	Control	1	2	3	4	5
	3.2200	2.8925	3.1600	3.4875	3.7825	3.8500

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.05218

2.8 Egg Mass Four Week Period
Egg_Mass_Period_1 (Week 21-24)

Variate: Egg Mass :Period 1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.00008333	0.00002778	0.68	
Replicate.*Units* stratum					
Treatment	5	0.01808333	0.00361667	87.97	<.001
Residual	15	0.00061667	0.00004111		
Total	23	0.01878333			

***** Tables of means *****

Variate: Period_1

Grand mean 0.2892

Treatment	Control	1	2	3	4	5
	0.3400	0.2675	0.2825	0.3075	0.2575	0.2800

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.00966

Variate: **Variate: Egg Mass Period:Period 2**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.00015000	0.00005000	1.07	

Replicate.*Units* stratum

Treatment	5	0.30880000	0.06176000	1323.43	<.001
Residual	15	0.00070000	0.00004667		
Total	23	0.30965000			

***** Tables of means *****

Variate: Period_2

Grand mean 0.6675

Treatment	Control	1	2	3	4	5
	0.6900	0.5050	0.5375	0.6800	0.7900	0.8025

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.01030

Variate: **Variate: Egg Mass :Period_3**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.00061250	0.00020417	2.17	
Replicate.*Units* stratum					
Treatment	5	0.24657083	0.04931417	523.69	<.001
Residual	15	0.00141250	0.00009417		
Total	23	0.24859583			

***** Tables of means *****

Variate: Period_3

Grand mean 1.3521

Treatment	Control	1	2	3	4	4
	1.4375	1.1875	1.2900	1.2975	1.4250	1.4750

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.01463

Variate: **Variate: Egg Mass :Period_4**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.00010000	0.00003333	0.56	
Replicate.*Units* stratum					
Treatment	5	0.27380000	0.05476000	912.67	<.001
Residual	15	0.00090000	0.00006000		
Total	23	0.27480000			

***** Tables of means *****

Variate: Period_4

Grand mean 1.1900

Treatment	Control	1	2	3	4	5
	1.2725	1.0125	1.0900	1.1850	1.2825	1.2975

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.01167

3.0: DATA FOR LAYER PERFORMANCE (EXPERIMENT 2)

APPENDIX 2: LAYER PERFORMANCE FOR EXPERIMENT 2

3.1 FEED INTAKE (Kg/bird)

			Diets		
Weeks of age	Control 1 (Commercial)	Control 2 (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)
21	0.45	0.435	0.3825	0.443	0.453325
22	0.495	0.465	0.3925	0.4715	0.465
23	0.535	0.515	0.4075	0.4825	0.484
24	0.555	0.5325	0.4175	0.5	0.505
25	0.575	0.55725	0.43	0.51	0.535
26	0.595	0.5725	0.44	0.535	0.5675
27	0.615	0.595	0.455	0.575	0.5975
28	0.73875	0.695	0.467	0.605	0.62
29	0.7025	0.7075	0.6075	0.8075	0.835
30	0.7125	0.7175	0.655	0.825	0.865
31	0.7475	0.755	0.735	0.865	0.8825
32	0.775	0.7675	0.7725	0.895	0.9
33	0.7975	0.7775	0.785	0.91	0.9125
34	0.82	0.7925	0.81	0.9275	0.9275
35	0.8475	0.815	0.82	0.9375	0.9375
36	0.9175	0.835	0.83	0.9475	0.9475
Total	10.87875	10.53475	9.407	11.237	11.43483

3.2 Body weight (g)

Weeks of age	Control 1 (Commercial)	Control 2 (Non rice)	Diets 1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)
20	1556.85	1550.393	1556.7	1560.775	1560.288
21	1624.11	1587.5	1596.43	1577.44	1602.08
22	1635	1653.57	1598.51	1584.29	1612.2
23	1703.27	1683.93	1605.36	1624.29	1617.86
24	1714.58	1702.38	1634.82	1627.73	1622.32
25	1719.58	1707	1645.24	1630	1648.51
26	1724.73	1717.5	1655.54	1642.92	1664.29
27	1728.87	1724.96	1673.81	1655	1667.86
28	1751.965	1741.43	1703.95	1715.05	1709.925
29	17534.965	1749.43	1717.45	1719.05	1715.925
30	1755.17	1755.57	1725.54	1725.36	1719.29
31	1758.11	1760.36	1739.36	1745.18	1728.57
32	1762.858	1768.635	1764.02	1765.158	1762.61
33	1794.01	1795	1788.31	1776.98	1775.95
34	1798.34	1803.06	1801	1786.05	1799.78
35	1823.66	1814.86	1815.01	1807.19	1808.79
36	1860.15	1841.915	1830.6	1849.375	1844.35

20* Assessment of body weight commenced at the end of the 20th week since this marks weight at the start of 21st week

3.3 Egg Number/bird

Weeks of age	Diets Control 1 (Commercial)	Control 2 (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)
21	0.92	0.6025	0.4275	0.4875	0.4075
22	2.205	1.7975	1.53	1.9875	1.5675
23	2.6325	2.3325	1.8925	2.21	2.03
24	2.835	2.4775	2.14	2.3625	2.2875
25	3.0175	2.6925	2.1875	2.57	2.54
26	3.845	3.29	2.3625	2.6925	2.5875
27	3.895	3.3575	2.4	2.825	2.645
28	4.9275	3.54	2.4625	3.025	2.825
29	6.1	5.94	4.5625	5.3325	5.14
30	6.1375	6.06	4.6575	5.9525	5.665
31	6.2275	6.1325	5.035	6.4325	6.35
32	6.28	6.1625	5.9775	6.39	6.2925
33	5.8	5.935	5.64	6.0475	5.955
34	5.6875	5.735	5.4825	5.75	5.65
35	5.4825	5.4325	5.235	5.5125	5.3425
36	5.22875	5.21	4.935	5.3425	5.255
Total	71.22125	66.697	56.9275	64.92	62.54

3.4 Mean egg weight (g)

			Diets		
Weeks of age	Control 1 (Commercial)	Control 2 (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)
21	41.6	42.195	42.4	42.3	42.31
22	42.875	44.8625	42.725	43.15	43.16
23	44.075	46.605	44.45	43.425	43.435
24	45.675	49.8425	44.625	44.375	44.385
25	47.325	52.265	45.5	46.8	46.81
26	49.55	53.4275	47.175	49.625	49.635
27	51.425	54.275	48.5	50.6075	50.6175
28	52.95	54.755	50.675	52.725	52.735
29	55.075	58.605	52.9	54.5	54.51
30	58.55	58.7425	58.75	60.045	60.055
31	59.5	59.6475	59.17	60.4125	60.4225
32	59.7	59.7625	60.4	60.5625	60.5725
33	57.95	56.18	57.4	59.155	59.165
34	56.025	57.0725	54.25	56.275	56.285
35	56.6	57.53	55.475	57.725	57.735
36	57.7	57.7475	56.4	58.2	58.21

3.5 Egg mass (kg)

			Diets		
Weeks of age	Control 1 (Commercial)	Control 2 (Non rice)	1 (0 %-SCB)	2 (5 %-SCB)	3 (10 %-SCB)
21	0.03827	0.025414	0.018127	0.020622	0.017242
22	0.09454	0.080628	0.065369	0.08576	0.067653
23	0.116025	0.108766	0.084119	0.095971	0.088179
24	0.129488	0.123485	0.095499	0.104835	0.101532
25	0.142801	0.140755	0.099528	0.120274	0.118897
26	0.190521	0.175776	0.111451	0.133616	0.128427
27	0.200301	0.182224	0.116404	0.142964	0.13389
28	0.260909	0.19383	0.124785	0.159496	0.148978
29	0.335967	0.348117	0.241361	0.290621	0.280176
30	0.359349	0.355992	0.273621	0.357416	0.34021
31	0.370538	0.365785	0.299207	0.38861	0.383681
32	0.374917	0.368285	0.361204	0.386997	0.381148
33	0.336108	0.333437	0.323882	0.357734	0.352342
34	0.318641	0.327295	0.297426	0.323586	0.318007
35	0.310323	0.312528	0.290408	0.318205	0.308442
36	0.3017	0.300876	0.277719	0.310928	0.305896
Total	3.88	3.74	3.08	3.59	3.47

APPENDIX 4.0 ANALYSIS OF VARIANCE

<u>4.1 Variate</u>: Feed_efficiency

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	0.6973710	0.1743427	475.15	<.001
Residual	15	0.0055038	0.0003669		
Total	19	0.7028748			

Message: the following units have large residuals.

units 3	-0.0442	s.e.	0.0166
units 4	0.0397	s.e.	0.0166

Tables of means

Variate: Feed_efficiency

Grand mean 3.0173

Treatment	Control 1	Control 2	1	2	3
	2.8035	2.8144	3.0541	3.1234	3.2909

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.00958

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.01354

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Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.02887

Stratum standard errors and coefficients of variation

Variate: Feed_efficiency

d.f.	s.e.	cv%
15	0.01916	0.6

4.2 Analysis of variance (Feed Consumption)

Variate: Feed Consumption Experiment 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	10.237732	2.559433	315.10	<.001
Residual	15	0.121839	0.008123		
Total	19	10.359572			

Message: the following units have large residuals.

units 3	-0.169	s.e.	0.078
units 4	0.156	s.e.	0.078

Tables of means

Variate: Feed Consumption

Grand mean 10.698

Treatment	Control 1	Control 2	1	2	3
	10.879	10.535	9.407	11.237	11.435

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.0451

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.0637

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.1358

Stratum standard errors and coefficients of variation

Variate: Feed Consumption

d.f.	s.e.	cv%
15	0.0901	0.8

4.3 Analysis of variance (Feed Consumption 4-week-periods)

Variate: **Feed Consumption Experiment 2 Period 1**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	0.4319288	0.1079822	203.55	<.001
Residual	15	0.0079575	0.0005305		
Total	19	0.4398862			

Message: the following units have large residuals.

units 7 0.0425 s.e. 0.0199

Tables of means

Variate: Experiment 2
Grand mean 1.8774

Treatment	Control 1	Control 2	1	2	3
	2.0350	1.9475	1.6000	1.8970	1.9073

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.01152

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.01629

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.03471

Stratum standard errors and coefficients of variation

Variate: Feed Consumption Experiment 2 Period 1

d.f.	s.e.	cv%
15	0.02303	1.2

Analysis of variance
Variate: Feed Consumption Experiment 2 Period
2

Source of variation d.f. s.s. m.s. v.r. F pr.

Treatment	4	1.1832428	0.2958107	355.09	<.001
Residual	15	0.0124958	0.0008331		
Total	19	1.1957386			

Message: the following units have large residuals.

units 3	-0.0575	s.e.	0.0250
units 4	0.0525	s.e.	0.0250

Tables of means

Variate: **Variate:**Feed Consumption Experiment 2 Period 2

Grand mean 2.2468

Treatment	Control 1	Control 2	1	2	3
	2.4775	2.4198	1.7920	2.2250	2.3200

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.01443

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.02041

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.04350

Stratum standard errors and coefficients of variation

Variate: FC_expt_2_PD_2

d.f.	s.e.	cv%
15	0.02886	1.3

Analysis of variance

Variate: Feed Consumption Experiment 2 Period 3

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	1.5783300	0.3945825	401.95	<.001
Residual	15	0.0147250	0.0009817		
Total	19	1.5930550			

Tables of means

Variate Feed Consumption Experiment 2 Period 3

Grand mean 3.1035

Treatment	Control 1	Control 2	1	2	3
	2.9250	2.9475	2.7700	3.3925	3.4825

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.01567

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.02215

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.04722

Stratum standard errors and coefficients of variation

Variate: Feed Consumption Experiment 2 Period
3

d.f.	s.e.	cv%
15	0.03133	1.0

Feed Consumption Experiment 2 Period
3

Analysis of variance

Variate: Feed Consumption Experiment 2 Period
4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	1.1480200	0.2870050	301.58	<.001
Residual	15	0.0142750	0.0009517		
Total	19	1.1622950			

Message: the following units have large residuals.

units 3 -0.0600 s.e. 0.0267

Tables of means

Variate: Feed Consumption Experiment 2 Period
4

Grand mean 3.4305

Treatment	Control 1	Control 2	1	2	3
	3.2400	3.2200	3.2450	3.7225	3.7250

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.01542

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.02181

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.04649

Stratum standard errors and coefficients of variation

Feed Consumption Experiment 2 Period
4

d.f.	s.e.	cv%
15	0.03085	0.9

4.4 Analysis of variance (Egg_mass)

Variate: Egg_mass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	1.5003497	0.3750874	1638.99	<.001
Residual	15	0.0034328	0.0002289		
Total	19	1.5037825			

Tables of means

Variate: Egg_mass

Grand mean 3.5552

Treatment	Control 1	Control 2	1	2	3
	3.8804	3.7432	3.0801	3.5976	3.4747

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.00756

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.01070

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.02280

Stratum standard errors and coefficients of variation

Variate: Egg_mass

d.f.	s.e.	cv%
15	0.01513	0.4

4.5 Analysis of variance (Eggmass 4 week period)

Variate: Egg mass Period 1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	0.03560342	0.00890086	415.95	<.001
Residual	15	0.00032098	0.00002140		
Total	19	0.03592440			

Message: the following units have large residuals.

units 7	-0.0101	s.e.	0.0040
units 8	0.0123	s.e.	0.0040

Tables of means

Variate: Egg mass Period 1

Grand mean 0.3123

Treatment	Control 1	Control 2	1	2	3
	0.3783	0.3383	0.2631	0.3072	0.2746

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.00231

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.00327

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.00697

Stratum standard errors and coefficients of variation

Variate: Egg mass Period 1

d.f.	s.e.	cv%
15	0.00463	1.5

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Analysis of variance

Variate: Egg_mass_Period_2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	0.29965808	0.07491452	2806.20	<.001
Residual	15	0.00040044	0.00002670		
Total	19	0.30005852			

Message: the following units have large residuals.

units 6 0.0094 s.e. 0.0045

Tables of means

Variate: Egg_mass_Period_2

Grand mean 0.6052

Treatment	Control 1	Control 2	1	2	3
	0.794	0.6926	0.4522	0.5563	0.5302

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.00258

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.00365

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.00779

Stratum standard errors and coefficients of variation

Variate: Egg_mass_Period_2

d.f.	s.e.	cv%
15	0.00517	0.9

Analysis of variance

Variate: Egg mass Period 3

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	0.2024110	0.0506028	351.54	<.001
Residual	15	0.0021592	0.0001439		
Total	19	0.2045702			

Message: the following units have large residuals.

units 8 0.0218 s.e. 0.0104

Tables of means

Variate: Egg mass Period 3

Grand mean 1.3726

Treatment	Control 1	Control 2	1	2	3
	1.4408	1.4382	1.1754	1.4236	1.3852

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.00600

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.00848

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.01808

Stratum standard errors and coefficients of variation

Variate: Egg mass Period 3

d.f.	s.e.	cv%
15	0.01200	0.9

Analysis of variance

Variate: Egg_mass_Period_4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	0.03300037	0.00825009	87.15	<.001
Residual	15	0.00141997	0.00009466		
Total	19	0.03442034			

Message: the following units have large residuals.

units 7 0.0184 s.e. 0.0084

Tables of means

Variate: Egg_mass_Period_4

Grand mean 1.2651

Treatment	Control 1	Control 2	1	2	3
	1.2668	1.2741	1.1894	1.3105	1.2847

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.00486

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.00688

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.01466

Stratum standard errors and coefficients of variation

Variate: Egg_mass_Period_4

d.f.	s.e.	cv%
15	0.00973	0.8

4.6 Analysis of variance (Egg Number)

Variate: Egg_Number

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	445.42982	111.35746	3825.24	<.001
Residual	15	0.43667	0.02911		
Total	19	445.86649			

Message: the following units have large residuals.

units 5	-0.337	s.e.	0.148
units 8	0.383	s.e.	0.148

Tables of means

Variate: Egg_Number

Grand mean 64.461

Treatment	Control 1	Control 2	1	2	3
	71.221	66.697	56.928	64.920	62.540

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	0.0853

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	0.1206

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	0.2572

Stratum standard errors and coefficients of variation

Variate: Egg_Number

d.f.	s.e.	cv%
15	0.1706	0.3

4.7 Analysis of variance (Body weight gain)

Variate: Body Weight_Gain

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	1843.15	460.79	7.34	0.002
Residual	15	941.97	62.80		
Total	19	2785.12			

Message: the following units have large residuals.

units 12 14.2 s.e. 6.9

Tables of means

Variate: Body weight difference between the 20[th] and 36[th] week

Grand mean 288.3

Treatment	Control 1	Control 2	1	2	3
	303.3	291.5	273.9	288.6	284.1

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	3.96

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	5.60

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	11.94

Stratum standard errors and coefficients of variation

Variate: BW_diff_btw_20th_and_36th_wk

d.f.	s.e.	cv%
15	7.92	2.7

4.8 Analysis of variance (Body weight at 36 weeks)

Variate: Body Weight at 36 Weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	4	1862.31	465.58	7.57	0.002
Residual	15	922.23	61.48		
Total	19	2784.53			

Tables of means

Variate: Body Weight at 36 Weeks

Grand mean 1845.3

Treatment	Control 1	Control 2	1	2	3
	1860.2	1841.9	1830.6	1849.4	1844.4

Standard errors of means

Table	Treatment
rep.	4
d.f.	15
e.s.e.	3.92

Standard errors of differences of means

Table	Treatment
rep.	4
d.f.	15
s.e.d.	5.54

Least significant differences of means (5% level)

Table	Treatment
rep.	4
d.f.	15
l.s.d.	11.82

Stratum standard errors and coefficients of variation

Variate: Body Weight at 36 Weeks

d.f.	s.e.	cv%
15	7.84	

APPENDIX 5.0 Variate: EGG_PRODUCTION (Field Trials)

Source of variation	d.f.	s.s.	m.s.	v.r.	Fpr.
Treatment	2	24.302617	12.151308	4418.66	<.001
Residual	9	0.024750	0.002750		
Total	11	24.327367			

***** Tables of means *****

Variate: Egg_production

Grand mean 8.468

Treatment	Control	1	2
	10.360	6.927	8.118

*** Least significant differences of means (5% level) ***

Table	Treatment
rep.	4
d.f.	9
l.s.d.	0.0839

APPENDIX 6.0 Cost of ingredients price/kg (ksh)

1. Maize	16
2. Fish meal	30
3. Soya bean meal	35
4. Limestone	4
5. Dicalcium phosphate	40
6. Common salt	20
7. Layer premix	200
8. Fine bran	8.3
9. Broken rice	8.3
10. Special coarse bran	1.6
11. Corn oil	74
12. D, L - methionine	500
13. L - lysine	550
14. Carotenoids	200

6.1 Cost of Diets in experiment one

	Diets					
	1	2	3	4	5	
% Ingredients	(0% SCB)	(5% SCB)	(10% SCB)	(15% SCB)	(20% SCB)	Control
Maize	654.88	580.96	517.76	453.76	388.96	912.64
Special coarse bran	0	8	16	24	32	0
Fine bran	166	166	166	166	166	0
Corn oil	217.56	209.42	204.24	199.8	194.62	220.52
Soya bean meal	618.1	598.15	579.95	562.8	546.35	678.3
Fish meal	294	282.9	276	269.1	262.8	297.9
Limestone	27.28	26.4	25.76	25.12	24.52	31.8
Vitamin/Mineral Premix	100	94	92	90	88	100
Methionine	24.5	40	35	35	35	25
Lysine	27.5	27.5	27.5	22	22	27.5
Dicalcium phosphate	39.2	75.6	73.6	71.6	70	74.4
Carotenoids	4	4	4	4	4	4
Common salt	5	4.8	4.66	4.4	4.4	5
100 Kg	2178.02	2117.73	2022.47	1927.58	1838.65	2377.06
! Kg	21.8	21.2	20.2	19.3	18.4	23.8

6.2 Cost of Diets in experiment two

	Diets			
	(0%SCB)	(5%SCB)	(10%SCB)	
Ingredients	1	2	3	Control
Maize	115.2	49.92	28.16	912.64
Special coarse bran	0	8	16	0
Corn oil	0	0	0	222
Methionine	10	10	10	25
Lysine	22	22	22	27.5
Dicalciumphosphate	36.4	35.6	22.8	74.4
Carotenoids	4	4	4	4
Common salt	4.6	4.4	4.4	5
Limestone	25.6	24.96	20.4	31.76
Soya bean meal	512.05	496.65	446.6	678.3
Fish meal	301.5	294	287.1	297.9
Fine bran	166	166	166	0
Broken rice	332	332	332	0
Layer premix	92	90	86	100
100 Kg	1621.35	1537.53	1445.46	2378.5
1 Kg	16.2	15.4	14.5	23.8

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