EVALUATION OF RICE MILL BY-PRODUCT IN SWINE RATIONS

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CERTIFICATION

This thesis "Evaluation of Rice Mill By-Product in Swine Rations" by Samuel Tijani Omale Attah meets the regulations governing the degree, Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

To my dear wife, Rachel and my beloved children, Ochune, Achele, Ojonugwa, Ojomachewn, Achenyo, Emmanuel and Uneku for their patience and prayers.

DECLARATION

I declare that this work is wholly the author's and has not been part of any presentation for any other qualification.

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ABSTRACT

Three studies were conducted to evaluate the utilization of rice mill by-product using soyabean meal and groundnut cake as protein supplements in the diets of pigs. In the first trial, eighteen (18) crossbred (Large White X Landrace) pigs with average initial weight of 35.9 kg were fed rice by-product at 0, 5 or 10 percent of the 15 percent crude protein diet. Treatments were randomly assigned to each pen of pig in 6 replications. During the 14.2-day trial period, average daily feed (ADF) increased linearly (P/ 0.01) and a quadratic (P/ 0.01) increase was observed for average daily gain (ADG). Feed per unit gain, increased with increasing level of rice by-product.

In the second trial lasting 28 days, twelve (12) crossbred (Hampshire X Yorkshire X Landrace) barrows and gilts of average initial weight of 16.5kg were used for digestibility balance trials. Rice by-product was fed at O, 10, 20 or 30 percent of the 18 percent crude protein diet. All pigs were fed at 14 percent and or 6 percent body weight daily. Rice by-product diets fed to the growing pigs depressed gains and feed to gain ratios but did not affect average daily feed intake (ADF). Digestion coefficients for dry matter (DM), N and energy decreased linearly with increasing level of rice by-product. Digestible energy (DE) values of the diets decreased linearly with increasing levels of rice by-product.

in the third trial, twenty four (24) growing-finishing (Landrace x Large White X Hampshire) pigs (barrows and gilts) of average initial weight of 35.5 kg liveweight were fed for 56 days with graded levels of rice by-product to test its effects on performance and carcass characteristics. Rice by-product replaced 0, 15, 30 or 45% of the maize in iso-nitrogenous pig finisher diets. Animals were slaughtered in three sequential groups beginning with the first two replicates.

Performance data was based on 56 days while animals were on the experimental diets prior to slaughter. Carcass measurements were taken. Results showed significant differences among treatments with respect to average daily gain (ADG), efficiency of feed utilization and carcass weight, but the average daily feed (ADP) and digestible energy intakes were not significantly affected during the period. Generally, pigs on the control diet , tended to perform better than those on rice by-product diets, but the differences were not always statistically significant. Carcass quality measurements did not show significant differences among treatment means, but there was a tendency towards lower fat plus skin measurements and higher lean parameters as the levels of rice by-product increased in the diets. It is suggested that rice by-product can be economically used to replace the more expensive maize component at most up to 30 percent level tested in this trial without adversely depressing the performance of growing-finishing pigs.

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ABBREVIATIONS

GE	-	Gross Energy
DE	-	Digestible Energy
ME	-	Metabolisable Energy
NE	-	Net Energy
N	-	Nitrogen
CP	-	Crude Protein
CF	-	Crude Fibre
EE	-	Ether Extract
NFE	-	Nitrogen Free Extract
BV	-	Biological Value
FG	-	Feed to Gain Ratio
Kcal	-	Kilo Calorie
Mcal	-	Mega Calorie
NB	-	Nitrogen Balance
ADF	-	Average Daily Feed
ADG	-	Average Daily Gain
RBP	-	Rice By-Product

INTRODUCTION

Feed cost has always determined the profitability of a swine enterprise. In economic terms feed costs account for 75 to 80 percent of the total cost of pig production in the feeding herd and 60 to 65 percent in the breeding herd (Thorton, 1978). The problem of rising feed costs in the swine industry is compounded by limited supply of food grains such as maize and sorghum, most of which are channelled to meet human dietary demands in the developing countries. In order to alleviate the problem of feed shortage, utilization of agro-industrial by-products should be emphasized through research, proper feed formulation and also considering cost. However, formulating very efficient diets high in energy and protein involves cost which may prove uneconomic and impractical to local swine producers. Lowered feed cost means that a swine farmer can realize a wider profit margin. With the continued astronomical rise in the price of energy and protein feed stuffs, livestock producers cannot afford to feed any nutrient in excessive amount. Although high in fibre rice by-products contain a wide range of both essential and non-essential amino acids in varied concentrations (Appendix I). Inadequacies of most vitamins and micro minerals can be corrected by supplementation with vitamins, amino acids and micro minerals in a premix.

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PROBLEMS OF SWINE INDUSTRY IN AGRICULTURAL SUB-SECTOR

The greatest constraint to the production of existing livestock population of about 9 million cattle, 30 million sheep and goats, 0.86 million pigs and 134 million poultry is inadequate nutrition both in quality and quantity (Adebowale, 1983). He attributed this problem to the over-dependence on the conventional feed sources particularly the feed grains which are in great demand for human consumption. Alternative feed sources exist in the form of farm crop residues, agro-industrial by-products and animal waste products. The current prohibitive prices of cereal grains and the high demand by human beings, poultry and the swine industry has made it become necessary to find suitable and cheap energy sources. Researchers have shown a re-newed interest in the use of agro-industrial by-products for feeding livestock. According to Devendra and Raghavan (1978) there is an economic advantage for utilizing higher levels of agro-industrial by-products such as rice milling by-products, wheat offals, and brewers' dried grains in swine and poultry diets. This view is justified and is associated with three important considerations: firstly, inadequate feed supply to support livestock populations, secondly, the high cost of feeding animals and thirdly, the need to increase productivity from the animals. These authors concluded that every attempt must therefore be made to utilize these by-products in diets of farm animals.

PROSPECTS FOR INCREASED SWINE PRODUCTION IN NIGERIA

Although pork and its associated products like ham, bacon and sausage suffer from religious discrimination by some Nigerians, their continued rise in price in catering houses is indicative of an increase in demand by consumers in the country. This trend is tied up with one of the most important advances made in the last few years in the field of both nutrition and feeding of growing-finishing pigs. It concerns the reduction of feeding costs in relation to total production costs. The animal required is lean; its growth though not necessarily the most rapid, is the most advantageous from an economic point of view. This is in terms of feed efficiency and carcass quality. In most cases feed efficiency and the resulting body composition are related. Productivity therefore depends on the performance of the animals during both the rearing and growing-finishing periods. Since independence, considerable emphasis has been given to increasing animal protein in the diets of Nigerians. Thus swine production along scientific methods has great potential in achieving this goal because of the following economic traits in the pig:

1. High prolificacy
2. High growth rate
3. High efficiency of feed conversion
4. High dressing percentage
5. Modest requirements for buildings and equipment
6. The ability of the pig to utilize a wide range of agro-industrial by-products which are by far cheaper than grains.

Considerable interest has been shown by numerous workers in the formulation of high efficiency diets for all classes of pigs and poultry (Ademosun 1973, Oluyemi and Oyenuga, 1974). The use of locally produced agro-industrial by-products such as rice mill by-products in cutting down costs and producing cheap feed of acceptable quality will promote and sustain the interest of swine producers since feed cost has always determined the profitability of a swine enterprise. According to Adebowale (1983) it is the adaptation and transfer of research results for use by the majority of small scale producers who are responsible for more than 37 percent of the animal production in Nigeria that will accelerate animal production strategy for the country.

OBJECTIVE OF THE PROJECT

This project was carried out with a view to reducing feed cost especially the scarce cereal grains with their current prohibitive prices. The principal objectives of the Project were:

i) To investigate the utilization of RBP in the diets for various classes of pigs.

ii) To investigate the replacement value of RBP for maize and protein concentrate in swine rations and the effect of such replacement on performance characteristics of pigs.

iii) To find out how much the use of rice mill by-products can affect the overall feed cost.

It is hoped that the results of this piece of work will provide some useful information regarding the use of rice mill by-product as a partial replacement of the more costly grain component of swine diets.

LITERATURE REVIEW

During the processing of polished rice, several by-products are obtained. These include the husk, rice bran, rice polishings and broken rice (brewers' rice). Rice by-products vary in nutrient composition depending on the milling method used. In rice milling, approximately 17% of the paddy yield results in husk (Devendra, 1975), however, Ranjhan (1980) gave a range of 20 to 25%.

In order to appreciate the nutritive values of these rice milling by-products a brief description of each type is made herein.

RICE BRAN

Rice bran is produced in the process of milling paddy rice by removing the hulls, polishing to remove the epicarp, mesocarp, cross layers, testa, aleurone layer and perhaps one or two stages the outer layers. Rice bran is of a highly variable quality with regards to the fibre content which is sometimes raised by adulteration with husk. The method of distinction of rice milling by-products according to Arnott and Lim (1966) is based on their fibre content. Analysing samples of Malaysian rice bran and polishings they observed that rice bran contained 11.3% crude fibre, 12.3% crude protein, 12.1% ether extract, 10.2% ash, 0.85% calcium, 0.67% magnesium, 1.34% phosphorus and 2.02% silica on dry matter basis.

NUTRITIVE PROFILE OF RICE BRAN

Although rice bran is used widely in the tropics, its full feeding value is often not realized due to contamination with hulls, deterioration in storage and incorrect diet formulation.

Loosli (1954) carried out extensive digestibility trials feeding rice bran to growing pigs in the Philipines. He observed that the lack of uniformity of fibre content of rice bran and failure to regulate its quality were serious handicaps to the profitable production of eggs, pork and milk in that region. National Research Council (NRC)(1971) recognised rice bran as an energy source of feed supplying 2907 kcal/kg (as fed) digestible energy. Brooks and Lumunta (1975) in a digestion trial with barrows and gilts averaging 39 and 66 kg live weight reported percent composition and digestion coefficients respectively for rice bran; crude protein 13.4 and 69.7, nitrogen free extract 49.2 and 76.8, ether extract 14.8 and 91.4, and gross energy 4.7 kcal/g and 66.0; crude fibre and ash composition were also reported as 12.4 percent and 10.2 percent respectively. More recently Robles and Ewan (1982) fed rice and rice bran to young pigs in a comparative slaughter experiment and reported that average energy values for rice and rice bran in kcal/g of dry matter respectively were; gross energy 3.70, 3.88; metabolizable energy, 3.58, 3.71; N-corrected metabolizable energy, 3.35, 3.50; and net energy, 2.51, 2.03.

RICE POLISHINGS

Rice polishings are obtained from the inner part of the grain. Thus rice polishings do not vary very widely as rice bran in composition. The fibre content is much lower but when high, it indicates adulteration with husk.

NUTRIENT PROFILE OF RICE POLISHINGS

Rice polishings contain as much protein and nearly as much fat as rice bran, and therefore tends to become rancid in storage like rice bran. Thus it should be fed when as fresh as possible. Rice polishings are rich in thiamine and especially high in niacin Morrison, (1959) and Osuji, (1982). Ranjhan (1980) gave nutrient composition (proximate values) of 3% crude fibre, 12% fat and 12 to 14% protein for rice polishings. The author recommended rice polishings as an excellent source of energy for swine and poultry.

RICE HUSK

Arnott and Lim (1966) in their investigation into the quality of rice bran and polishings amongst numerous varieties of Malayan rice by-products reported rice husk to contain 11 to 19% silica. The gross energy of rice husk has been reported to vary from 1900 to 3200 kcal/kg dry matter (Devendra and Raghavan 1978). However, most of this energy is unavailable to the pig due to the high fibre content in rice husk. Campabadal et al. (1968) and Osuji (1982) observed that when rice husk is present in high amount in rice bran, it exhibits a deleterious effect on the walls of the stomach and the small intestine owing to its abraisive characteristics and its high content of silica. Husk contains about 5.9% silica. According to Ranjhan (1980) rice husk contains 8 to 11% water, 15.7 to 22.6% ash, 14.5 to 17.5% acid soluble ash, 2.9 to 3.6% crude protein, 0.8 to 1.2% ether extract, 39 to 42% crude fibre and 25 to 29% nitrogen-free extract. He observed that unground rice husk is unpalatable to farm animals. Thus rice husk may be

of little or no use to farm animals particularly pigs and poultry with limited capacity for bulkiness and fewer micro-floral population that can attack fibrous feeds. Elucidating further on the effect of the use of rice hulls on pig-finisher ration, Sudaryanto *et al*. (1983) conducted a trial using 24 finisher pigs (12 males and 12 females) with an initial weight averaging about 40kg for a period of six weeks. Rice hulls replaced rice bran at 0%, 25%, 50% and 75% in a 15% CP diet. Their results showed that intake tended to decrease with increasing levels of rice hulls in the diets while average daily gain was depressed. A similar trend was observed with efficiency of feed utilization, but differences between treatments were not significant.

BREWERS' RICE (RICE MEAL)

Brewers' rice consists of the small pieces of the broken kernels in the milling process. It is used chiefly in the brewing industry but sometimes fed to livestock in the developed countries. It is a rich source of energy. In 22 experiments with fattening pigs brewers' rice has been worth about 6 percent more than corn but in one test with fattening cattle, it was not equal to corn (Morrison, 1959). According to the authority, brewers' rice is known to produce hard pork.

RICE MEAL BY-PRODUCT

Rice meal by-product is the entire by-product obtained in the milling of paddy rice to produce polished rice. It includes the hulls, rice bran, rice polishings and broken grains. It is sometimes called "rice meal feed". According to Morrison (1959)

its fibre content should not exceed 30% while about 60% of such product is rice hulls. Gohl (1975) described rice meal feed as containing 60% hulls, 35% bran and 5% polishings. Rice meal by-product in descriptive term is similar to the rice by-product used in this study, however, in terms of nutrient composition the product used in the study is comparable to the proximate analysis of rice husk as given by Ranjhan (1980).

RICE BY-PRODUCTS IN PIG DIETS

As early as 1924 Allas observed that rice bran was superior to sweet potato vines for growing and fattening pigs. Emasiri (1940) also reported that rice bran was better than corn bran when used as energy source in combination with copra meal and shrimp meal as protein supplements for growing pig rations. Thus, rice bran may partly replace the grain in pig diets (Noland and Scott 1963; Thrasher and Mullins, 1965; Thrasher et al. 1963). Noland and Scott (1963) reported that the replacement of 25 to 50% of the maize with rice bran in the diet of pigs did not affect gains but did result in poorer feed conversion. Other studies by Thrasher and Mullins (1965) indicated that not more than 20% of rice bran can be fed to growing pigs without depressing the performance. In contrast, Moncada and Maner (1966) noted improved performance with pigs fed up to 30% rice bran, but at 40% level, gain was depressed. Alcantara et al. (1968), studied the effects of rice bran fish-meal combination with varying protein levels of 12 to 22% on growth rate and feed efficiency of growing pigs. They observed that average daily gain increased from 0.41 to 0.66 kg as the protein level of the diet increased.

Daily gains of pigs fed with 18, 20 and 22 percent protein diets were significantly better than those fed the 12 percent protein diet. They further observed that average feed efficiency ranged from 2.92 to 5.72. It was also observed that the cost of feed per kilogram gain showed no trend. Balderama et al. (1968) studying the simple combinations of rice bran soyabean meal in growing pig rations reported that gain of pigs fed 19.7 percent crude protein ration was significantly higher than those fed 11.28 percent crude protein diets. Bray (1943) as reported by Pond and Maner (1974) observed that rice bran has approximately the same feeding value as maize if the level of sustitution does not exceed 30 percent of the total ration. Solvent extracted rice bran has the same feeding value as maize when included at levels not exceeding 30 percent of the total ration (Pond and Maner 1974). Maner et al (1972) observed that rice bran is a poor source of feed for pigs when used to replace all the grain in grower-finisher diets. Brooks and Lumunta (1975), in one trial fed four levels of rice bran (0, 30, 50 and 70%) at three different energy levels (3.3, 3.4, 3.5 kcal/g) with isocaloric diets to growing-finishing pigs and reported that daily gains and feed conversion ratio decreased with increased levels of rice bran. They observed that differences in gains and feed to gain ratio between the two higher levels (50 and 70% rice bran) and the basal were highly significant. When higher levels of rice bran 40, 60 and 80 percent of total diets were fed to finishing pigs Brooks and Lumunta (1975) observed that average daily gain decreased and feed to gain ratios increased with increasing levels of bran in the diet.

Campabadal et al. (1976) investigated the effects of feeding graded levels of rice bran (5, 10, and 15%) in both weaner and finisher pig diets containing 12% crude protein, 12% minimum fat, and 12% maximum crude fibre. Their results showed no significant differences in daily gains and feed to gain ratios due to the bran fed. However, pigs fed the highest level of rice bran tended towards reduced performance with daily gain 8.6 percent lower and feed to gain ratio 3.4 percent higher than the control.

In a second trial the performance of 45 weaner pigs fed rice bran with or without added fat was investigated. Rice bran fed at 20% level with 1.19% fat or without fat was compared to the control diet. The 20% bran diet resulted in significantly poorer gains and feed conversion when compared to the control and bran plus fat diets. The supplementation of rice bran diet with fat increased palatability and therefore feed intake resulted in faster gains.

In the third trial, rice bran was fed at 0, or 40% with or without fat addition. These workers observed that the addition of fat resulted in decreased consumption of the control diet but increased consumption of the bran plus fat diet.

In the fourth trial, they observed that rice bran fed at 30% level had no significant effect on gains or feed conversion of growing and finishing pigs. However, feeding higher levels of 35, 40 and 45% rice bran resulted in significantly less daily gains of finishing pigs; whereas feed to gain ratios increased significantly with each increase in amount of rice bran above 35 percent. They suggested that rates up to 15 to 30 percent in weaner and growing-finisher diets respectively may be safe.

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Mehta et al. (1969) described rice polishing as a concentrate of high digestibility and good nutritive value. Sharda et al. (1975) fed maize replaced with rice polishing at 15 and 30% levels to 18 Yorkshire growing pigs. They observed no adverse effects on average daily gain, feed efficiency, carcass quality and organ growth.

In an attempt to formulate economic rations based on rice by-products for growing Large White Yorkshire pigs, Rao' and Prasad (1980) fed both isocaloric and isonitrogenous diets which had maize in the basal diet replaced by 0, 30 or 40% rice polishings or by 13% rice polishings plus 10% molasses, or by 12% rice polishings plus 15% molasses. In the sixth diet, rice bran replaced wheat bran rather than maize. Their results initially showed very low rate of gain by pigs on 30% and 40% rice polishings diets which were also reported deficient in Zinc (Rao' and Prasad, 1980). However, when zinc was included at 100 mg/kg feed, feed intake per kilogramme gain was nearly similar in all treatments but tended to be greatest with 40% rice polishings. The next best diets reported in this trial were 30% rice polishings with zinc and 13% polishings with 10% molasses. It has been known that zinc deficiency in pig diets results in poor feed efficiency (Ranjhan, 1980).

RICE BY-PRODUCTS IN POULTRY DIETS

Several investigations have reported successful use of diets containing 20 to 45% rice bran or polishings in trials with chicks (Din et al. 1975; Din et al. 1979; Zombade et al. 1981; Piliang et al. 1982; Wiranga et al. 1982 and Fonseca et al. 1983).

Din et al. (1979) fed 74.7% rice bran diet to laying chickens and observed 43.5% egg production. In another experiment, Wiranga et al. (1982) fed a diet containing 74.7% of autoclaved rice bran diet to laying chickens and observed a 64.6% egg production, which was not significantly different from the control diet. Zombade et al. (1981) fed diets in which parboiled rice bran replaced 50, 75 or 100% of the maize to White Leghorn pullets and observed no adverse effect on growth rate. Piliang et al. (1982) in three experiments using 20 week-old pullets fed diets contaiing 81.5% rice bran and observed that birds laid significantly fewer eggs than pullets fed a standard breeder diet. However, when the same diets were supplemented with zinc carbonate, no significant differences were observed between the high rice bran groups and the control group.

In order to determine the best level of brewers' rice in poultry diets, Fonseca et al. (1983) fed 480 broiler type chicks substituting corn with brewers' rice at 0, 20, 40, 60, 80 and 100% level supplemented with oil at 0 and 3 percent. In their second trial, corn was isometrically replaced by brewers' rice at six levels of substitution (0, 20, 40, 60, 80 and 100%) with and without inclusion of soyabean oil. They observed that brewers' rice could replace all the corn without significantly affecting weight gain, feed consumption and conversion; and egg production and weight. These workers on the other hand, reported that shanks and egg yok pigmentation decreased significantly with the use of brewers' rice. Menheswar et al. (1982) studied the effects of various heating methods upon chemical characterization

of rice-mill feed and its value for poultry at high dietary levels. Heated rice-mill feed consisting of bran, polishings, rice and groats at either 85 - 90 (LH) or 100 - 105^{o} (HH) replaced 60% (low) 80% (medium) or 100% (high) of the corn in broiler diets. They observed that there were no apparent differences in proximate analysis of rice-mill feed due to heat treatment. However, greatest treatment effect on feed conversion and growth rate occurred in broilers from 0 - 6 weeks on high rice-mill feed diets with high temperature treatment when compared to diets of unheated rice-mill feed. Broilers on low heat treatment diets at 100% of corn replacement gained more and were more efficient than birds on unheated diets. It was also reported that performance response to heated rice-mill feed was less at lower dietary levels of rice-mill feed. In the same trial, they reported that growing swine fed wet heated rice-mill feed for 6 weeks gained significantly faster than those receiving unheated rice-mill feed. It was further observed that swine fed heated rice-mill feed consumed less feed per kilogram body weight compared to swine fed unheated rice-mill feed.

The nutritional consequences of feeding rice hulls of up to 30% level in diets of chickens have been reported (Demet and Kompiang, 1983). These researchers observed that increasing rice hull levels above 10% of the diet exponentially reduced feed conversion efficiency. They observed that bulk density of rice bran, is another factor affected by milling technique shown to have an effect on chick growth. They have recommended that the best rice brans contain less than 10% hulls and have a bulk density of more than 0.34 kg/litre.

Rancidity of rice bran when the product is poorly stored is one of the vital factors affecting the feeding value of rice bran for chickens. Ahmed and Kratzer (1982) observed among several others that wheh rancid rice bran was fed at 60% of the diets to growing chickens, growth rate was reduced than when fresh rice bran was fed. It was further observed that even when rancidity was retarded by the addition of ethylenediamine tetra acetate (EDTA), its addition had no effect on rice bran that was already rancid or in which the lipase activity had been destroyed by autoclaving.

UTILIZATION OF FIBRE BY THE PIG

Crude fibre has been defined as that portion of a feedstuff that is insoluble, less digestive and ash-free and which remains after rigorous boiling with dilute alkali and then with dilute acid (Lloyd et al. 1978; Feltwell and Fox, 1978; Cullison, 1979). It consists primarily of cellulose and lignin which is almost nutritionally valueless to monogastric animals. Mitchell (1964) defined cellulose as a carbohydrate, a polymer of D-glucose while lignin obtained in non-crystalline form consists of a phenyl propanoid building units and is not a carbohydrate.

In feeding pigs and poultry, it is important to know the fibre content of the various feed ingredients since fibre of different origin vary in digestibility. Feeds of high fibre content are normally fluffy and low in nutrient density per unit volume rather than per unit weight (Feltwell and Fox, 1978). The bulky nature of high fibre feeds affects feed intake.

In comparing the digestibility of fibre from different sources Crampton and Harris (1969) indicated that although fibres from wheat shorts and wheat offals are presumably the same material, digestibility ranges from 53 to 90 percent. Similarly digestibility for oats, oat chippings, rolled oats and oat hulls ranges from 38 to 80% since these figures were obtained from ruminants and species differ in the extent to which they can digest fibre, and even among individuals of the same species, the above figures will considerably differ in the case of monogastric animals which have smaller microfloral population in their gastro-intestinal tract. Albanese (1963) stated that although monogastric animals do not have the necessary enzymes for degrading cellulose; nevertheless in some cases a considerable amount of the cellulose may be utilized. He further explained that in cases like this, bacteria present in the intestines have cellulases capable of degrading cellulose. Lloyd et al. (1978) observed that the digestibility of crude fibre in the pig ranged from 3 - 25 percent and this occur in the caecum and colon while that of poultry ranged from 20 to 30 percent occuring in the caeca. Fetuga (1977) attributed differences in available energy contents of different feed materials to essentially radical differences in their chemical composition, particularly fractions as fat, nitrogen free extracts (NFE) and crude fibre. He observed that cellulose, hemi-cellulose and lignin are usually regarded as being unavailable to monogastric animals.

It is well known that fibre gives bulk to feeds.

According to King (1961) fibre aids digestion because its bulk stimulates peristalsis and secretions. Peristaltic movements open up concentrated foods so that digestive juices come into close contact with them. Bulk also increases surface area of food particles in the alimentary canal. This increase in feed surface area can be accomplished by feeding high levels of less digestible materials such as crude fibre. Bulk promotes the elimination of feed residues in the digestive tract. This is essentially based on the laxative properties of the fibre. Lloyd et al. (1978) observed that feeds high in crude fibre which are high in fatty acid or have high water retention capacity are the most laxative. Feeds high in crude fibre content limit the weight of food eaten by the pig and thereby placing physical limitation upon the intake of digestible nutrients. High fibre diets reduce energy intake due to the low energy density of roughage feeds. High fibre diets also have a relatively high heat increment and therefore contribute to heat stress in farm animals reared under hot environment.

Baird et al. (1969) conducted two feeding trials using 8 lots per test and 10 or 11 pigs per test. The animals were fed rations containing 14.5% crude protein and 2,866 kcal ME/kg with fibre levels ranging from 4% to 8% using seven different plant industrial by-products. They observed no significant differences in performance due to level or source of fibre. Similarly, dry matter and crude protein digestibilities were not affected by level or source of crude fibre.

In a comparative study of the digestibility of forage cellulose and hemi-cellulose Keys et al. (1969) fed sheep, swine and rats legume alfalfa and grass hays at 100%, 5% and 50% respectively. They observed greater digestibility coefficient for dry matter for the grasses than for alfalfa although these differences were not significant. Results of the swine trial showed no significant differences in dry matter or cell wall constituent digestibility but digestion coefficients for hemi-cellulose were higher than those of cellulose in all the treatments.

Glover and Duthie, 1958; Dijkastra (1966) and Waldo (1968) had also observed that increasing the level of fibre in the diet decreases the apparent digestibility of crude protein due to increased levels of metabolic faecal nitrogen in the faeces.

Similar trials carried out at Georgia Experimental Station (Baird et al. 1969) fed rations with two levels each of crude fibre (4% and 8%) crude protein (13% and 17%), and productive energy (2095 and 2536 kcal/kg) to Poland China pigs during two tests from a weight of 18 to 91 kg. They observed that levels of crude fibre and crude protein had no effect on average daily gain with low energy fed pigs gaining significantly less than the high energy lots.

In an earlier work by Treelsen and Bell (1962) a total of 60 gilts and 60 barrows averaging 100 $\pm$ 5 pounds were individually fed to 200 $\pm$ 5 pounds on a basal diet comprising of equal parts of wheat and barley with soyabean meal and meat meal as protein supplements. This ration was diluted at three levels each with

oat hulls, alfalfa meal, wheat bran, cellulose and ground corn cobs so as to obtain estimated energy levels in the rations of 62, 65 and 68 percent. Results of this work showed that daily feed intake varied depending on the diluent used. Thus revealing that factors other than energy levels influenced feed consumption. They further observed that DE intake per day decreased by 43, 45, 36, 56 and 92 kcal for each one percent increase in the amount of oat hulls, alfalfa meal, wheat bran, cellulose or corn cobs respectively. They found that pelleting increased DE intakes by 10 to 15 percent, mainly as a result of improved digestibility of energy components.

Experimenting on the influence of crude fibre from cereals on the net energy value of diets for growing pigs, Just (1980) fed varied levels of crude fibre from different sources and concluded that the negative influence of fibre on digestibility and net energy value depended to some degree on the crude fibre source. In another trial with growing pigs, Just et al. (1981) fed graded levels of wheat and oat bran at 12,9.4, 6.6,4.7% and 6.8, 21.0, 37.0 or 51.0% respectively, incorporating barley, maize, soyabean meal, meat and bone meal to adjust crude protein levels to vary from 22% in the basal to 21.2, 19.1, 17.4, 15.5 and 13.8 in the other five diets. Crude fibre content of diets varied from 3.4% in the control to 16.2% the highest of the test diets. They observed that crude fibre exerted very important effect on the amount of gut content, and noted that while daily gain decreased with increasing dietary fibre levels, when adjustment was made for differences in gut contents, the daily gain of the different groups was almost identical. They concluded

that crude fibre had a highly significant negative influence on the digestibility of all nutrients except soluble carbohydrate which was 99% digestible in all the diets.

In another trial with 42 growing pigs selected from 6 different litters, Just (1982) fed different diets formulated in principle on a balanced diet but supplemented with up to 30 percent ground barley straw and 50g digestible crude protein per kg straw dry matter to account for an expected greater loss of endogenous protein in faeces according to Just (1970). He observed identical average daily gains in all treatments except where difference in gut fill is considered; and further concluded that addition of barley straw or crude fibre to the diets had a highly significant negative influence on the digestibility of nutrients except the nitrogen-free extracts, which was 99 - 100 percent digestible in all diets.

In a similar trial, Ehle et al. (1982) studied the influence of dietary fibre on digestibility, rate of passage and gastro-intestinal fermentation in pigs by feeding alfalfa, coarse bran, and cellulose diets fortified with 3% corn oil and mineral/vitamin premixes at 3 different fibre levels of 30.8%, 31.2% and 47% and 15% cellulose. Their results showed that the extent of digestion in vivo is related to competition between rate of passage and rate of digestion. They concluded that relative digestibilities of feeds with similar digestion rates e.g. coarse bran diets depend on rate of passage and that those of diets with longer retention in the pigs than fine bran will show great apparent cell wall digestibility. In this trial, no differences in apparent digestibilities of energy between diets were observed.

In a more recent trial using a total of 192 growing-finishing pigs Frahk et al. (1983) fed 16% CP diets containing either 0,7.5 or 15% corn cobs and observed linear decreases in both ADG and feed:gain with increasing levels of dietary corn cobs. Average daily feed intakes increased linearly but average daily DE intake tended to decrease with increasing dietary fibre level. They also observed that gain/DE was not affected by dietary treatment. They concluded that the ability of the pig to maintain satisfactory weight gains when fed higher than normal levels of fibre is apparently a function of the capacity to increase total feed intake in order to maintain similar daily intakes of DE. They observed that differences in daily nitrogen intake was attributed largely to differences in daily feed intake resulting in linear decrease in nitrogen digestibility although no significant differences were observed among performance groups.

EFFECTS OF RICE BY-PRODUCTS ON CARCASS QUALITY OF PIGS

The problems of swine production technique have been changing in recent years due to modifications in animal production practice and in human eating habits. In the past, the main concern of farmers was increased productivity, but now it is associated with quality of production. The carcasses of pigs produced according to traditional method are too fat for present consumers taste. The present trend therefore, is to produce lean meat with precise control of the method of production.

In order to produce lean carcasses, it is necessary to reduce the energy content of diets for finishing pigs. Reduction in energy content of feed can be effected by reducing the amount of

feed supplied to the pig or by diluting the feed with fibrous ingredients such as oat hulls, rice bran, maize bran, maize cobs (ground), wheat offals and brewers' dried grains.

As early as 1939, McMeekan and Hammond found that a high level of nutrition during the early stages of growth followed by a low level of nutrition during the later stages of growth of swine intensifies early development of tissues (skeletal frame work and muscle) and inhibits later developing tissue (subcutaneous fat) thus producing a lean pig. Many studies carried out in the sixties (Thrasher et al. 1963; Balderama et al. 1968; and Bistoyong et al. 1968) using rice by-products such as rice bran mixed or without hulls in the diets of growing-finishing pigs have resulted in the production of lean carcasses. Thrasher et al. (1963) fed sixty pigs averaging 128 lb initially with varied levels of ground ear corn plus 10% bagasse and observed that carcass back-fat was decreased significantly by the ear corn ration, but percent lean cuts was not improved significantly. They further observed that increased carcass value did not offset the increased production cost for pigs on the high fibre diets. Bistoyong et al. (1968) fed rice bran-fish meal combination with varying protein levels to 48 growing pigs. Very high levels of rice bran ranging from 94.5% (control) to 63.5% of the other five treatments were used, while protein levels ranged from 22% to 12.2%. Carcass quality measurements from this trial showed no significant difference among treatments for back-fat thickness and carcass length or other characteristics.

Back fat thickness tended to decrease and loin eye area also tended to increase as the level of rice bran increased.

In a similar trial, Balderama et al. (1968) fed graded levels of rice bran at 0, 40, 60 and 80% with molasses 16%, zinc 40 ppm with methionine supplementation. They observed that back-fat thickness decreased and loin eye area tended to increase as rice bran level increased. These workers concluded that among the causes limiting performance and carcass quality of pigs fed rice bran are fibre (or hull) content, the availability and balance of amino acids (protein quality), the interaction of minerals and the effect of prolonged storage with its attendant problem of rancidity. Campabadal et al. (1976) demonstrated the deleterious effect of feeding high levels of rice bran containing high amounts of hull (fibre). They fed rice bran containing hulls at 0, 35, 40 and 45 percent to two hundred and thirty five finisher pigs and observed that of the pigs examined at slaughter, all pigs fed rice bran but one on the control diet displayed some degree of inflamation of the gastro-intestinal tract. It was further observed that inflamation of the gastro-intestinal tract was progressively more severe as the amount of bran increased.

In an earlier work in Georgia, Baird et al. (1968) fed rice mill feed diet containing 3.5, 5.5, 7.5, 9.5, 11.5 and 13.5% crude fibre to finishing pigs and observed that fibre levels produced no significant effect on carcass length, loin eye area and backfat thickness. Dressing percent was lowered with increasing rice-mill feed level as was percent trimmed hams belly and loin marbling.

They observed no other signif
increasing (fibre) rice-mill
increasing the fibre level wi
content of the ration would n

NUTRIENT UTILIZATION

Cereal grains such as ma
major energy sources in diets
contributing 60 to 80% of the
Their current prohibitive pri
as staple human foods in the
feed costs. Thus the future
of pork and its products woul
alternative sources of energy
of human dietaries. Rice mil
rice polishings and brewers'
humans. Although variable in
have been fed to pigs extensi
utilization by the pigs and p
because of their high fibre/s
content irritates the gastro-i
inflamations of the G.I.T., a
nutrient utilization in feedi
The rice by-product used in t
crude fibre, 6 percent crude
as fed .166% Ca, .492% P and
High fibre content limits nut
pigs on diets fed along with

Loosli et al. (1954) observed that rice bran with less crude fibre had more digestible organic matter and protein than rice bran high in fibre content. In a total of 31 digestion trials carried out by these workers, to test the value of different grades of rice bran, various coconut products, and concentrate mixtures containing these feeds, it was observed that the digestibility of diets containing two kinds of rice bran varied appreciably. Protein, organic matter, fibre and N.F.E. of fresh coconut meal were more digestible than those of copra meal. Although the digestibility of crude fibre and ether extract in the different grades of rice bran fed did not differ greatly, it was the authors' opinion that the lack of uniformity of rice bran and the failure to regulate its quality are serious handicaps to the profitable production of eggs, pork and milk in the Philippines.

In another experiment, Brooks and Lumunta (1975) carried out 2 digestion trials with growing pigs to determine the digestibility coefficients of nutrients of rice bran at 3 levels 0, 40 and 80 percent. They reported the following digestion coefficients for rice bran: crude protein, 69.7; NFE, 76.8; EE, 91.4, and GE 66.0. Their results showed that with each increment of rice bran, there was a slight decrease in digestibility of dietary dry matter, crude protein, Nigrogen free extract, crude fibre and G.E. Digestibility of ether extract increased with addition of rice bran. They observed no difference in DE value due to level of bran fed.

In a similar trial, Campabadal et al. (1976) using growing pigs fed rice bran at 0, 20, 25, 30, 35, 40 and 45 percent to test the effect of rice bran on its digestibility. They reported

decreased dry matter digestibility of all diets progressively as the proportion of bran was increased. Dry matter digestibility of rice bran decreased with increasing level of rice bran (85.2% at 20% of diet VS 75.4% at 45% inclusion). Crude protein digestibility of both the diet and rice bran decreased as the amount of bran was increased. Ether extract digestibility of the diet slightly increased with increasing levels of rice bran while that of the bran remained fairly constant at about 74 percent.

Farrell and Warren (1980) fed broken rice (brewers' rice), rice pollard, and rice hulls to pigs and obtained the ME values of 4.13, 4.18 and .89 Mcal/kg dry matter respectively. More recently, Robles and Ewan (1982) in a digestion trial with growing pigs reported a linear decrease in digestion coefficients for dry matter and nitrogen with increasing increments of dietary rice bran. The DE and ME values of the diets decreased linearly with increasing levels of rice bran. Average energy values for rice and rice bran in kcal/g of dry matter were, respectively: GE 4.38, 4.65; DE 3.70, 3.88; ME 3.58, 3.71; N-corrected ME 3.35, 3.50 and NE, 2.51, 2.03.

In recent times, various industrial by-products have been utilized by the pig to facilitate the production of lean pork to meet the present consumer taste and demand. Rice mill by-products are some of these low energy feedstuffs that serve as energy diluents in the production of pork. Because of their availability and relatively cheaper costs, rice mill by-products can be used to partially replace the more costly grains to reduce feed cost of pork production by swine farmers.

CHAPTER III

E X P E R I M E N T S.

EXPERIMENTAL CONDITIONS

i. Location: The experiments were conducted at the Ahmadu Bello University Farm using facilities provided by the National Animal Production Research Institute Shika. The farm is located at 22 kilometres North-West of Zaria along the Zaria-Sokoto road. Shika lies within the Northern Guinea Savannah zone of Kaduna State at Latitude 11° 15' N and Longitude 7° 32 E and at an altitude of 609.6 m (2,000 ft) (Keay, 1959). The climate is monsoonal and has a mean annual precipitation of about 1100 mm most of which falls between April and October.

ii. Experimental Animals: The pigs used in the three experiments were crossbred (Large White X Landrace) in experiment 8303 and a three-way crossbred barrows and gilts (Yorkshire X Landrace X Hampshire) as in experiments 8305 and 8307 respectively. The three experiments conducted were:

a) A growth trial with growing-finishing pigs. Experiment 8303

b) A digestibility trial. Experiment 8305

c) Slaughter and carcass evaluation experiment with 24 growing-finishing pigs comprising of 12 barrows and 12 gilts. Experiment 8307.

iii. Management of Animals: The management of all experimental animals for experiments 8303 (growth trial) and experiment 8307 (slaughter and carcass evaluation trial) with growing-finishing pigs were similar. All the pigs were managed on concrete floor pens (3.05 x 1.22 m/pen) in open sided pig houses with metal pipes and wooden construction.

THE EFFECTS OF REPLACING MAIZE WITH RICE MILL BY-PRODUCT ON THE PERFORMANCE OF GROWING FINISHING PIGS

EXPERIMENT 8303

OBJECTIVE:

To evaluate the effects of feeding graded level of rice by-product on the performance of growing-finishing pigs.

EXPERIMENTAL PROCEDURE:

Eighteen (18) crossbred (Large White X Landrace) pigs of average initial weight of 35.9 kg (Table 2) were fed rice mill by-product at 0, 5 or 10% of the 15% crude protein diet for treatments 1 to 3. All diets were iso-nitrogenous but not iso-caloric (Table 1). All animals were dewormed with baminth one week to commencement of the trial. There were three treatments and six replications in a randomized block design. All animals were individually housed and fed weighed quantities of feed twice daily at 8 am and 4 pm throughout the 42 day experimental period. Refused or wasted feed were collected daily, oven dried at 52°C for 24 hours, allowed to come to room temperature before weighing. Pigs were weighed weekly and the level of feeding adjusted according to scale. Drinking water was continuously available from concrete drinking troughs. Performance of pigs in terms of feed intake, weight gain, and feed to gain ratios were evaluated for the three periods (14 days, 28 days and 42 days) (Table 2). The data was analysed according to the method of Snedecor and Cochran (1967).

Table 1: Graded level of rice by-product in pig diets. Composition of diets and calculated analysis.

Ingredients	Treatments 1	2	3
Yellow maize	77.29	77.90	66.50
Soyabean meal	18.55	18.94	19.34
Rice by-product	0.00	5.00	10.00
Bone meal	2.00	2.00	2.00
Vegetable oil	1.00	1.00	1.00
Lysine	0.25	0.25	0.25
Methionine	0.26	0.26	0.26
Vitamin Premix[a]	0.15	0.15	0.15
Common salt	0.50	0.50	0.50
	100.00	100.00	100.00
Calculated Nutrient Levels:			
Crude protein (%)	15.00	15.00	15.00
ME, Kcal/kg	3392	3367	3342
Calcium (%)	.62	.64	.66
Phosphorus (%)	.58	.59	.61
Crude fibre (%)	3.12	5.10	7.11
Lysine (%)	.97	.98	.98
Methionine (%)	.76	.74	.75

[a] Roche VM502 Contributed the following per kg of diet: Vitamin A, 12,000I.U.; Vitamin D_3, 1,200I.U., Vitamin E, 3.6I.U.; Vitamin K, 1.8mg; Vitamin B_2 3.6mg; Nicotinate, 18mg; Calcium-d-Pantothenate, 9.6mg; Biotin, 0.36mg; Vitamin B_{12} .012mg; Choline chloride 120mg; Chlortetracyline, 48mg; Manganese, 24mg; Iron, 48mg; Zinc, 96mg; Copper, 60mg; Iodine, 1.8mg; Cobalt, .48mg.

Table 2: Experiment 8303: Effect of Feeding Graded level of Rice by-products on performance of growing pigs.

14-Day performance data, Feed intake, Average daily gain, Average daily feed, Feed:gain.

	Level of Rice by-product				
Parameters	0%	5%	10%	MEAN	SE
Feed intake, kg	34.69[a]	34.92[b]	34.93[b]	34.85	2.54*
Average daily gain, g	990[b]	1080[a]	950[b]	1006.67	2.14**
Average daily feed, kg	2.26	2.13	2.13	2.17	0.57
Feed: gain	2.55	2.33	2.64	2.51	1.35

a,b Means on the same line with different superscripts differ significantly ($P \leq 0.05$)

* Significant linear ($P \leq 0.01$) effect of level of feeding.

** Significant quadratic ($P \leq 0.01$) effect of level of feeding.

Table 3: Experiment 8303: Effect of Feeding Graded level of Rice by-products on performance of growing pigs.

28-Day performance data, Feed intake, Average daily gain, Average daily feed, and Feed:gain

	Level of Rice-by-product				
Parameters	0%	5%	10%	MEAN	SE
Feed intake, kg	70.55[a]	73.64[b]	73.39[b]	72.50	3.47
Average daily gain, g	869	878	796	848	1.29
Average daily feed, kg	2.52[a]	2.63[b]	2.62[b]	2.59	3.85
Feed: gain	2.93	3.02	3.31	3.09	2.02

a, b Means on the same line with different superscripts differ significantly ($P \leq 0.05$)

RESULTS:

The results obtained in experiment 8303 for the first 14-day period are presented in (Table 2). Pigs fed rice by-product consumed more feed compared to the control pigs. A significant ($P \leq 0.05$) linear effect of level of feeding rice by-product (RBP) was observed. Feed intake increased linearly ($P \leq 0.01$) with increased level of RBP in the diets.

Average daily gain, tended to decrease with increased level of RBP fed to the pigs. Pigs fed the 5% level RBP diet exhibited the best gains, closely followed by pigs fed the control diet and there was a significant ($P \leq 0.01$) quadratic effect of level of feeding.

Average daily feed intake, decreased with increased level of RBP fed, however, differences between treatment means were not significant.

Feed to gain ratio tended to increase with increased level of RBP in the diets fed. Pigs fed the 10% RBP diet required more feed per unit gain compared to pigs fed the 5% RBP and control diets respectively. However, there was no significant difference between treatment means.

Performance data for the 28-day period are presented in (Table 3). Feed intake tended to increase with increased level of RBP fed to the pigs. Aquadratic ($P \leq 0.01$) effect of level of feeding was observed as % RBP increased from 0 to 10% level. Pigs on the control diet significantly ($P \leq 0.05$) had the least feed intake compared to pigs on the 5 and 10% RBP diets respectively.

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Average daily gain tended to decrease with increased level of RBP fed to the pigs. Pigs fed the 5% RBP diet had the best gains followed by pigs fed the control diet. However, differences between treatment means were not significant.

Table 4: Experiment 8303. Effect of Feeding Graded level of Rice by-products on performance of growing pigs.

Parameters	Level of rice by-product (0%)	(5%)	(10%)	MEAN	SE
Avg. initial wt., kg	35.98	35.93	35.85	35.92	
Avg. Final wt., kg	72.96	74.02	69.25	72.07	
Total Gain per pig, kg	36.98	38.09	34.57	36.55	
Avg Daily Gain, g[a,c]	880	907	795	860.70	20.2
Avg Daily Feed,kg[a,b]	2.75	2.91	2.87	2.84	.03
Feed:Gain[a,d]	312	3.23	3.62	3.32	.08
Cummulative Feed Intake 14 days, kg[a,b]	34.69	34.92	34.93	34.85	2.54
Cummulative Feed Intake 28 days, kg[a,b]	70.55	73.64	73.39	72.50	3.47
Cummulative Feed Intake 42 days, kg[a,b,c]	115.55	122.42	120.36	119.44	1.7
Feed cost per kg gain,₦	1.97	2.10	2.09	2.05	.04

a) Significant treatment effect (P/_ 0.01)

b) Significant linear effect of level of feeding (P/_ 0.05)

c) Significant quadratic effect of level of feeding (P/_ 0.01)

d) Significant linear effect of level of feeding (P/_ 0.01).

Average daily feed increased with increased level of RBP in the diets. There was a quadratic (P/_0.01) effect of level of feeding on average daily feed intake. Average daily feed intake of pigs fed the 5 and 10% RBP diets respectively were similar and the lowest average daily feed intake was observed on pigs fed the control diet.

Feed to gain ratios increased with increased level of RBP fed to the pigs. The control pigs required the least amount of feed per unit gain, however, differences between treatment means were not significant.

Performance data for the 42-day period are presented in (Table 4). Pigs fed rice by-product diets consumed more feed compared to the control for the 42 days. Pigs on the control diet consumed the least amount of feed (71.59kg Vs. 73.14 and 73.39kg) when compared with pigs on the 5 and 10% RBP diets respectively. Pigs fed the 5% RBP diet had the highest amount of feed intake with pigs on the 10% RBP diet consuming slightly less (122.42kg Vs. 120.36kg) respectively. A quadratic (P/_0.05) increase was observed for average daily feed intake.

Average daily gain, increased for the 42 day period with a slight decrease at the 10% level of RBP inclusion in the diet. Average daily gain was best at the 5% level and there was a significant ($P/__0.01$) quadratic effect of level of feeding.

Feed to gain ratios, increased linearly ($P/__0.01$) with increased level of RBP. Pigs fed rice by-product diets required more feed per unit gain. Thus, with increased level of RBP, pigs tended to consume more feed in order to meet the body demand for the essential nutrients.

Feed cost per unit liveweight gain (Table 4) was similar between treatments. The control group had the cheapest gain when compared with pigs on rice by-product diets. Feed cost per unit liveweight gain tended to increase with increased level of rice by-product, however, differences between treatments were not significant.

DISCUSSION

The experimental findings with growing-finishing pigs (Table 4) indicated that the 10% level of rice mill by-product fed in ration 3 resulted in lowered performance of the pigs. The depression in the performance of this treatment group may be due to the low caloric and high fibre value of the diet which may not be conducive to optimum performance of growing pigs, and which might have lead to impairment of utilization by the pigs of essential nutrients (Boenker et al. 1969). By increasing the percentage of this low energy by-product in the rations, the fibre content of the entire rations were increased and their energy densities lowered.

Feltwell and Fox (1978) explained that feeds of high fibre content are normally fluffy and low in nutrient density, per unit volume rather than per unit weight.

Feed consumption and feed efficiency were variable and were influenced by the dietary treatments. Generally, feed consumption of pigs feed rations containing rice by-product was higher than the control. This result is in agreement with the results of Ademosun (1973) and Din et al. (1979) who fed similar high fibre by-products brewers' dried grains and plant by-products to pullets respectively. The higher feed consumption may probably be due to the lower caloric values of the feeds that stimulated feed consumption in an attempt by the pigs to consume more energy to meet their daily requirement. Thus average daily feed showed a linear increase with increasing levels of rice by-product in the diets. This is as a result of the decreasing energy concentration as the levels of RBP and fibre in the diets increased. This is further supported by Frank et al. (1983) who fed to pigs 7.5 or 15% corn cobs (a high fibre by-product) and observed linear decreases in average daily gain and an increase in feed to gain ratios ($P \leq 0.001$) with increasing levels of dietary corn cobs.

Average daily gain was best at the 5 percent level of rice by-product inclusion in the diet, although consumption was highest at the same level. Just (1982) fed high fibre diets to growing pigs and also observed that daily gain decreased with increasing dietary fibre levels. Total gain was highest for pigs fed the 5% level of RBP diet when compared with pigs fed the control diet.

This result could be attributed to the fact that

the addition of 1% vegetable oil increased palatability and thereby stimulating feed intake which provided more nutrients for the pigs. Addition of RBP at 5% level resulted in energy dilution thereby inducing the pigs to consume more feed to meet their nutrient requirements. These results and observations are in agreement with those of Campabadal et al. (1976), who reported that adding fat to coarse rice bran, a similar by-product improved the performance of growing pigs by improving the palatability and or digestibility of the by-product rather than correcting an energy deficiency.

Feed to gain ratios increased with increasing level of rice by-product fed to the pigs. A significant linear treatment effect ($P \leq 0.001$) was observed for feed to gain ratios. This result is probably associated with the lower caloric content of the feed rations as the level of RBP was increased. Thus, pigs had to consume more of the low energy feeds in order to satisfy their nutrient requirements (Troelsen and Bell, 1962).

Feed cost per unit liveweight gained tended to increase with increasing levels of rice by-product in the diets. The control proved to be the most efficient and least costly in terms of liveweight gained of all the treatments. Differences between cost means were not significant. Alcantara et al. (1968) studied the effects of rice bran-fishmeal combination with varying protein levels of 12 to 22% on growth rate and feed efficiency of growing pigs and reported that the cost of feed per kilogram gain showed no trend. The results of feed costs per kilogram gain in the three diets tended to show that higher levels of RBP would have to be fed before significant differences in feed costs can be attained.

RICE MILL BY-PRODUCT COMPOSITION AND DIGESTIBILITY BY THE PIG

EXPERIMENT 8305

OBJECTIVE:

A digestibility trial was conducted to determine the digestibility of nutrients of practical diets containing graded levels of rice mill by-product for growing pigs. Rice by-product replaced maize and groundnut cake in the basal diet.

EXPERIMENTAL PROCEDURE:

The trial was conducted at the Ahmadu Bello University Farm Shika. The research data were on file recorded as experiment 8305 at the National Animal Production Research Institute Shika. The pigs were housed in a unit equipped with twelve metabolism crates measuring 71.5 x 131.5 x 150cm^3 (with slatted metal floor) arranged in two rows. The experimental animals were a three-way crossbred barrows and gilts (Yorkshire X Landrace X Hampshire). During the trial twelve pigs were allotted from litter outcome groups to three replications of four treatments. Treatments were allotted to pens within each replicate.

The grower pigs were dewormed twice before the commencement of the trial with banminth at the rate of 25mg per kilogramme body weight. The treatment groups were equalized in initial weight averaging 15.6kg liveweight.

All pigs were fed the experimental diets (Table 3) for a seven-day adjustment period. All diets were iso-nitrogenous and rice mill by-product replaced maize and groundnut cake in the basal diet. The four diets were fortified with 1% vegetable oil

EXPERIMENT 8305: Table 5 : Composition of Diets containing graded levels of Rice by-product fed to young pigs.

Ingredients	RATIONS 1	2	3	4
Yellow maize	68.74	57.97	47.19	36.42
Groundnut cake	26.55	27.32	28.10	28.87
Rice by-product	0.00	10.00	20.00	30.00
Vegetable oil	1.00	1.00	1.00	1.00
Bone meal	2.50	2.50	2.50	2.50
Lysine	0.25	0.25	0.25	0.25
Methionine	0.26	0.26	0.26	0.26
Vitamin Premix[a]	0.20	0.20	0.20	0.20
Common salt	0.50	0.50	0.50	0.50
	100.00	100.00	100.00	100.00
Calculated Nutrient Levels:				
Crude protein (%)	18.00	18.00	18.00	18.00
ME, Kcal/kg	3202	3150	3095	3042
Calcium (%)	.78	.79	.81	.83
Phosphorus (%)	.68	.70	.73	.76
Crude fibre (%)	5.17	9.17	13.17	17.17
Lysine (%)	.84	.84	.84	.84
Methionine (%)	.77	.75	.73	.70

[a] Roche VM502: Contributed the following per kg of diet: Vitamin A, 16,000I.U.; Vitamin D_3, 1,600I.U.; Vitamin E, 4.8I.U.; Vitamin K, 2.4mg, Vitamin B_2 4.8mg; Nicotinate 24mg; Calcium-d-Pantothenate, 12.8mg; Biotin, .048mg; Vitamin B_{12}; .016; Choline Chloride, 160mg; Chlortetracycline, 64mg; Manganese, 32mg; Iron, 64mg; Zinc, 128mg; Copper, 80mg; Iodine, 2.4mg; Cobalt, .64mg.

to improve palatability, vitamin and mineral premix VM502 and synthetic lysine and methionine. Diets were fed to treatment groups at 4% of body weight during the first seven-day adjustment period.

The experimental treatments were: pigs fed the basal ration with zero percent rice by-product (ration 1) pigs fed 10% rice by-product (ration 2), pigs fed 20% rice by-product (ration 3) and pigs fed 30% rice by-product (ration 4) (Table 5).

Refused feed was collected and pooled for each pig within the two seven-day collection periods; the pigs being individually fed and maintained in 12 metabolism units designed to permit separation of urine and faeces. Faeces were either collected from the surface of the slatted metal floor of the cage or from two other metal trays fitted below the slatted floor. The two trays fitted below the slatted metal floor were perforated at the centre to facilitate urine collection in plastic bucket receptacles placed on the concrete floor directly at the centre of each metabolism crate.

Management of the Animals.

The pigs were fed twice daily at 8 am in the morning and 4 pm in the afternoon. One half of the daily feed allotment was offered in the morning, and the other half offered in the afternoon. Each metabolism crate was equipped with fixed water trough and pigs were allowed water ad-libitum. Feed was weighed out at each feeding and the amount recorded on feeding chart. Fresh water was supplied in the drinking troughs daily. The pigs were weighed the same day weekly and the feeding levels were adjusted weekly.

There were two periods each consisting of a 7-day adjustment phase and a 7-day collection of total urine and faeces. All pigs were fed at 4% of body weight and at 6% of body weight respectively during the first and second periods respectively. Each daily feed allotment was divided into two lots with one-half offered at 8.00 hour and 16.00 hour.

Sample collection and preparation.

Faecal collection was made daily in respect of each animal and stored in transparent ploythene bags. Each collection was pooled per replicate at the end of each period. After drying the faeces at 40^{o}C, the samples were allowed to attain equilibrium with air moisture, and were weighed and ground in Willey mill equipped with a mess screen.

Urine was collected in plastic bucket receptacles containing 25 ml of concentrated drochloric acid and 25 ml of toluene. At the end of each collection period, urine was diluted to a constant volume. An aliquot was taken and stored in a refrigerator until analysed for nitrogen.

Chemical Analysis.

Proximate chemical analysis was carried out on all test ingredients, feed samples, faeces and urinary nitrogen determined according to the method of A.O.A.C. (1970). The values are presented in (Table 6) and (Table 7) respectively. Gross energy of the diets and test ingredients and faeces were determined by Parr Adiabatic oxygen bomb calorimeter.

Statistical Analysis.

The data were analysed according to the method of Snedecor and Cochran (1967). The pig was considered as the experimental unit.

Table 6: Proximate Chemical Composition of the major ingredients used in ration formulation
(%Air dry basis)

Items	Ingredients Maize	Groundnut Cake	Rice by-product	Bone Meal
Gross energy kcal/g	3.99	4.65	3.47	
Dry matter	91.76	95.71	91.81	98.40
Crude protein	11.31	43.94	6.32	2.34
Ether extract	2.15	13.93	2.26	0.01
Crude fibre	2. 5	5.63	41.7	2.14
Ash	1.17	6.77	15.8	89.34
Calcium	0.03	0.16	1.66	34.88
Phosphorus	0.27	0.63	4.92	15.97

Table 7: Experiment 8305. Proximate chemical composition of Experimental diets for digestibility trial
(% Air dry basis)

Items	Levels of Rice by-product 0%	10%	20%	30%
Gross energy kcal/g	3.95	3.92	3.91	3.87
Dry matter %	93.67	92.59	94.01	94.12
Crude protein %	23.19	21.75	20.56	21.0
Ether extract %	3.35	3.70	3.36	3.93
Fibre, %	8.23	12.58	15.96	21.0
Ash, %	4.91	6.93	9.25	11.72

Table 8: Experiment 8305. Average daily feed. Average daily gain and Feed to gain ratio of Diets containing Rice by-product

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Average daily feed, g						
1	653	660	664	661	659.5		
2	1285	1208	1293	1223	1252.3		
Avg.	969	934	978.5	942	955.9	1.65	
	Average daily gain, g						
1	348	310	204.7	276	284.8		
2	495	519	304.7	248	390.5		
Avg.	421.5^{a}	414.5^{a}	254.7^{b}	262^{b}	337.6	638	**PXT
	Feed : gain						
1	1.92	2.20	3.59	2.48	2.53		
2	2.67	2.40	4.53	5.05	3.0		
Avg.	2.30^{a}	2.30^{a}	4.06^{c}	3.74^{b}	3.10	9.62	*P ***TLn

a,b,c Means on the same row with different superscripts are significantly different ($P \leq 0.05$)

*P Significant period effect ($P \leq 0.05$)

**PXT Period X treatment effect of level of feeding ($P \leq 0.05$)

***TLn Significant treatment linear effect ($P \leq 0.01$)

RESULTS

Performance characteristics of pigs during the two periods are presented in (Table 8). Average daily feed intake tended to increase with increased level of RBP fed to the pigs in both periods. Average daily feed intake in period 2 increased by nearly 100 percent over that in period 1 as levels of feeding rose from 4 percent to 6 percent in periods 1 and 2 respectively. Pigs fed the 20 percent RBP diet had the highest average daily feed intake followed by pigs fed the control diet. Level of RBP fed did not significantly affect daily feed intake.

Throughout the two 7-day collection periods, average daily gains decreased with increased levels of rice by-product in all the diets. Pigs on the control diet consistently exhibited the best weight gains followed by pigs fed the 10 percent RBP diet. However, in period 2, pigs fed the 10 percent RBP diet had a slightly better weight gain (519g Vs. 495g) than the control group. Average daily weight gains were depressed for pigs fed with the 20 percent and 30 percent RBP diets respectively. However, when all the RBP levels were compared, the 10 percent level promoted growth better than the 20 and 30 percent RBP levels. The poorest growth rate was on the 20 percent RBP diet. There was a significant period X treatment effect for weight gain ($P \leq 0.05$).

The feed to gain ratios increased significantly ($P \leq 0.05$) with increased levels of RBP in the diets. There were highly significant ($P \leq 0.05$) differences between treatment means and between periods with respect to feed to gain ratios. Feed to gain ratio was highest for the pigs fed 20 percent RBP diet which was significantly ($P \leq 0.05$) higher than the ratios on the control and the 10 percent RBP diets.

Total dry matter intake, faecal dry matter, apparent dry matter digested, and dry matter digestibility (%) data of the pigs are presented in (Table 9). Total dry matter intake of the pigs increased as the level of RBP in the diets increased. In period 1, pigs fed the 20% RBPcontaining diet had the highest dry matter intake followed by pigs fed the 30% RBP containing diet. Pigs fed the 10% RBP diet consumed the least amount of dry matter followed by pigs fed the control diet. In period 2, total dry matter intake of all treatment groups nearly doubled the level of intake in period 1, and there was a significant (P/0.05) period effect for dry matter intake. Differences between treatment means, however, were not significant.

Faecal dry matter also increased correspondingly with increased levels of RBP fed. Faecal output nearly doubled in period 2 of the trial when compared with total faecal output in period 1. There was a significant (P/0.05) period effect of level of feeding RBP in the diets. Pigs fed the 20% RBP containing diet which consumed the highest amount of dry matter had the highest faecal dry matter. The least faecal dry matter output was exhibited by pigs fed the control diet. In period 2, the highest faecal dry matter output was obtained from pigs fed the 30% RBP diet. Pigs on the 10% RBP diet which consumed the lowest total dry matter had the least faecal dry matter. There was a significant (P/0.05) period X treatment effect of level of feeding rice by-product.

Apparent dry matter digestibility, decreased with increased levels of RBP fed to the pigs. In period 2 of the trial, the highest apparent dry matter digested was shown by pigs fed the 10% RBP diet followed by pigs on the control diet. There was a significant (P/0.05) period effect of

Table 9: Experiment 8305. Dry matter Intake and Digestibility of Diets containing Rice by-product

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Total dry matter Intake, g						
1	4284	4278	4370	4349	4320		
2	8428	7829	8509	8315	8207		
Avg.	6356	6054	6439	6209	6264	994.2	*P
	Faecal dry matter, g						
1	847	1210	1604	1496	1289		
2	2057	1967	3243	3324	2349		
Avg.	1392[a]	1589[a]	2424[b]	2410[b]	2069	490.2	**PxT
	Apparent dry matter digested, g						
1	3437	3068	2765	2853	3031		
2	5371	5852	5265	4991	5370		
Avg.	4904[a]	4465[b]	4015[c]	3799[d]	4296	720.1	**PxT
	Dry matter digestibility, %						
1	80.2	71.7	63.3	65.6	70.1		
2	76.7	74.7	62.0	60.0	68.1		
Avg.	78.3[a]	73.1[b]	62.8[c]	61.9[c]	69.0	4.5	**PxT

a,b,c,d Means on the same row with different superscripts are significantly different ($P \leq 0.05$)

*P Significant period effect of level of feeding ($P \leq 0.05$)

**PxT Period X treatment effect ($P \leq 0.05$)

level of feeding RBP to the pigs. Pigs fed the 30% RBP containing diet recorded the least apparent dry matter digestibility, while pigs on the control diet had significantly ($P \leq 0.05$) higher apparent dry matter digestibility compared to the pigs on the remaining RBP diets.

Dry matter digestibility, % was slightly higher in period 1 compared to dry matter digestibility values in period 2. Pigs on the control diet had the best digestibility in both periods compared to pigs fed RBP containing diets. The poorest dry matter digestibility was shown by pigs on the 30% RBP diet. Dry matter digestibility decreased appreciably with increased levels of RBP fed to the pigs. A significant ($P \leq 0.05$) period effect was observed for dry matter digestibility. There was a significant ($P \leq 0.05$) period X treatment effect for the feeding of RBP. The best digested diets were the control and 10% RBP diets, which were significantly better digested than the 20 and 30% RBP diets.

Nitrogen intake and digestibility data are presented in (Table 10). Nitrogen intake, decreased with increased levels of RBP in the diets of the pigs, with the control diet having the highest value for the two periods (1 and 2) of 235.8g as compared to 210.7, 211.1 and 208.6g respectively for the 10%, 20%, and 30% RBP diets. A significant ($P \leq 0.05$) period effect of level of feeding was observed on nitrogen intake. As would be expected, significantly more nitrogen was consumed during period 2 compared to period 1. However, the differences between treatments were not significant for the two periods combined.

Faecal nitrogen excretion increased as the level of RBP in the diets increased. Faecal nitrogen excretion in period 2 doubled period 1 values, and a significant ($P \leq 0.05$) period effect was observed.

Table 10: Experiment 8305. Nitrogen Intake and Digestibility of Diets containing Rice by-product.

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Nitrogen Intake, g						
1	158.9	148.9	143.8	146.4	149.5		
2	312.7	272.5	279.9	270,8	284.0		
Avg.	235.8	210.7	211.8	208.6	216.7	34.93	*P
	Faecal nitrogen, g						
1	29.6	33.0	34.7	32.7	32.5		
2	64.1	52.7	75.6	64.9	64.3		
Avg.	46.8	42.8	55.1	48.8	48.4	13.24	*P
	Nitrogen digested, g						
1	129.4	115.9	109.1	113.7	118.9		
2	248.6	219.0	204.4	205.9	221.6		
Avg.	189.0	167.8	156.7	159.8	168.3	25.21	
	Apparent nitrogen digestibility, %						
1	81.7	77.8	76.1	77.6	78.3		
2	80.0	80.4	73.4	76.0	77.1		
Avg	80.8^{a}	79.1^{a}	74.8^{c}	76.8^{b}	77.9	2.90	***TLn

a,b,c Means on the same row with different superscripts are significantly different ($P/_ 0.05$)

*P Significant period effect of level of feeding

***TLn Significant treatment linear effect ($P/_ 0.01$)

Pigs on the 30% RBP diet excreted the highest quantity of faecal nitrogen while pigs on the 10% RBP diet excreted the least quantity of faecal nitrogen. However, differences between treatment means were not significant.

Nitrogen digestibility decreased with increased levels of RBP but differences between treatment means were not significant during periods 1 and 2. The control diet had the highest nitrogen digestibility figure while the 20% RBP diet had the poorest nitrogen digestibility closely followed by the 30% RBP diet. For the two periods combined amount of nitrogen digested decreased linearly ($P \leq 0.01$) as level RBP increased. Apparent nitrogen digestibility coefficients in both periods decreased with increased levels of RBP fed to the pigs. Nitrogen digestibility in period 1 was better than in period 2. There was a significant treatment linear ($P \leq 0.01$) effect for apparent nitrogen digestibility coefficient. The control diet had the best nitrogen digestibility figure, closely followed by the 10% RBP diet. Nitrogen digestibility for both control and the 10% RBP diets were significantly ($P \leq 0.05$) better than those for the 20 and 30% RBP diets.

Nitrogen excretion and retention data are presented in (Table 11). Urinary nitrogen excretion was depressed as levels of RBP in the diets increased. Total urinary nitrogen excretion values in period 2 was only about 40% of total urinary nitrogen excreted in period 1. Pigs fed the control diet excreted more nitrogen in urine than pigs fed RBP containing diets although differences between treatment means were not significant.

Table 11: Nitrogen Excretion and Retention of Diets containing Rice by-product.

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Urinary nitrogen, g						
1	45.7	28.3	32.3	24.7	32.8		
2	12.8	8.5	18.4	12.7	13.1		
Avg.	29.2	18.4	25.4	18.7	22.9	8.69	NS
	Nitrogen balance (NB)						
1	83.7	87.6	76.8	89.0	86.1		
2	235.8	211.3	186.0	193.2	182.5		
Avg.	159.7	149.4	131.4	141.1	145.4	27.03	NS
	Nitrogen balance as % of intake						
1	52.2	58.5	52.8	60.7	56.1		
2	75.9	77.1	67.0	71.3	72.9		
Avg.	64.1	67.8	59.9	66.0	64.5	6.46	NS
	Nitrogen balance as % of digested						
1	64.0	65.4	69.5	78.2	69.3		
2.	94.9	95.9	91.2	93.9	94.0		
Avg.	79.5	80.6	80.4	86.1	81.6	8.34	NS

NB - Nitrogen intake minus urinary nitrogen plus faecal nitrogen.

NS - Not significant.

Nitrogen balance (NB), (nitrogen intake minus urinary nitrogen plus faecal nitrogen) showed no definite trend in both periods. Nitrogen balance was highest for pigs fed the control diet while pigs on RBP diets showed depressed nitrogen retention values. Differences between treatment means were not significant. Nitrogen balance when expressed as % of nitrogen intake and digested did not present clear-cut trend and the differences between treatments were not significant.

Energy intake and digestibility figures are presented in (Table 12). Energy intake by the pigs tended to increase with increased levels of RBP fed. Pigs fed the 20% RBP diet had the highest intake of energy followed by pigs fed the control diet. Pigs fed the 10% RBP diet had the lowest energy intake figure, however, differences between treatment means were not significant.

Faecal energy doubled in period 2 compared to period 1. In both periods, faecal energy losses increased with increased levels of RBP fed to the pigs. Pigs fed the 20% RBP diet had the highest faecal energy loss while the lowest faecal energy loss was exhibited by pigs fed the control diet. However, difference between treatment means were not significant.

Energy digested in both periods 1 and 2 linearly ($P \leq 0.01$) decreased with increased levels of RBP in the diets fed to the pigs. Energy digested by the pigs in both periods decreased linearly ($P \leq 0.05$) with increased level of RBP in the diet. Pigs on the 20 and 30% RBP diets had similar energy digestibility figures which were significantly ($P \leq 0.05$) lower than energy digestibility figures for the control and the 10% RBP diets respectively.

Table 12: Experiment 8305. Energy intake and Digestibility of Diets containing Rice by-product.

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Energy intake, Mcal/g						
1	16.92	16.77	17.10	16.83	16.91		
2	33.30	30.69	33.27	32.18	32.36		
Avg.	25.11	23.73	25.19	24.51	24.63	1.27	
	Faecal energy, Mcal/g						
1	3.50	4.69	5.82	5.21	3.50		
2	8.68	7.82	12.14	12.14	10.20		
Avg.	6.10	6.25	8.98	8.68	6.85	0.73	
	Energy digested, Mcal/g						
1	13.42	12.10	11.28	11.62	12.10		
2	24.62	22.87	20.13	20.04	21.92		
Avg.	19.02[a]	17.49[b]	15.71[c]	15.83[c]	17.01	3.72	
	Apparent energy digestibility, %						
1	79.31	72.03	65.96	69.04	71.60		
2	73.93	74.52	62.19	62.27	68.23		
Avg.	76.62[a]	73.28[b]	64.10[c]	65.66[c]	69.92	1.73	*T

a,b,c, Means on the same row with different superscripts are significantly different ($P \leq 0.05$).

*T - Significant treatment effect.

Apparent energy digestibility coefficient similarly decreased linearly ($P \leq 0.01$) with increased levels of RBP fed to the pigs. Energy digestibility in period 1 was better than energy digestibility in period 2. The control diet had the best energy digestibility. Pigs fed RBP containing diets progressively showed decreased energy digestibility as the levels of RBP increased from 10 to 30% in the diets and differences between treatment means were significant ($P \leq 0.05$).

Ether extract intake and digestibility figures are presented in (Table 13). Ether extract intake consistently increased with increased levels of RBP fed to the pigs. In period 2, ether extract intake increased by 100% compared with ether extract intake in period 1. Pigs fed the 30% RBP diet had the highest level of intake while pigs on the control diet consumed the least amount of ether extract. However, differences between treatment means were not significant.

Faecal ether extract decreased as the level of RBP increased in the diets. Faecal ether extract in period 2 showed an appreciable increase of over 100% above faecal ether extract in period 1. However, there were no significant differences between treatment means.

Ether extract digested, increased correspondingly with increased RBP levels in the diets fed to the growing pigs. There was an appreciable increase in ether extract digested in period 2 compared with period 1. Ether extract digested decreased significantly ($P \leq 0.05$) as the level of RBP increased in the diet from 0 to 30%.

Table 13: Experiment 8305. Ether extract Intake and Digestibility of Diets containing Rice by-product.

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Ether extract Intake, g						
1	143.5	146.8	158.3	171.2	155.0		
2	282.4	285.8	289.7	316.8	293.7		
Avg.	213.0	216.3	224.0	244.0	224.3	1.31	
	Faecal ether extract, g						
1	56.7	46.5	38.6	24.9	41.7		
2	112.7	107.6	97.4	78.5	99.1		
Avg.	84.7	77.1	68.0	51.7	70.4	1.28	
	Ether extract digested, g						
1	86.8	100.4	119.7	146.4	113.3		
2	169.6	178.3	192.3	238.3	194.6		
Avg.	128.2^{d}	139.4^{c}	156.0^{b}	192.4^{a}	154.0	6.12	*T
	Ether extract digestibility, %						
1	60.8	68.2	75.4	85.7	72.5		
2	61.4	62.9	66.2	75.5	66.5		
Avg.	61.1^{c}	65.6^{b}	70.8^{b}	80.6^{a}	64.6	8.55	*T

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a,b,c,d, Means on the same row with different superscripts are significantly different (P/_0.05).

*T - Significant treatment effect of level of feeding (P/_0.05).

Ether extract digestibility coefficient in both periods increased with increased level of RBP fed to the growing pigs. Ether extract digestibility for period 1 was better than that of period 2. The 30% RBP diet had the best ether extract digestibility followed by the 20% and 10% RBP diets respectively, which had significantly ($P \leq 0.05$) better digestibility than the control.

Nitrogen-free extract intake, and digestibility figures are presented in (Table 14). Nitrogen-free extract intake decreased with increased levels of rice by-product fed to the pigs. Nitrogen-free extract intake increases in period 2 were higher than those in period 1. However, differences between treatment means were not significant.

Faecal nitrogen-free extract increased in both periods as the levels of RBP in the diets increased. Faecal nitrogen-free extracts in period 2 nearly doubled the values of NFE in period 1. Faecal nitrogen-free extracts were consistently higher in the RBP diets compared to the control diet in both periods. Differences between trestment means were not significant.

Nitrogen-free extract digested steadily decreased with increased levels of RBP in the diets fed to the pigs. NFE was better digested in period 2 compared to period 1. However, differences between treatment means were not significant. The digestibility coefficient of nitrogen-free extract was depressed as the level of RBP in the diets increased. Although the control diet had the best NFE digestibility, however, differences between treatment means were not significant.

Table 14: Experiment 8305: Nitrogen-free extract Intake and Digestibility of Diets containing Rice by-product.

Period	Level of Rive by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Nitrogen-free extract Intake, g						
1	5701.0	5220.2	5439.5	5099.4	5365.0		
2	7139.2	6375.7	6581.9	6030.8	6531.9		
Avg.	6420.1	5798.0	6010.7	5565.1	5948.5	0.85	
	Faecal Nitrogen-free extract, g						
1	295.8	483.1	661.5	767.9	552.1		
2	591.0	746.6	1097.9	1340.0	943.9		
Avg.	443.5	614.9	879.7	1050.0	748.0	0.488	
	Nitrogen-free extract digested, g						
1	5405.1	4737.1	4778.0	4331.5	4812.9		
2	6548.2	5629.1	5484.0	4690.8	5588.0		
Avg.	5976.7	5183.1	5131.0	4511.5	5201.6	0.06	
	Nitrogen-free extract Digestibility, %[a]						
1	94.8	90.7	87.8	84.9	89.6		
2	91.7	82.9	83.3	77.8	83.9		
Avg.	93.3	86.8	85.6	81.4	86.7	0.304	

a Nitrogen-free extract digestibility was expressed as % of nitrogen-free extract intake.

Crude fibre intake and digestibility data are presented in (Table 15). Crude fibre intake, increased linearly ($P/_ 0.01$) as the levels of rice by-product in the diets increased. The amount of crude fibre consumed by pigs in all treatments in period 2 nearly doubled crude fibre intake by the pigs in period 1. Pigs fed RBP diets had higher crude fibre intakes than the control in both periods. Pigs on the 30% RBP diets had the highest crude fibre intake figure followed by pigs fed the 20% RBP diet, which were significantly ($P/_ 0.05$) higher than crude fibre intake figures of 0 and 10% RBP diets.

Faecal fibre correspondingly increased with increased levels of RBP fed in both periods 1 and 2, although faecal fibre values in period 2 appreciably increased by nearly 60% compared to period 1. Differences between treatment means were highly significant ($P/_ 0.05$). Crude fibre digested by the pigs in period 1 tended to increase with increased levels of RBP fed to the growing pigs. Pigs on the 10% RBP diet proportionately digested less crude fibre than pigs on the control diet in period 2. Differences between treatment means for quantity of crude fibre digested were highly significant ($P/_ 0.05$), with pigs on the 30% RBP diet having the highest crude fibre digested figure. The control pigs had the lowest crude fibre digested figure.

Crude fibre digestibility coefficient was significantly ($P/_ 0.01$) depressed as the level of RBP in the diets increased. Crude fibre digestibility figures for pigs on the control diet in both periods were similar. The highest crude fibre digestibility figure was obtained on the control. The 10% RBP diet, was also significantly ($P/_ 0.01$) better compared to the 20% and the 30% RBP diets. The lowest crude fibre digestibility of 25.7% was obtained from the 30% RBP diet.

Table 15: Experiment 8305. Crude-fibre intake and Digestibility of Diets containing Rice by-product.

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effect
	Crude fibre Intake, g						
1	352.6	538.1	697.4	915.0	625.8		
2	693.7	895.0	1357.5	1692.6	1159.7		
Avg.	523.2^{d}	716.6^{c}	1027.5^{b}	1302.8^{a}	892.8	6.69	***TLn
	Faecal fibre, g						
1	209.6	403.6	588.2	710.3	467.9		
2	414.2	586.3	924.9	1196.6	780.5		
Avg.	311.9^{a}	495.0^{b}	756.6^{c}	953.5^{d}	624.3	32.90	***TLn
	Crude filre digested, g						
1	143.0	134.6	149.2	204.8	157.9		
2	279.4	398.7	432.6	496.0	401.7		
Avg.	211.2^{d}	266.7^{c}	290.9^{b}	350.4^{a}	279.8	3.97	*T
	Crude fibre digestibility, %						
1	41.5	24.8	22.2	22.1	27.7		
2	41.4	39.7	32.2	29.2	35.6		
Avg.	41.5^{a}	32.3^{b}	27.2^{c}	25.7^{c}	31.7	8.8	*T

a,b,c,d, Means on the same row with different superscripts are significantly different (P/_ 0.05).

***TLn - Significant treatment linear effect of level of feeding (P/_ 0.01)

*T - Significant treatment effect of level of feeding (P/_ 0.05).

Ash consumption and digestibility figures are presented in (Table 16). Throughout the two periods, ash consumption increased linearly ($P \leq 0.01$) with increased levels of RBP fed to the pigs. Ash consumption figures in period 2 nearly doubled ash consumed in period 1. Pigs fed RBP containing diets consistently consumed more ash than the pigs fed the control diet in both periods. Pigs fed the 30% RBP diet had the highest ash consumption figure while pigs on the control diet had the lowest ash consumption figure.

Faecal ash increased linearly ($P \leq 0.01$) as the level of dietary RBP increased from 0 to 30%. Faecal ash output increased appreciably in period 2 compared with faecal ash output in period 1. In both periods, pigs fed the control diet had the lowest faecal ash excretion while pigs fed the 30% RBP diet had the highest faecal ash excretion.

The quantity of ash digested increased with increased RBP levels in the diets. More ash was digested by pigs fed the RBP containing diets than the pigs fed the control diet. Ash digested figures in period 2 nearly doubled ash digested figures in period 1, and differences between treatment means were significant ($P \leq 0.05$).

Ash digestibility %, decreased with increased levels of RBP fed to the pigs. Pigs fed the control diet had the best ash digestibility figures throughout the two periods compared to pigs fed RBP diets. Differences between treatment means were significant ($P \leq 0.05$) with the control pigs having better ash digestibility than pigs fed the rice by-product diets.

Table 16: Experiment 8305. Ash consumption and Digestibility of diets containing Rice by-product.

Period	Level of Rice by-product (0%)	(10%)	(20%)	(30%)	Mean	SE	Significant Effects
	Ash consumption, g						
1	210.4	296.4	404.2	510.7	355.4		
2	413.8	542.6	786.8	944.7	672.0		
Avg.	312.1^{d}	419.5^{c}	595.5^{b}	727.7^{a}	513.7	18.54	*TLn
	Faecal ash, g						
1	110.4	188.0	262.6	328.0	222.3		
2	232.3	291.7	486.5	599.6	402.5		
Avg.	171.4^{a}	239.9^{b}	374.6^{c}	463.9^{d}	312.5	6.28	*TLn
	Ash digested, g						
1	99.9	108.4	141.6	182.5	133.1		
2	181.5	250.9	300.3	345.1	269.5		
Avg.	140.7^{d}	179.7^{c}	221.0^{b}	263.8^{a}	201.3	4.49	*TLn
	Ash digestibility, %						
1	48.4	36.6	35.9	35.4	39.1		
2	45.2	45.1	38.5	36.4	41.3		
Avg.	46.8^{a}	40.8^{b}	37.2^{b}	35.9^{b}	40.2	1.25	*TLn

a,b,c,d, Means on the same row with different superscripts are significantly different ($P \leq 0.05$).

*TLn - Treatment linear effect ($P \leq 0.01$).

DISCUSSIONS

Results of performance characteristics of the pigs are presented in (Table 8). A quadratic increase (P/0.01) in average daily feed intake was observed with increased levels of RBP fed to the pigs. Average daily feed intake doubled in period 2 when compared to period 1, but the differences between treatment means were not significant. The appreciable increase in feed intake in period 2, was associated with the increased feed intake from 4% of body weight to 6% of body weight. Obeka (1985) fed a similar by-product (rice offals) to chickens and observed that although average daily feed intake increased with the age of the pullets, average daily feed intake, of the birds failed to reach significant levels with increased levels of rice offals in the diets. Pigs on the 10% RBP diet had the least ADF intake when compared to the other treatment groups. Average daily gains decreased significantly (P/0.05) with increased levels of rice by-products. The relatively lower energy densities of the high fibre RBP diets fed to the pigs resulted in decreased gain. Energy intake of the pigs decreased with increased levels of RBP and could have had negative influences on gains, especially as the dry matter intake and nitrogen-free extracts intake decreased with increased levels of RBP fed to the pigs. Other growth-promoting nutrients such as nitrogen and nitrogen-free extracts had impaired digestibilities due to the negative influence of fibre. The presence of high fibre levels in the diets increased metabolic faecal nitrogen excretion (Just 1980). Although the rice by-product fed to the growing pigs in this trial is not equivalent nutrient-wise to rice bran, its effect on gains tends to suggest that feeding RBP higher than 30% level in swine diets would not improve gains because of its high fibre content. Campabadal et al. (1976) had earlier observed that high fibre rice bran diets fed at levels higher than 35% to pigs resulted in significantly less daily gain.

Feed to gain ratios (Table 8) increased significantly (P/0.05) with increased levels of rice by-product fed to the pigs. Although feed to gain ratio for the control diet and the 10% RBP diets were similar, the feed to gain ratios of pigs fed the 20% and 30% RBP diets were significantly poorer (P/0.05) than these two. The increased feed to gain ratio in this trial is in agreement with the findings of Obeka (1985) who fed rice by-product (rice offals) to growing chickens and reported increased feed to gain ratios for chickens fed rice offal diets when compared with those on the control diet.

There was a quadratic (P/0.01) decrease in dry matter intake (Table 9) in both periods 1 and 2 as the levels of RBP in the diets of the pigs increased. Dry matter intake of the pigs increased in period 2 by approximately 100%. This significant increase in dry matter intake in period 2 could be attributed to the increased intake of feed from 4% body weight to 6% of body weight. The pigs attempted to consume the high fibre lower energy diets in sufficient amounts to meet their nutrient requirements, however, the bulky nature of these diets limited their consumption by the pigs, thus leading to impairment of nutrients available to the pigs for efficient growth. Some high fibre diets influence rate of passage, thus, reducing the time available to the pig for nutrient absorption and intestinal fermentation. Ehle et al. (1982) showed that the extent of digestion in vivo is related to competition between rate of passage and rate of digestion.

Faecal dry matter (Table 9) also increased correspondingly with increased levels of RBP in the diets. Faecal output doubled in period 2 of the trial when compared with total faecal output of the pigs in period 1. This result is probably tied up

with increased feed intake from 4% of body weight in period 1 to 6% of body weight in period 2. Apparent dry matter digested (Table 9) showed a significant (P/0.05) period effect of level of feeding RBP in both periods. Apparent dry matter digested was depressed as the level of RBP increased in the diets of the pigs. This result is attributed to the increasing levels of fibre in diets which could have reduced digestibility of DM and might have increased rate of passage. The apparent dry matter digestibility decreased significantly (P/0.05) with increased levels of RBP in the diets. Brooks and Lumunta (1975) fed graded levels of rice bran to growing pigs and also reported decreased dry matter digestibility. The low digestibility can be associated with the high fibre content of the by-product as a result of contamination with hulls and its high silica content. Arnott and Lim (1966) observed that the high silica content of rice by-products causes irritation of the gastro-intestinal tract of the pig thereby preventing proper digestion and assimilation of nutrients by the pig. Campabadal et al. (1976) also reported lacerations of the gastro-intestinal tract of growing pigs fed diets containing varied levels of rice bran. However, no such observations were made in this trial.

Nitrogen intake (Table 10) decreased with increased levels of RBP in the diets of the pigs, with the control diet having the highest value for the two periods (235.8g Vs 210.7 Vs 211.1 Vs 208.6g). This result is in agreement with those of Loosli et al. (1954) who reported decreasing nitrogen consumption with increased high fibre rice bran diets fed to growing pigs. Frank et al. (1983) observed that differences in daily nitrogen intake by growing pigs was due largely to differences in daily

feed intake that resulted in decreased nitrogen digestibility, eventhough significant differences were not observed among treatment groups. Faecal nitrogen (Table 10), increased appreciably in period 2 when compared to faecal nitrogen excretion in period 1. There was a significant ($P \leq 0.05$) period effect, for faecal nitrogen excretion. The total increase observed in the faecal nitrogen excretion is tied up with increased fibre levels of the RBP fed to the pigs. High fibre diets promote faecal nitrogen excretion Just (1980). The increased intake of total dry matter in period 2 must have correspondingly increased nitrogen intake and hence its increased faecal excretion. Faecal nitrogen excretion was highest for pigs fed the 20% RBP diet which correspondingly consumed highest level of fibre. This result could be attributed to the fact that high fibre diets promote the excretion of metabolic faecal nitrogen (Waldo, 1968 and Just, 1970). The metabolic fractions are composed of body excretions into the digestive tract such as juices, enzymes secreted into the gastro-intestinal tract, abraisons from walls of the gastro-intestinal tract, cells sloughed from the walls of the tract and bacteria and protozoa.

Nitrogen digested (Table 10) showed significant ($P \leq 0.05$) treatment effect in period 1 of the trial. Nitrogen digested decreased with increased RBP levels fed to the pigs. This result is due to the fact that the higher RBP levels contained more crude fibre which had a negative effect on digestibility of nitrogen. The higher fibre levels of the RBP diets must have progressively promoted metabolic faecal nitrogen excretion and contributed to reduced digestibility of nitrogen. Although nitrogen digested in period 2 increased appreciably above that of period 1, differences between treatment means were not significant. The increase is associated with

increased nitrogen intake as levels of feed intake increased from 4% of body weight in period 1 to 6% of body weight in period 2. Apparent nitrogen digestibility coefficient (Table 10) decreased linearly ($P \leq 0.05$) with increased level of RBP in the diets. This result could be due to the fact that high fibre diets fed to the pigs increased metabolic faecal nitrogen excretion, and this trend was observed by Just (1980) who fed high fibre diets to pigs. Differences between nitrogen digestibility coefficient values for periods 1 and 2 did not differ appreciably. This observation is attributed to the fact that diets fed throughout the two periods were the same in chemical composition (nutrient-wise) while nitrogen excretion increased with increased consumption and fibre contents of the diets.

Nitrogen excretion and retention figures are presented in (Table 11). More urinary nitrogen was excreted in period 1 than period 2. The control pigs excreted more nitrogen in urine than pigs fed RBP diets. This observation is due to the fact that the control pigs consumed more dry matter and hence excreted more of the nitrogen consumed. Calculated crude protein (18%) of the control diet was less than the determined value (23.19%), and no reason could be given to explain this difference. Determined crude protein values of the diets (Table 7) were (23.19, 21.75, 20.56 and 21.0) for the control, 10, 20 and 30% diets respectively. Nitrogen balance (NB) as % of intake (Table 11) was highest for pigs fed the control diet compared to pigs fed the RBP diets. This was due to the fact that the pigs on the control diet had the highest nitrogen intake while pigs on the other treatments consumed less nitrogen and excreted more owing to the fibrous nature of the RBP diets.

Just (1980) attributed this to the negative influence of higher fibre contents in the rations. Although nitrogen balance consistently decreased with increased RBP levels fed to the pigs, differences between treatment means were not significant. Nitrogen balance as percent of digested (Table 11) did not show any definite trend. Although diets used in this trial were iso-nitrogenous and not iso-caloric, results of nitrogen digestibility value (Table 11) is in agreement with those of Rao and Prasad (1980) who fed iso-caloric and iso-nitrogenous diets with rice polishings and reported decreased growth rate and increased feed to gain ratios.

Energy intake and digestibility results are presented in (Table 12). Energy intake, tended to increase with increased levels of RBP in the diets. Energy intake in period 2 nearly doubled its consumption by the pigs in period 1. This result is associated with the increased dry matter intake which increased from 4% body weight in period 1 to 6% body weight in period 2. Pigs fed the higher fibre diets consumed slightly more energy than pigs fed the control diet. This observation can be attributed to the fact that the RBP containing diets were of lower energy density than the control. Faecal energy (Table 12) increased with increased RBP levels in the diets. The amount of energy excreted in period 2 doubled that excreted in period 1. This result is tied up with increased feed intake level in period 2 over the quantity fed in period 1. The increase in faecal energy output is also tied up with the increased fibre content of the diets; high fibre diets reduce nutrient digestibility while fibre in itself is of no nutritional consequence because of its high content of hemicellulose and lignin which are highly indigestible in themselves (Boenker et al. 1969). Differences between treatment means with regard to faecal energy were not significant.

Because of increased faecal energy losses, energy digested (Table 12) in both periods 1 and 2 correspondingly decreased with increased levels of RBP fed to the growing pigs. Energy digested by pigs on the control diet was significantly ($P/_0.05$) higher than energy digested by pigs fed RBP containing diets. Energy digested by pigs on diets containing the 20 and 30% RBP levels were similar and significantly lower than energy digested by pigs fed the 10% RBP diet. Apparent energy digestibility figures decreased linearly ($P/_0.05$) with increased levels of rice by-product fed to the pigs. This result is due to the higher fibre content of the RBP diets. Apparent energy digestibility in period 1 was slightly higher than in period 2. Boenker et al. (1969) explained that fibre has low nutrient value and contributes little if any digestible nutrient. Just (1982), elucidating on this fact observed that the proportion of digested energy disappearing in the hind gut of the pig increased with increased content of crude fibre, because more nutrients were transferred to this region. He further explained that the negative influence of crude fibre acts as an indicator of the composition of the NFE substances. Thus with increasing content of crude fibre, the proportion of soluble carbohydrate in the NFE decreases and the proportion of the other fractions mainly, hemicellulose increases. The relatively low apparent digestibilities of energy of the RBP diets can be explained in line with the findings of Ehle et al. (1982) who studied the influence of dietary fibre on digestibility, rate of passage and gastro-intestinal fermentation in pigs fed alfalfa, coarse bran and cellulose diets. They observed that the extent of digestion in vivo is related to competition between rate of passage and rate of digestion. In this experiments, pigs on the RBP diets with higher fibre

contents may have higher rate of passage than those of pigs on the control diet with longer retention and better digestibility. There were significant (P/ 0.05) differences between treatments with respect tc energy digestibility. However, Ehle et al. (1982) observed no differences in apparent digestibility of DE in the high fibre plus cellulose diets fed to growing pigs.

Ether extract digestibility figures are presented in (Table 13). Ether extract intake, increased with increased levels of RBP fed to the pigs. Ether extract intake by the pigs doubled in period 2 when compared with its intake in period 1. Pigs fed the control diet consistently had the lowest intake figures in both periods compared to pigs fed the RBP containing diets. The highest ether extract intake figure was obtained from pigs fed the 30% RBP diet. Differences between treatment means were however, not significant. Faecal ether extract decreased with increased rice by-product levels in the diets. Faecal ether excretion in period 2 increased by over 100% above period 1, however, differences between treatment means were not significant. The increased faecal ether extract must have been due to increasing fibre levels in the RBP diets. Ether extract digested figures increased with increased RBP levels in the diets fed to the pigs. Ether extract digested in period 2 increased considerably above the period 1 levels. Ether extract digested increased linearly (P/ 0.05) with increased levels of RBP fed to the pigs. Earlier work by Brooks and Lumunta (1975) reported linear increases in ether extract digestibility of rice bran diets fed to growing pigs. Ether extract digestibility coefficient was generally better in period 1 compared to period 2. For the two periods combined, ether

extract digestibility increased as the level of RBP increased in the diets. Pigs fed the control diet had the lowest ether extract digestibility coefficient while pigs fed the 30% RBP diet had the highest ether extract digestibility coefficient. Ether extract digestibility coefficient for the 10 and 20% diets were significantly ($P/_ 0.05$) higher than that of the control diet which was significantly lower than the digestibility of the 30% RBP diet. This result is supported by those of Robles and Ewan (1982) who reported significant linear increases in ether extract digestibility of rice bran diets fed to young pigs.

Nitrogen-free extract intake and digestibility figures are presented in (Table 14). Intake of NFE decreased with increased levels of RBP fed to the pigs. Nitrogen-free extract intake, in period 2 increased appreciably over that of period 1. While pigs fed the control diet had the highest intake of NFE, pigs fed the RBP diets showed decreased intake of NFE as the levels of RBP increased. Differences between treatment means were however, not significant. Faecal nitrogen-free extract increased with increased levels of RBP in the diets. More faecal NFE was excreted in period 2 compared to period 1. Pigs fed the control diet had the least faecal NFE figure while pigs fed the 30% RBP diet had the highest faecal NFE figure. These observations are associated with the negative influence of crude fibre levels on nitrogen-free extract digestibility. Nitrogen-free extract digested decreased as the level of RBP fed increased from 0 to 30%. NFE digested figures in period 2 were higher than NFE digested figures in period 1. The control diet had the highest NFE digested figure while the 30% RBP diet had the lowest NFE digested figure. This result is associated with the level of fibre contained in each diet

although differences between treatment means were not significant. Nitrogen-free extract digestibility coefficient similarly decreased as the levels of RBP in the diets increased. There was appreciable difference between NFE digestibility figures of period 1 and those of period 2. The higher levels of fibre in RBP containing diets must have adversely affected the digestibility of NFE in these diets. The control diet had the highest NFE digestibility coefficient, while the 30% RBP diet had the least digestibility coefficient of nitrogen-free extract. Differences between treatment means, however, were not significant.

Crude fibre intake and digestibility data are presented in (Table 15). Intake of crude fibre by the pigs increased as the levels of RBP increased in the diets. Significant increases in crude fibre intake were observed in period 2 when compared with period 1 intake. A quadratic ($P/__ 0.01$) effect of level of feeding RBP was observed for crude fibre intake. This result is due to the increased dry matter intake of pigs in period 2 and the fact that the pigs had to consume more of the high fibre diets in order to meet their energy demand. Faecal fibre also increased as the levels of RBP in the diets increased. More fibre was excreted in period 2 than in period 1 due to increased intake of dry matter by the pigs. Faecal fibre increased significantly ($P/__ 0.05$) with RBP containing diets having higher faecal fibre output than the control in both periods. The control diet had the lowest faecal fibre while the 30% RBP diet had the highest faecal fibre. This result is also probably attributed to the fact that the higher levels of fibre in RBP diets made them less digestible and could have also increased their rate of passage through the gastro-intestinal tract, thereby providing lesser retention time for proper nutrient digestion and assimilation.

The quantity of crude fibre digested increased with increased RBP levels in the diets of the pigs. Crude fibre digested in period 2 nearly doubled the figures obtained in period 1. All the RBP containing diets had significantly (P/0.05) higher crude fibre digested figures than the control which had the least crude fibre digested figure. However, crude fibre digestibility coefficient (Table 15) consistently decreased with increased levels of RBP in diets. This low digestibility coefficient of crude fibre could be associated with RBP contamination with hulls and other indigestible components. It has been well known that fibre digestibility could be influenced by source or kind (Crampton and Harris, 1969). Besides there may be higher proportions of highly indigestible components - hemicellulose, pentosans and silica in the RBP.

Ash consumption and digestibility results of diets containing rice mill by-product fed to growing pigs are presented in (Table 16). As consumption increased as the level of feeding RBP increased. Pigs fed the RBP diets significantly (P/0.05) had better ash consumption figures than pigs fed the control diet.

Faecal ash (Table 16) increased significantly (P/0.05) as the level of RBP increased. All the RBP containing diets had significantly higher faecal ash than the control diets in both periods. Faecal ash increased as a result of decreased fibre digestibility in the diets and increased dry matter intake exhibited by the pigs in period 2. Ash digested (grams) increased significantly (P/0.05) with increased levels of of RBP fed to the

pigs. This is as a result of increased dry matter intake in period 2 compared to the level of dry matter intake in period 1. All the RBP containing diets were significantly better digested with respect to ash content than the control. Ash digestibility coefficient (Table 16) does not show much disparity between the figures in periods 1 and 2. However, there was a significant ($P < 0.05$) difference between the ash digestibility coefficient of the control and all the RBP containing diets. The trend was that ash digestibility coefficient decreased linearly ($P < 0.01$) as the levels of rice mill by-product increased in the diets fed to the pigs.

EFFECTS OF GRADED LEVELS OF RICEMILL BY-PRODUCTS IN THE DIETS OF PIGS ON THEIR PERFORMANCE CHARACTERISTICS AND CARCASS QUALITY

EXPERIMENT 8307

OBJECTIVE:

The experiment was planned to study the replacement value of rice mill by-product for maize using varied levels of RBP in a maize groundnut cake based diets for growing-finishing pigs. The effects of the replacement on the performance and carcass characteristics of pigs were also studied.

EXPERIMENTAL PROCEDURE:

Twenty four (24) crossbred (Hampshire x Large White x Landrace) barrows and gilts of average initial weight of 35.5kg were assigned to pens depending on initial weight and sex. Treatments were allotted to pens within each replicate. There were four treatments and six replications in a randomized block design. Pigs were housed in an enclosed barn opened at the sides but closed at the ends. Rice by-product replaced maize on proportional basis in the control diet. All the diets (Table 17) were served in weighed quantities to the individual pigs in their individual troughs. Animals were individually fed twice daily at 8 am and 4 pm for the 56 days trial period. Feed was increased as the appetite of the pigs improved. Water was supplied ad-libitum, and refused feed or wasted feed was collected daily, oven-dried and weighed back on coming to room temperature. Animals were weighed weekly throughout the experimental period. Gross energy values of the diets (Table 18) were determined using Parr adiabatic bomb calorimeter. All the data on feed consumption, live weight gains, calculated feed to gain ratios and the carcass measurements were subjected to the analysis of variance according to the method of Cochran and Cox (1957) and differences between means compared using Duncan's Multiple range test (Steel and Torrie, 1960).

Table 17 : Experiment 8307. Percentage composition of experimental diets.

Ingredients	Treatments % Maize Replaced 0	15	30	45
Yellow maize	78.95	67.11	55.26	43.42
Rice by-product	-	11.48	23.69	35.55
Groundnut cake	17.89	17.89	17.89	17.89
Bone meal	2.00	2.00	2.00	2.00
Common salt	0.50	0.50	0.50	0.50
Lysine	0.26	0.26	0.26	0.26
Methionine	0.25	0.25	0.25	0.25
Vitamin Premix[a]	0.15	0.15	0.15	0.15
	100.00	100.00	100.00	100.00
Calculated Nutrient Levels:				
Crude protein (%)	15.0	14.67	14.34	14.00
ME Kcal/kg	3360	3117	2884	2664
Calcium (%)	.62	.64	.65	.67
Phosphorus (%)	.58	.61	.63	.66
Crude fibre (%)	4.30	8.94	13.59	18.23
Lysine (%)	.74	.72	.71	.70
Methionine (%)	.71	.67	.64	.60

[a] Roche VM502: Contributed the following per kilogram of diet: Vitamin A, 12,000I.U.; Vitamin D_3, 1,200I.U.; Vitamin E, 3.6I.U.; Vitamin K, 1.8mg; Vitamin B_2, 3.6mg; Nicotinate, 18mg; Calcium-d-Pantothenate, 9.6mg; Biotin, .036mg; Vitamin B_{12}, .012mg; Choline chloride, 120mg; Chlortetracycline, 48mg; Manganese, 24mg; Iron, 48mg; Zinc, 96mg; Copper, 60mg; Iodine, 1.8mg; Cobalt, .48mg.

All pigs were slaughtered at the Ahmadu Bello University Meat Processing Laboratory. Carcass information (Table 19) was obtained on both the warm carcass and after chilling for 24 hours at 3.3 to 5°C. They were weighted for cooler shrink and measured for back fat thickness.

Backfat thickness was measured opposite the first rib, 10th rib and junction between the second and the third lumbar vertebrae. Carcass length was measured from the anterior edge of the aitch bone to the anterior edge of the first rib adjacent to the vertebra. The ham was removed by a cut between the second and third sacral vertebrae and perpendicular to the long axis of the shank. The feet were removed for the hind feet at the hock joint while the fore leg was removed slightly above the knee joint. The fore quarter was removed between the first and second ribs. The loin was removed by cutting across the 10th rib. Area of longissimus dorsi (eye muscle) was determined by a planimeter measurement from a tracing of a cross section of the right L.dorsi cut perpendicular to the linear axis at a point immediately posterior to the junction of the 10th rib and 10th thoracic vertebra counting from the anterior end of the carcass. The belly was removed by separating the loin by a cut through the tender loin muscle. (Figure 1).

All carcass yield trimmed and untrimmed were weighed and calculated as percent of live weight. Trimmed cuts were obtained by maximally removing external fat thickness plus the skin and weighed. Warm weights of internal organs were recorded, and lengths of the small and large intestines were measured and recorded. Dressing percentage was based on live weight after 24 hours of fasting. Warm carcass length was measured and recorded.

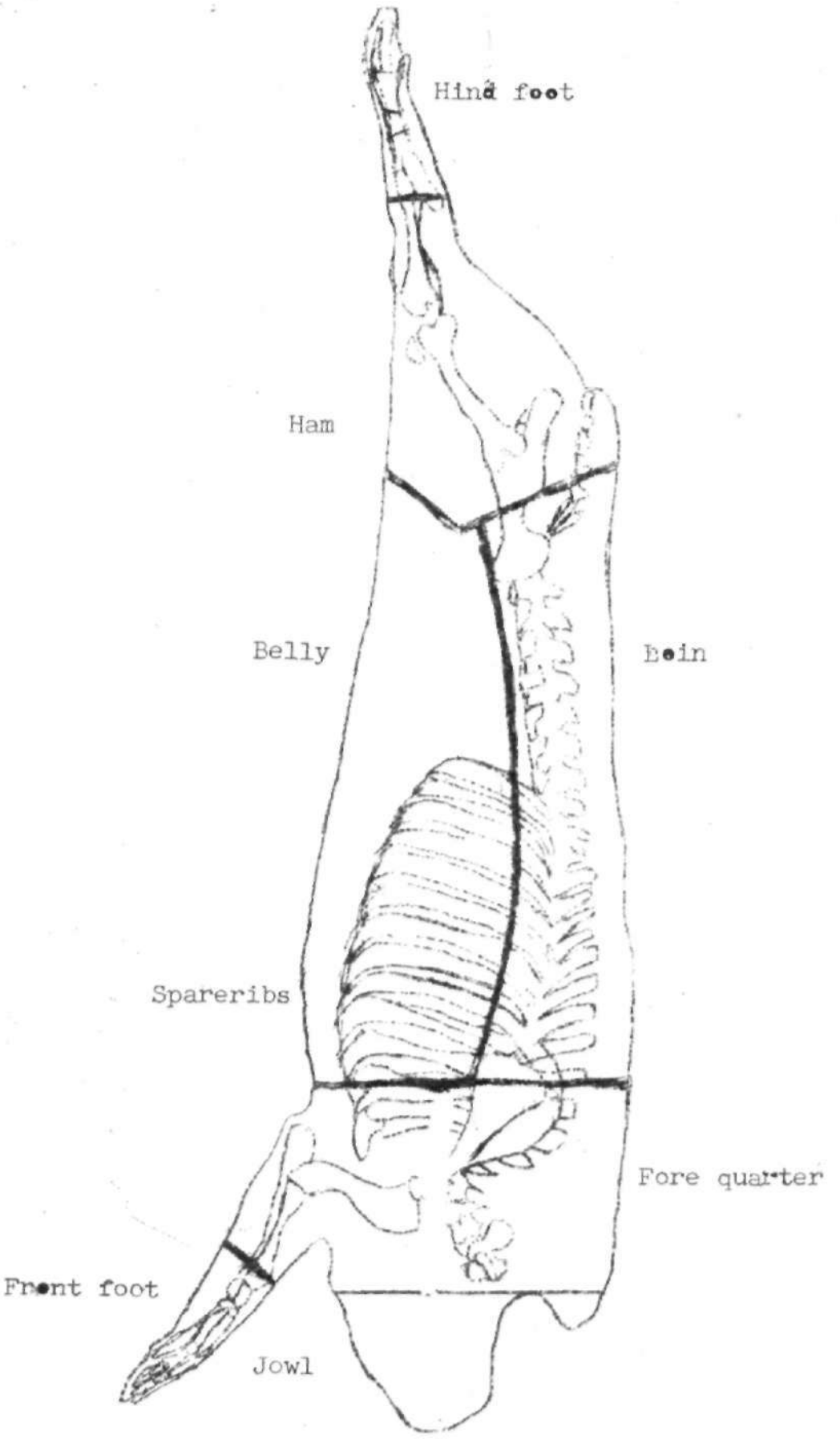


Figure (1). Skeletal diagram of a pork carcass to illustrate the anatomical references for cutting the wholesale (primal) cuts.

RESULTS

Final weight at slaughter and other performance characteristics data are presented in (Table 18). Final weight at slauther decreased while average daily gain was depressed as levels of RBP in the diets increased. Pigs on the control diet had the best gains while pigs fed with RBP diets exhibited poorer performance in daily gains. Average daily gain of pigs fed the control and the 15% maize replacement diets was significantly ($P/0.05$) better than pigs fed with 30 and 45% maize replacement diets. Average daily feed intake, of pigs (Table 18) increased with increased levels of RBP in the diets but there were no significant differences between treatment means.

Feed to gain ratios (Table 18) showed reduced efficiency of feed conversion by the pigs as the level of rice by-product increased in the diets. Feed to gain ratio for pigs fed the 45% maize replacement diet was significantly ($P/0.05$) different from the other treatments. Efficiency of feed conversion was best with pigs on the control diet followed by pigs fed diet in which 15% RBP replaced maize. Pigs fed the 45% RBP replacing maize diet had the poorest feed conversion.

Feed cost per kilogramme gain was not significantly affected by the level of RBP fed to growing finishing pigs (Table 18), showing that although pigs on RBP diets were less efficient in utilizing feed for gain, the overall cost of putting on a unit gain on the bulky diet is similar to the control. Thus, the more expensive maize could be saved but pigs will be kept slightly longer to attain market weight, especially at the highest level of feeding RBP.

Evaluation of the carcass characteristics (Table 19) showed that differences between means of slaughter weights were highly significant ($P/0.05$). Final slaughter weights decreased with increased levels of RBP in the diets. Warm carcass weights correspondingly decreased with increased levels of RBP fed.

Table 12: Experiment 8307. Effect of Rice by-product Diets on performance characteristics of growing-finishing pigs.

	% Maize Replaced					
Parameter	0%	15%	30%	45%	Mean	SE
Days on trial	56	56	56	56	56	
Initial wt, kg	33.6	35.4	36.5	35.4	35.7	
Final wt at slaughter,kg	77.3[a]	76.3[a]	74.0[b]	68.5[c]	73.5	2.12
Avg daily gain, g	753[a]	729[a]	687[b]	543[c]	678	47.3
Avg daily feed, kg	2.96	2.93	3.01	3.03	2.98	.43
Feed: Gain ratio	3.97[a]	4.07[a]	4.39[a]	5.68[b]	4.53	0.37
Feed cost/kg live weight gain, (₦)	2.44	2.27	2.21	2.41	2.4	0.805
G.E. kcal/g (diet)	3947	3923	3906	3869		

a,b,c Means on the same row with different superscripts are significantly different (P/0.05).

Table 19: Experiment 8307. Effect of Rice by-product Diets on carcass characteristics of Growing-Finishing pigs.

	Level of Rice by-product Replacing Maize					
Parameter*	0%	15%	30%	45%	Mean	SE
Slaughter wt, kg	77.8[a]	76.3[a]	74[b]	68.5[c]	73.5	2.13
Warm carcass wt, kg	55.4[a]	51.4[b]	51.6[b]	44.5[c]	50.8	3.68
% Dressing (warm)	69.5[a]	67.5[b]	69.6[a]	67.8[b]	68.6	3.76
% Dressing (chilled)	66.3[a]	63.5[b]	65.0[b]	61.6[c]	64.1	1.92
Carcass length (cm)	74.4	71.4	70.1	72.2	72.0	.45
% ham (untrimmed)	18.3	18.7	18.5	18.6	18.5	0.07
% ham (trimmed)	13.8	14.6	14.3	16.1	14.7	1.08
% loin (untrimmed)	9.8	8.5	9.3	8.0	8.9	0.71
% loin (trimmed)	5.9	6.0	5.6	5.4	5.7	0.08
% belly (untrimmed)	9.1	8.9	8.1	7.7	8.5	0.36
% belly (trimmed)	3.9	4.2	3.8	3.5	3.9	0.31
% forequarter (untrimmed)	26.4	26.4	27.9	29.5	27.6	0.25
% forequarter (trimmed)	20.2	19.9	21.5	22.1	20.9	0.78
% lean	43.5	44.1	44.5	46.6	44.7	0.29

a,b,c Means on the same row with different superscripts are significantly different ($P \leq 0.05$).

*Trimmed and untrimmed carcass as % of (live weight).

However, dressed carcass weights between 15 and 30% diets were similar and were significantly ($P \leq 0.05$) different from those on the control and the 45% maize replacement diets. Dressing % (warm) (Table 19) tended to decrease with increased RBP levels in the diets. Although differences between treatment means were significant ($P \leq 0.05$), dressing % obtained from the 30% maize replacement diet was similar to the control as were the values obtained for the 15% and 45% maize replacement respectively. Dressing % (chilled) followed similar trend and differences between treatments were significant ($P \leq 0.05$).

Carcass length (Table 19) decreased with increased levels of RBP in the diets, but differences between treatments were not significant. Percent ham untrimmed increased as the level of maize replaced with RBP in the diets increased but differences between means were not significant. Percent loin untrimmed decreased as levels of RBP replacing maize increased while percent loin trimmed did not show any definite trend. Percent belly untrimmed decreased with increased RBP replacing maize in the diets. Percent belly (trimmed) followed similar trend but differences between treatment means were not significant. Percent forequarter untrimmed increased with increased levels of RBP fed. Similarly, % forequarter (trimmed) increased as the levels of RBP replacing maize increased in the diets. However, differences between treatment means were not significant. The overall percent (trimmed) carcass yield (% lean plus bone) (Table 19) increased with increased levels of RBP inclusion in the diets although differences between means were not significant.

Table 20: Experiment 8307. Effect of Rice by-product Diets on carcass characteristics of Growing-Finishing pigs.

	Level of Rice by-product Replacing maize					
Parameter	0%	15%	30%	45%	Mean	SE
Backfat thickness (cm) (warm)	2.6[a]	3.0[c]	2.8[b]	2.6[a]	2.8	.241
Backfat thickness (cm) (chilled)	3.3[c]	3.0[c]	2.9[b]	2.7[a]	3.0	.434
Area Longissimus dorsi (cm^2)	24.6	27.2	25.6	26.1	25.9	.247

a,b,c Means on the same row with different superscripts are significantly different ($P \leq 0.05$).

Table 21: Experiment 8307. Effect of Rice by-product Diets on carcass characteristics of Growing-Finishing pigs.

	Level of Rice by-product Replacing Maize					
Parameter*	0%	15%	30%	45%	Mean	SE
Percent fat plus skin	21.4[c]	18.5[b]	20.1[b]	15.2[a]	18.8	2.44
Head % of live weight	8.6	8.6	8.3	8.8	8.6	0.19
Feet % of live weight	2.8	2.9	2.9	3.1	2.9	0.53

a,b,c Means on the same row with different superscripts are significantly different ($P \leq 0.05$).

*Expressed as % of (live weight).

Backfat thickness (warm) (Table 20) tended to decrease with increased levels of PBP replacing maize, with the pigs on the control and 45% RBP diets having significantly (P/0.05) better backfat thickness than the 15 and 30% maize replacement diets. Backfat thickness measurement (chilled) showed that pigs on the control and 15% maize replacement diets had significantly (P/0.05) poorer backfat thickness than pigs fed the 30% and 45% maize replacement diets. Area Longissimus dorsi muscle (Table 20) increased as the level of maize replaced by RBP increased in the diets. However, differences between means were not significant. Percent fat plus skin (Table 21) decreased with increased levels of RBP replacing maize. Although the 15 and 30% maize replacement diets had similar fat plus skin yields, these two were significantly (P/0.05) different from those of pigs fed the control and 45% RBP replacing maize diets. The lowest % fat plus skin yield was obtained on the 45% RBP replacing maize diet while the highest yield of % fat plus skin was obtained from pigs fed the control diet. Mean weight of head expressed as % live weight of the pigs (Table 21) showed no definite trend. Percent feet was not significantly different between treatments.

Table 22: Experiment 8307. The effect of feeding rice by-product on performance and carcass characteristics of barrows and gilts.

	Sex			
Parameter	Barrows	Gilts	Mean	SE
Initial wt, kg	36.0	35.0	35.5	
Final wt at slaughter, kg	74.5	65.6	70.1	2.12*
Average daily gain, g	620	670	650	47.3**
Average daily feed, g	3100	2900	3000	.43 NS
Feed to gain ratio	4.7	4.3	4.5	.37**
Percent dressing (warm)	69.8	68.2	69.0	3.76 NS
Percent " (chilled)	64.5	63.7	64.1	1.92 NS
Carcass length (cm)	72.7	73.0	72.9	,448 NS
Backfat thickness (cm)	2.8	3.0	2.9	.241**
Area Longissimus dorsi (cm^2)	25.5	26.0	25.9	.247 NS
Percent Ham (untrimmed)	18.1	18.9	18.5	.065 NS
Percent Ham (trimmed)	14.3	15.1	14.7	1.08 NS
" total fat plus skin	19.7	17.9	18.8	2.44 NS

* = Significant at (P/_ 0.05)

** = Significant at (P/_ 0.01)

NS = Not significant.

On the basis of sex (Table 22) the final weight at slaughter for barrows was significantly (P/_ 0.05) higher than for gilts. Average daily gain for barrows was significantly (P/_ 0.01) better than for gilts. Average daily feed intake, however, did not show any significant difference between treatment means. Feed to gain ratios for barrows was significantly (P/_ 0.01) higher than the ratios for gilts.

Carcass traits influenced by sex are also shown in (Table 22). Dressing % warm for both barrows and gilts were similar. Barrows exhibited lesser backfat thickness than gilts (2.8cm Vs. 3.0 cm) respectively which was significantly (P/_ 0.01) better than backfat measurements for gilts. Percent total fat plus skin yield for barrows was higher than for gilts (14.5kg Vs. 12.5kg) respectively, but differences between means for both sexes were not significant.

Weights of internal organs and gastro-intestinal measurements are presented in (Table 23). Weights of the heart, spleen, kidneys and lungs, all tended to decrease as the level of RBP replacing maize in the finisher diets increased. Weights of the stomach, diaphragm and the liver increased with increased levels of RBP inclusion in the diets. Inspite of the wide differences between mean weights of organs recorded, differences between mean weights of organs did not attain significant levels. Length of the small intestine tended to increase with increased levels of RBP fed to the pigs but differences between treatment means were not significant. Length measurement of the large intestine, however, decreased as the level of RBP fed increased even-though differences between treatments were not significant.

Table 23: Experiment 8307. Effect of feeding rice by-product on organ weights and gut lengths of Finisher pigs.

	Level of RBP replacing maize					
Organs & Gut lengths	0%	15%	30%	45%	Mean	SE
Mean organ weights and Gut lengths						
Heart wt; g	266.7	300	258.3	246.7	267.9	37.8
Liver wt; g	1550	1500	1558	1450	1514	82.8
Spleen wt; g	150	150	183.3	116.7	150	43.3
Diaphragm wt; g	200	217	200	233	212.5	21.6
Stomach wt; g	675	716.7	683	683	689.5	57.6
Kidney wt; g	225	292	167	208	235	24.7
Lung wt; g	742	783	700	700	731	50.2
Length of small intestine, mm	1772	1842	1717	1802	1783	100.3
Length of large intestine, mm	500	497	457	462	479	32.9

DISCUSSION

The effects of rice by-product diets on performance characteristics of growing-finishing pigs are presented in (Table 18). Final weight of finisher pigs decreased with increased levels of RBP fed to the pigs. Pigs fed the control and the 15% RBP replacing maize diets had significantly ($P/0.05$) better slaughter weights than pigs fed the 30' and 45% RBP replacing maize diets. This result could be tied up with the fact that the diets fed in this trial (Table 17) were not iso-caloric and the digestible energy (DE) of RBP containing diets would tend to decrease with increased levels of the by-products fed. Thus, available energy and other nutrients required for maintenance and growth of the pigs on higher levels of RBP replacing maize diets might have been inadequate due to their higher fibre contents. Boenker *et al*. (1969) explained that fibre has a low nutrient value in itself, decreases apparent dry matter digestibility, contributes little if any digestible nutrient, and also makes other nutrients less available.

Average daily gain of pigs decreased with increased levels of RBP inclusion in the diets fed to the pigs. Daily gains were (753, 729, 687 and 543 g) for pigs on diets with 0, 15, 30 and 45% RBP replacing maize respectively. The control diet was significantly ($P/0.05$) different from diets in which 30 and 45% of the dietary maize were replaced with rice by-product. The decreasing growth rate of pigs in this trial must have been due to the negative influence of high fibre contents of the diets fed to the pigs. Crampton and Lloyd (1955) Hochstetler *et al*. (1958), Pond *et al*. (1962) and Cameron (1972) experimenting with growing-finishing pigs fed low-energy high fibre diets and observed significant reduction in growth rate of the pigs.

Average daily feed intake of the pigs increased as the levels of RBP replacing maize in the diets increased. Although there was no significant difference between treatment means, pigs fed the 45% maize replacement diet had the highest feed intake followed by pigs on the 30% maize replacement diet. Pigs on the control and the 15% maize replacement diets had similar average daily feed intakes. Cole et al. (1967), Owen and Ridgman (1967), Dinnuson et al. (1969) had earlier noted that pigs ate primarily to satisfy their energy requirements. However, in this experiment, despite the increased fibre levels in RBP replacing maize diets, the pigs did not increase their intakes significantly above that of the control. This result can be attributed to the bulky nature of the RBP diets.

Feed to gain ratio showed a decreasing trend of feed conversion efficiency as the levels of RBP replacing maize in the diets increased. Differences between treatment means were not significant until the 45% RBP replacing maize level was reached. It was probable that the lowered feed conversion efficiency of pigs fed RBP replacing maize diets was due to the reduction in digestibility of nutrients arising from a relatively shorter time of feed retention in the gastro-intestinal tract. Ehle et al. (1982) reported a reduction in apparent digestibility of dry matter, nitrogen-free extracts and crude protein when higher levels of fibre were fed to growing pigs. Baird et al. (1970) however, observed that the wide variation of dietary crude fibre levels did not affect the efficiency of live weight gain when the energy level of diets remain almost constant.

Feed costs per kilogramme (Table 18) live weight gain values for 0, 15, 30 and 45% RBP replacing maize diets were (2.44, 2.27, 2.21 and 2.41) ₦ respectively. Feed cost per kilogramme gain for the control and the 45% RBP replacing maize diets were similar and higher than values for pigs on 15 and 30% RBP replacing maize diets. Differences between mean values of cost per kilogramme live weight gain were not significant. The increased cost of the control diet could be attributed to the higher cost of basic ingredients used in formulating this diet (Appendix 2). The next higher feed cost per kilogramme gain observed in 45% RBP replacing maize diet could be due to increased feed intake by the pigs to meet their nutrient requirements and the lower efficiency of this diet to provide adequate nutrients for rapid growth of the pigs. The results obtained from this experiment on feed cost per kilogramme gain have shown that it was more economical to produce a kilogramme of pork using rice by-product to replace 30% of the maize component of the diet.

Carcass data obtained from experiment 8307 are presented in (Table 19). Carcass values were expressed as percent of live weight at slaughter. Warm carcass weight decreased with increased levels of RBP replacing maize fed to the pigs. Differences between treatment means were significant ($P \leq 0.05$) pigs fed the control diet had the highest warm carcass weight while pigs on the 45% maize replacement diet had the least warm carcass weight. Weights of warm carcasses from pigs on 15 and 30% maize replacement diets were similar. The relatively lower carcass yield of pigs fed with maize replacement diets could be tied up with the lower digestibilities of these diets arising from their high fibre contents compared with the control.

Dressing percent warm (Table 19) tended to decrease as the level of RBP in the diets fed to the pigs increased. However, the dressing percent for pigs on the control and the 30% RBP diets were similar. It was probable that the 30% maize replacement RBP level supported better digestibility than the other two lower levels (0 and 15%) respectively.
Dressing percent (chilled) decreased with increased levels of RBP in the diets fed. The decrease in dressing percentages observed in this experiment was due to the influence of fibre contents of the diets. Bohman et al. (1955) and Merkel et al. (1958) reported that the inclusion of fibrous feeds in the diets for pigs increased the percentages of viscera and hence reduced the dressing percentage of the carcasses. In this slaughter experiment, mean weights of viscera (Table 23) increased as the level of RBP replacing maize increased in the diets fed. Thus, the higher weights of viscera of pigs fed RBP diets (Table 23) may have accounted for the observed low dressing percentage of the carcasses. Mean weights of spleen, liver, diaphragm and stomach tended to increase with increasing levels of RBP fed, but differences between treatments were not significant.

Carcass length (Table 19) decreased with increasing levels of rice by-product fed to the finisher pigs. Mean carcass length measurements was highest for pigs fed the control diet and closely followed by carcass length measurements of pigs fed 45% RBP replacing maize diet (74.4cm Vs. 72.2cm) respectively. Carcass length of pigs on the 15% maize replacement diet was (71.4cm) slightly higher than that of pigs fed the 30% maize replacement diet (70.1cm). However, differences between mean carcass length measurements were not significant, and were in agreement with the results of Walker et al. (1968) and Baird et al. (1970).

Percent ham (untrimmed) (Table 19) tended to increase with increased levels of rice by-product fed. Pigs on the control diet gave the lowest % ham (untrimmed) when compared with total ham yield of pigs fed the RBP containing diets. The highest yield of total ham (untrimmed) was from carcasses of pigs fed the 15% maize replacement diet. However, there were no significant differences between treatments for the percent ham yield, trimmed or untrimmed. Boa-Amposem (1973) also reported a non-significant increase in weight of ham for pigs fed high fibre rice bran diets (6.89, 7.82 and 8.9% CF). Much higher fibre levels were fed (Table 17), (4.3, 8.94, 13.59 and 18.23% crude fibre) in this trial. However, earlier report by Sharda et al. (1975) confirmed significant increases in ham weight of pigs fed high fibre diets. Percent ham (trimmed) similarly followed the same trend as percent ham (untrimmed).

Percent loin (untrimmed) did not show any definite trend, so was the observation with % loin (trimmed). Differences between treatments for % loin trimmed and untrimmed were not significantly different. Percent belly (untrimmed) (Table 19) decreased non-significantly with increased levels of RBP in the diets. The control diet produced the highest % belly (untrimmed) closely followed by the 15% RBP replacing maize diet. The least % belly was produced by pigs fed the 45% maize replacement diet. Percent belly (trimmed) also decreased non-significantly as the level of RBP increased. The highest % belly (trimmed) was produced by pigs fed the 15% maize replacement diet, while the least % belly (untrimmed) was produced by pigs fed 45% maize replaced RBP diet.

Percent forequarter (untrimmed) (Table 19) increased with increased levels of RBP in the diets fed to the pigs. Percent forequarter value of the control group was the same as for the 15% maize replacement RBP diet. The highest yield of % forequarter was recorded in the 45% maize replacement RBP diet and was closely followed by that of the 30% maize replacement RBP diet. Differences between treatment means were however, not significant. After the removal of fat plus skin, (trimming) percent forequarter also increased with increased levels of RBP in the diets. The 15% maize replacement diet had the least % forequarter (trimmed) of 19.9 while the 45% maize replacement diet had the highest (22.1%) respectively. Differences between treatment means of % forequarter were not significant.

Percent lean (Table 19) increased as the levels of RBP fed increased. Percent lean of carcasses were 43.5, 44.1, 44.5 and 46.6) for diets containing RBP at 0, 15, 30 and 45% replacing maize respectively. Differences between means of % lean did not reach significant levels. This result was supported by Thrasher et al. (1963) who fed 60 pigs with varied levels of ground ear corn plus 10% bagasse and observed that while backfat thickness was decreased significantly by the earcorn ration, percent lean cut was not improved significantly.

Backfat thickness (Table 20) decreased as the levels of RBP fed to the pigs increased. Carcasses of pigs fed the 45% maize replacement diet had the least backfat, and was the same with backfat thickness of pigs fed the control diet when taken as warm carcass. However, backfat thickness measurements for pigs fed 15 and 30% maize replacement diets were significantly ($P \leq 0.05$) higher than these two. On chilled carcass however,

backfat thickness decreased linearly (P/_0.05) as the level of rice by-product increased in the diet of the pigs. Bistoyong et al. (1968) observed that backfat thickness tended to decrease when growing-fattening pigs were fed rice bran diets. This observation was further confirmed by Babatunde et al. (1975) who fed in addition to the basal diet brewers' dried grains and maize cobs at 5, 10 and 15% levels to pigs reared from about 17 to 92kg and reported a decrease in backfat thickness as the levels of these fibrous feeds increased in the diets. Area of Longissimus dorsi muscle (Table 20) increased with increased levels of RBP replacing maize fed to the pigs. The 15% maize replacement diet produced the best Area of Longissimus dorsi muscle followed by the pigs fed the 45% maize replacement diet. The poorest Area of Longissimus dorsi muscle was obtained frpm pigs fed the control diet. However, differences between means were not significant.

Percent fat plus skin (Table 21) decreased significantly (P/_0.05) with increased levels of RBP replacing maize diets. Percent fat plus skin was lowest for pigs fed the 45% RBP replacing maize diet, while the highest % fat plus skin was produced by pigs fed the control diet. There were no differences between treatment means among the pigs fed RBP containing diets until the 45% level of RBP replacing maize was reached. The lower yield of skin plus fat in the RBP diets was attributed to the fact that these diets contained higher levels of fibre than the control, thus reducing energy (DE) content of the diets so that the pigs were not able to lay down excess fat. This further supported the fact that the pigs on RBP diets were leaner as evidenced by higher percentages of trimmed carcass or % lean. Axelsson and Erickson (1953) had earlier

observed that feeding high fibre level diets to growing-fattening pigs amounted to restricted feeding, thus, causing a reduction in digestible energy and other nutrients which in effect produced leaner carcasses.

When heads of carcasses were severed, and weights (fresh) of all treatment groups were expressed as percent live weight of the finisher pigs, mean values tended to increase with increased levels of RBP fed, except in the 30% RBP diet, which also had the least % head of live weight. Differences between treatments were however, not significant. Percent feet also increased with increasing levels of RBP fed to the pigs, although differences between treatments were also not significant.

On the basis of sex, final weight at slaughter was significantly ($P \leq 0.05$) (Table 22) higher for barrows than gilts. Average daily gain was significantly ($P \leq 0.05$) higher for gilts than barrows. Gilts gained more rapidly and consumed less feed than barrows. This observation was in contrast to that of Hale *et al*. (1968) who reported no sex effect on gains of individually fed pigs. Average daily feed intake for barrows was slightly higher than for gilts although mean differences were not significant. This result is supported by that of Newell and Bowland (1972) who experimented with 48 growing pigs and observed non-significant differences in average daily feed intake between barrows and gilts. In this trial, feed to gain ratios of barrows and gilts showed that gilts were more efficient ($P \leq 0.01$) than barrows in converting feed to gain. This result is supported by those of Bowland and Berg (1959) and Bell (1965). They all reported that females are more efficient in feed utilization than males.

Percent ham yield, untrimmed and trimmed for both barrows and gilts did not show any appreciable differences.

In the present trial, the backfat thickness for gilts was significantly ($P/_ 0.01$) higher than for barrows. However, Ellis et al. (1983) experimenting with growing-finishing barrows and gilts reported that gilt carcasses had less backfat than those of castrates. Total fat plus skin for barrows were higher than total fat plus skin for gilts. This could probably be explained on the basis of higher feed intakes for barrows than gilts which resulted in some of the dietary energy being laid down as fat. In this trial, sex did not influence carcass length, dressing % and the Area of Longissimus dorsi muscles. Young et al. (1968) experimenting with boars, barrows and gilts had earlier reported that sex did not influence carcass length of the pigs when fed with varied levels of energy and protein.

Weights of internal organs and gastro-intestinal measurements are presented in (Table 23). Inspite of the wide differences in fresh weights of organs recorded, differences between mean weights of organs did not attain significant levels. Although length of the small intestine tended to increase with increased RBP levels in the diets, differences between treatment means were not significant. Length measurement of the large intestine, however, decreased as the level of RBP fed increased eventhough differences between treatments were also not significant.

GENERAL SUMMARY

During the 42-day experimental period, cummulative feed intake was significantly ($P \leq 0.05$) better for the pigs fed the 5% level of RBP than for the other two treatments. This result showed that the 5% RBP level which contained (5.10% CF) calculated induced the pigs to consume more feed than the other two treatments. Although average daily feed intake of the 5 and 10% RBP fed pigs were similar, ADF was linearly increased as RBP increased in the diet. In general agreement with results of this study, Baird et al. (1975) reported similar ME intakes when low and high fibre (4 Vs. 8%) diets were fed to growing-finishing pigs, eventhough the pigs consumed slightly more of the high fibre diets. Average daily gain increased with increased levels of RBP fed. The 5% level of RBP inclusion supported the best gain and was significantly ($P \leq 0.05$) better than the other two levels (0 and 10%) RBP fed to the pigs. Feed to gain ratio of the finisher pigs showed significant ($P \leq 0.01$) linear treatment effect of level of feeding RBP. Pigs fed the control diet had the best feed to gain ratio while pigs fed the (5 and 10%) RBP diets tended to consume more feed per unit live weight gain. Thus, efficiency of feed utilization by the pigs tended to decrease with increased levels of rice by-product fed. The results of experiment 8303 suggest that average daily gain was improved when 5% RBP was included in the diet but gain was slightly depressed when higher levels were included. This apparent improvement in daily gain was due primarily to increased feed and DE intakes as there were only slight changes in feed per unit gain at the lower level of feeding RBP.

In the second trial (Experiment 8305), when higher levels of RBP were fed to growing pigs the dry matter intake of pigs decreased ($P \leq 0.01$) with increased levels of RBP fed to the pigs. Dry matter intake by the pigs nearly doubled in all treatments in period 2 of the trial showing a significant period effect ($P \leq 0.01$). Faecal output doubled in period 2 when compared with period 1 values. This increase in faecal output could be due to high content of the less digestible components of RBP (hulls, pentosans, hemi-cellulose and silica). Kornegay (1978) fed soyabean hulls to growing-finishing pigs and attributed increased faecal output of the pigs to the less digestible fractions of the by-product. Apparent dry matter digestibility decreased linearly and there was a significant ($P \leq 0.05$) period effect for levels of RBP fed. Apparent dry matter digestibility was 60% higher in period 2 when compared with apparent dry matter digested by the pigs in period 1. This result was attributed to the fact that dry matter digestibility decreased with increased levels of fibre in the diets fed.

With regards to performance characteristics in this digestibility trial, average daily gain decreased linearly with increased levels of RBP fed ($P \leq 0.05$). However, significant levels were not reached until the 20% level of RBP inclusion in the diets was fed. Daily gains decreased at the higher levels of RBP fed, eventhough average daily feed intake tended to increase. However, DE intake by pigs on all treatments was not different. This suggests some beneficial effect of the RBP at a level of about 10% in the diet which is difficult to explain in the light of decreases in the digestibility of dry matter, energy and nitrogen obtained in this trial. Feed to gain ratio tended to increase as the

level of RBP fed increased. There was a significant (P/0.01) period X treatment effect observed for feed to gain ratios. However, differences between treatment means for both periods only reached significant levels only when the 20% level of RBP was fed.

Nitrogen intake of growing pigs fed graded levels of RBP (0, 10, 20 and 30%) decreased as the levels of RBP increased. Nitrogen intake increased by 15% in period 2 when compared with nitrogen intake of the pigs in period 1. A significant (P/0.05) period effect of level of feeding RBP to the pigs was observed. This significant increase in nitrogen intake of the pigs could be due to the increased level of feeding from 4% body weight to 6% body weight in periods 1 and 2 respectively, coupled with increased nitrogen consumption by the pigs for maintenance and normal growth.

Apparent nitrogen digestibility decreased linearly as the level of RBP fed increased. This result was due to the negative influence of fibre on nitrogen digestibility. Just (1982) experimenting with growing pigs fed varied levels of crude fibre and concluded that high fibre levels have negative effect on nitrogen digestibility due to increased metabolic faecal nitrogen excretion.

Energy intake tended to increase with increased RBP in the diets. Energy intake in period 2 doubled its intake in period 1. This increase in intake of energy was closely associated with increased dry matter intake from 4% body weight to 6% body weight. Pigs fed the RBP diets consumed slightly more energy than pigs fed the control diet. This observation can be attributed to the fact that the RBP containing diets were of lower energy density than the control. Faecal energy output in period 2 increased by 100% over that of period 1. This observation was linked with increased energy

intake in period 2 coupled with increased fibre intake during the same period. Differences between treatments were not significant. Energy digested and energy digestibility coefficient both decreased significantly ($P/0.05$) as the level of RBP increased in the diets. The low apparent energy digestibility might have been due to the effects of high fibre levels on nutrient digestibility, rate of passage and retention time.

Nitrogen-free extract digestibility decreased appreciably as the level of RBP fed increased. This result could be due to the fact that RBP containing diets had more of the less digestible fractions of the by-product. The overall results of nitrogen, crude fibre and ash digestibilities in this trial were in agreement with those reported by Devendra (1975) who fed Malaysian sheep with graded levels of rice husk in molasses-urea diets and observed that dry matter, N.F.E., crude protein, crude fibre and ash digestibilities all decreased with increased levels of rice husk inclusion.

While almost all nutrients digested in this trial decreased with increased levels of RBP fed, ether extract digested, and its digestibility coefficient increased linearly and significantly ($P/0.05$) as the levels of RBP in the diets increased. This result is in agreement with the observations of Brooks and Lumunta (1975) who fed coarse rice bran diets to growing pigs and reported increased digestibility of ether extract as the level of the bran increased in the diets.

Crude fibre intake, increased linearly as the level of RBP increased. Due to its energy diluting effect, diets containing higher levels of RBP which were also lower in energy density were consumed more by the pigs in order to meet their energy requirements. Both faecal fibre and crude

fibre digestibility increased linearly as the level of RBP in the diets increased. Crude fibre digested showed significant period effect and the quantity of crude fibre digested in period 2 was about 100% higher than in period 1. Crude fibre digestibility decreased linearly as the level of RBP inclusion increased in the diets. This result was due to the high fibre content of RBP containing diets which could have reduced the digestibility of other nutrients in addition to the fact that crude fibre in itself may be of no nutritional consequence depending on source and type (Crampton and Harris 1969). In experiment 8305, results of crude fibre digestibility for the 20 and 30% RBP diets (27.2 and 25.7%) respectively were in agreement with the observations of Lloyd et al. (1978) that crude fibre digestibility in the pig ranged from 3 to 25%.

Ash consumption increased linearly with increasing levels of RBP in the diets of the growing pigs and differences between treatments were significant (P/0.05). Faecal ash increased linearly (P/0.05) with increased levels of RBP. Ash digestibility decreased (P/0.05) with increased level of RBP fed, and the control diet was better digested (P/0.05) compared to the rice by-product treatments.

In the third trial, rice mill by-product was fed to growing-finishing pigs and effects of the product on performance and carcass traits are presented in (Tables 18 and 19) respectively. Average daily feed intake increased linearly with increased level of RBP fed. But differences between treatments were not significant. Although pigs were able to increase their feed intake, the DE consumed daily was less on the high fibre diets. The similarity of feed intake in the treatment groups was due to the fact that the increased fibre level in the RBP diets sort of reduced the quantity of

feed consumed and consequently the energy intake as a result of bulk.

Average daily gain decreased linearly (P/0.05) with increased levels of RBP fed to the finisher pigs. However, differences between treatment means only reached significant levels when 30% RBP replacing maize level was fed.

Feed to gain ratio increased linearly (P/0.05) as RBP level replacing maize increased in the diet. This may be because the diets were not iso-nitrogenous as proportional replacement of maize with RBP led to lower protein and energy contents of diets. Other factors that might have caused reduced feed efficiency included low digestibility of the product of NFE fractions consisting largely of pentosans and silica (Campabadal et al. 1976), and the increased crude fibre content of the diets Young et al. 1968). In the slaughter experiment (8307) pigs fed 15 and 30% maize replacement diets produced more economical gains per kilogramme of feed consumed (Table 18) and were slightly better than the control. This trend could be explained by the fact that these high fibre diets contained higher levels of RBP replacing maize, which comparatively was cheaper than the maize component of the control diet. Pigs fed the 30% RBP replacing maize produced the best and most economical gain in the trial.

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On carcass merits, dressing percentages (warm) and (chilled) both tended to decrease with rising levels of RBP replacing maize fed. (Table 19). The apparent decrease in dressing % was due to the fact that the weights of the visceral organs tended to increase generally with increased levels of RBP fed. Carcass length, and Area of Longissimus dorsi were not affected by level of RBP fed. Backfat thickness, however, decreased significantly (P/0.05) as levels of RBP fed increased. Other carcass

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parameters, % forequarters, loin, ham and helley including % lean did not attain significant levels, but % total fat plus skin decreased significantly (P/0.05) as the level of RBP fed to the finisher pigs increased.

On the basis of sex, barrows gained significantly (P/0.01) better than gilts. Feed to gain ratio was significantly (P (P/0.01) higher for barrows than for gilts. Backfat thickness measurements for gilts was significantly (P/0.01) higher for gilts than barrows. However, total yield of fat plus skin was higher for barrows than gilts eventhough differences between treatments were not significant.

From the stand point of economic considerations, rice mill by-product can be fed to young growing pigs at lower levels of 5 to 10% of total diet without adversely affecting growth rate of pigs. However, RBP can replace 30% of the maize in a 15% crude protein diet for growing-finishing pigs. Rice mill by-products can be used to facilitate the production of the much desired lean pork by partially replacing the more costly maize thereby reducing feed cost of pork production by swine farmers.

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APPENDICES

APPENDIX I

AMINO ACID PROFILE OF RICE MILL BY-PRODUCT AND MAIZE USED IN RATION FORMULATION (% AIR DRY BASIS)

AMINO ACID	YELLOW MAIZE	RICE BY-PRODUCT
Alanine	0.72	0.23
Arginine	0.49	0.23
Aspartic acid	0.58	0.31
Cystine	0.51	0.05
Glutamic acid	1.60	0.48
Glycine	0.37	0.19
Histidine	0.39	0.11
Isoleucine	0.31	0.13
Leucine	1.19	0.25
Lysine	0.31	0.14
Methionine	0.15	0.05
Phenylalanine	0.55	0.17
Proline	0.87	0.20
Serine	0.44	0.16
Threonine	0.32	0.15
Tryptophan	0.47	1.09
Valine	0.41	0.19

NAPRI (1983)

APPENDIX 2

PRICES OF INGREDIENTS AT TIME OF EXPERIMENTS 8303, 8305 AND 8307. (JANUARY 1983).

Ingredient	Price per kg (₦)
Yellow maize	0.50
Soyabean meal	0.75
Groundnut cake	0.75
Rice by-product	0.03
Bone meal	0.08
Vegetable oil	1.40
Lysine	12.00
Methionine	12.00
Vitamin Premix (VM502)	13.00
Common salt	0.67

APPENDIX 3

Feed cost per kg gain calculations.

This was arrived at by calculating the total amount of feed consumed per replicate and per treatment group. For example Diet 2 of experiment 8307 feed cost per kg gain was arrived at as follows:

Total feed consumed x % ingredient x unit price of ingredient = Cost of ingredient consumed. Total cost of ingredients consumed divided by total liveweight gained per treatment group, therefore represents feed cost (₦) per kg liveweight gained.

Eg. Replicate 1 of Diet 2 (15% RBP)

Intredient Ingredient	Feed consumed	% ingredient	Unit cost of ingredient	Total
Maize	167.1 kg	X 67.11	.50	56.07
RBP	167.1	X 11.84	.03	.59
G/cake	167.1	X 17.89	.75	22.42
Bone meal	167.1	X 2.0	.08	.27
Salt	167.1	X 0.5	.67	.56
Lysine	167.1	X .26	12.0	5.21
Methionine	167.1	X .26	12.0	5.01
VM502	167.1	X .15	13.0	3.26
Total				93.39

Total gain = 44.05 kg

Unit cost per kg live weight gained = $\frac{93.39}{44.05}$

i.e. ₦2.12 per kilogram live weight gained.

The mean value of all such costs per replicate represents feed cost per kg live weight gained of feed consumed per treatment. Thus mean value for diet 2, 15% RBP diet was ₦2.27 Mean values for the control, 20 and 45% RBP replacing maize diets were ₦2.44, 2.21 and 2.41 respectively.