REPLACEMENT VALUE OF WHEAT OFFALS FOR SORGHUM IN THE DIETS OF GROWING-FINISHING SWINE IN NIGERIA

BY

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DIGITIZED

DECLARATION

I hereby declare the originality of this piece of work which was carried out by me in the Faculty of Agriculture, Ahmadu Bello University, Zaria under the supervision of Dr. T.S.B. Tegbe, Professor J.M. Olomu and Dr. P. Njoku.

The work of other investigators is duly acknowledged and referred to. No part of this thesis has been previously submitted for a degree or diploma.

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THESIS APPROVAL

This thesis by Federico Villarin Santiago meets the regulation governing the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

I deeply dedicate this work to

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ABSTRACT

A 60-day growth trial was conducted using 70 Large White x Landrace (LW x LD) piglets with initial average weight of 11.67 kg and fed diets in which wheat offals replaced sorghum as energy source (weight for weight basis). Pigs were randomly allotted based on sex and weights and treatments assigned to pens. Pigs were fed ad libitum the treatment diets containing wheat offals at 0, 18.75, 37.5, 56.25 and 75% levels. Performance of pigs in terms of feed intake and weight gain were similar. Feed:gain ratio was significantly ($P<0.05$) better in pigs fed 75% wheat offals compared to the control diet. Cost of feed/kg. gain was significantly ($P<0.05$) lowered at every level of replacement of sorghum with wheat offals.

A 30-day finishing trial was conducted using 60 Large White x Landrace (LW x LD) pigs with initial average weight of I4.0.08 kg and fed diets in which wheat offals replaced sorghum as energy source in finishing ration. Pigs were randomly allotted to pens based on sex and initial weight. Treatments were allotted to pens in two replications. Pigs were fed ad-libitum.

Treatment diets in which wheat offals replaced sorghum weight for weight at 0, 20.55,41.10, 61.65 and 82.2% in the diets were tested. Results showed that

feed intake between treatments were similar; but, daily gains of pigs were significantly ($P<0.05$) better on diets containing 20.55, 41.10 and 61.65% wheat offals compared to control diet (0% wheat offal). At 82.2% wheat offals, pigs gained as fast as those in the control diet. Significantly better ($P<0.05$) feed:gain ratio was obtained in pig fed 41.10% wheat offals compared to those fed the control diet. Cost of feed/gain significantly decreased ($P<0.05$) where wheat offals replaced sorghum in the finishing diets.

Carcass of pigs was evaluated at the end of the finishing trial. The dressing percentage and percent shoulder were not significantly different between treatments. However, significantly higher ($P<0.05$) percent ham were obtained in pigs fed 61.65 and 82.2% wheat offals compared to those fed control diet. Significantly longer carcasses were obtained from pigs fed 20 and 82.2% levels of wheat offals compared to those fed the basal ration. Significantly ($P<0.05$) less thick backfat was obtained in carcass of pigs fed various wheat offals diets compared to those fed the control diet.

A digestibility trial was conducted in two periods using twelve pigs with initial average weight of 26.42 kg. Pigs were randomly allocated to metabolism crates

individually and treatment diets randomly allotted to crates. Treatment diets containing wheat offals 0, 15, 30 and 45% levels in the diets (isonitrogenous at 20% C.P.) were fed at 4 percent of body weight in the first adjustment and collection period and at 6% of body weight in the second adjustment and collection period.

Daily feed intake and feed:gain ratio were similar between treatments; however, significantly depressed ($P<0.05$) growth of pigs was observed at 45% wheat offals.

Apparent digestibility of nitrogen, crude protein, nitrogen balance (NB) as % of N consumption and biological value were similar between treatments.

Significantly higher ($P<0.05$) digestibility of ether-extract were observed with increased levels of wheat offals compared to the control diet and was highest at 15 and 30% levels. Apparent crude fibre digestibility was lowest ($P<0.05$) at 30 and 45% wheat offals compared to 0 and 15%.

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ABBREVIATIONS AND SYMBOLS

ADF	-	Average Daily Feed
ADG	-	Average Daily Gain
BV	-	Biological Value
CF	-	Crude Fibre
CP	-	Crude Protein
DE	-	Digestible Energy
DMRT	-	Duncan's Multiple Range Test
EE	-	Ether-Extract
F:G	-	Feed to Gain Ratio
GE	-	Gross Energy
Kcal	-	Kilocalorie
ME	-	Metabolizable Energy
N	-	Nitrogen
NB	-	Nitrogen Balance
NE	-	Net Energy
NFE	-	Nitrogen-Free Extract
Mcal	-	Megacalorie

CHAPTER I

INTRODUCTION

The energy and protein intake of the average Nigerian were estimated at 2,083 Kcal and 54 grams daily respectively. Of the total protein intake, only 8 grams come from animal sources, including fish and game animals (Olayide, 1972). Oyenuga (1974) observed that the average Nigerian is getting only a quarter of the minimum daily requirement of animal protein. Based on the estimate of population increase to 96 million by 1980, he predicted that unless food and livestock production is improved, a serious and widening gap would exist between food and protein needs and production. By 1980, he recommended that energy and total protein intake should increase to 2,500 Kcal and 65 - 70 grams protein should come from animal sources. He further stressed the need to close the protein gap by 1990.

Loosli and Oyenuga (1963) estimated that there were 28 cattle, 14 sheep, 38 goats, and 1 pig per 100 Nigerians. These figures are nearly comparable to animal and human population ratios in Europe, yet the consumption of protein is 5 grams for Nigerians and 40 grams for Europeans. Loosli and Blake (1974) pointed out that the limited supply of animal protein in the tropical countries is primarily more a result of low productivity rather than of small numbers of animals. As a consequence, low supplies of meat, milk and eggs in relation to demand tend to raise the price of

animal products beyond the purchasing power of the bulk of the population (Oyenuga, 1974).

Several factors have been identified by different authors to be responsible for the low productivity of livestock in the tropics. Some of these factors are diseases, high heat and humidity, poor genetic potential of the animals, lack of training and experience of the local people in animal husbandry, and poor feeding and management practices (Loosli and Blake, 1973; Oyenuga, 1973; Babatunde, 1975; Balogun, 1979).

The Pig Industry in Nigeria

Balogun (1979) expressed grave concern over the low level of swine production in relation to other livestock. He noted that pig production is given little attention and thus had remained stagnant over the years. The over-all contribution of pork to the national meat supply is low. He asserted that if self-sufficiency in meat production is to be attained, pigs along with other farm animals must be given better attention.

Fabunmi (1980) stated that during the twelve-year period, 1968 to 1979, the number of pigs slaughtered reached a peak of 81,000 in 1974, but, precipitously declined to 70,000 in 1975 and to a further low of 57,000 in 1976. From then on, there was only an annual increase of 1,000 pigs each year for 1977, 1978 and 1979. She further emphasized

that Nigeria will be a net importer of livestock products for many years to come, unless drastic effort is made to accelerate livestock production.

This bleak trend and uncertain prospect of the pig industry to be an effective contributor to the total meat supply of the country, may be more of a direct result of the perennial short supply and high cost of feedstuffs, especially grains. This is best exemplified by the predicament of the feedmilling industry. Jakonda (1975) observed that only 2 million tons of grains are left for livestock, manufacturing and others, out of a total output of 7.5 million tons for that year (1975). Fabunmi (1980) stated that compound feed for monogastric animals is in short supply even though the existing feedmills have an installed milling-capacity of over 600,000 metric tons which is adequate to manufacture compound feeds to meet the needs of the country. The mills are under-utilized due to scarcity of raw materials like maize, fishmeal and vitamin - mineral premixes. This is a dangerous situation. She further added that the experience of 1979 is still fresh in our minds when certain government decision on maize resulted in a shortage of feed, high cost of what is available, farmers selling-off stocks prematurely and even temporary shortage of eggs and escalated cost of production.

The Compelling Need for Replacing Grains in the Feed of Pigs in Nigeria

The major predicament of the pig industry in Nigeria is recurrent shortage and high cost of feedstuffs, especially grains. Pigs being monogastric animals have dietary requirements similar to man. Their requirement for energy is generally derived from an important human staple food - cereal grains, which make up 80% of their diets. Presently in Nigeria, there is great competition existing between the livestock industry and humans for the limited cereal grains. Obviously, the demand by the human population is first met and the amount available to the livestock industry is probably less than 10% of the available cereal grains. The only solution is the use of unconventional feedstuffs such as agro-industrial by-products in the livestock rations.

According to Goodwin (1974) feed accounts for 75 - 80% of the total cost in swine production - 60% for breeding and 80% for fattening pigs. Viewed from this economic standpoint, the challenge facing the industry would seem formidable indeed. Any attempt to arrest the decline in pork production and resuscitate the industry to an economically viable and profitable venture, would require drastic and unconventional approaches aimed at solving the problem of swine feeding

and nutrition in Nigeria. The compelling need is to reduce, if not remove the reliance and dependence on conventional feedstuffs like maize or sorghum as primary energy source in pig diets.

As Fetuga (1977) aptly suggested, alternative sources of energy in compounding the feed must have to be explored using locally available materials. However, he added, that dearth of information of nutrient requirement, as well as, nutrient levels, including those on extent of utilization and processing requirements at any particular environment is the key factor preventing use of local materials for compound rations.

In Nigeria, one of the agro-industrial by-products of good prospect and importance in the manufacture of livestock feeds is wheat offals. It is a by-product of the flour-mill industry which has since expanded operations and had increased in number. Wheat offals is cheap and abundant. It could offer a major alternative energy source - partially or wholly - for pigs intended for the market.

The objective of this study is to evaluate the replacement value of wheat offals for sorghum in the diets of growing-finishing pigs, as well as its effects carcass characteristics and nutrient utilization.

CHAPTER II

LITERATURE REVIEW

Wheat Bran as Livestock Feed

Wheat by-products are distinguished by their fibre content - a currently accepted method. Wheat bran contains more than 9.5% crude fibre; middling or mill-run, maximum of 9.5%; shorts, gray shorts, gray middlings or flour middlings, 7%; red dog, white shorts, or white middlings, 4% and feed flour, 1.5% (Pond and Maner, 1974).

Wheat offals are residues left after milling. The extraction rate of flour obtained from wheat varies; but generally around 70%, leaving 30% offals which are usually in the ratio of 2 parts middlings to one part bran - i.e. the outer coat. (Goodwin, 1974, Martin and Leonard, 1967; Nelson, 1978).

The nutrient composition of wheat bran from different sources is presented in Appendix VI.

Most studies reported in the literature evaluated wheat bran as a source of fibre in the diet of livestock. however, Pond and Maner (1974) observed that wheat bran is palatable and has a laxative effect. According to them, its amino acid balance is superior to that of whole wheat but inferior to that of most protein supplement. Wheat bran could therefore be considered as energy source for swine.

Wheat bran has a relative feeding value of 75 compared to yellow corn which is considered the base feed with a value of 100. On the other hand, sorghum compared to yellow corn has a value which varies between 85 to 95% and can replace corn entirely. The superiority of yellow corn and sorghum is undoubtedly due to their high energy content, low fibre content of kernel and the high digestibility of its starch (Pond and Maner, 1974).

Wheat middling consist of bran, germ + little of red dog. They are appreciably more digestible than wheat bran and have 77.21lbs TDN/100lbs in comparison to 66.01lbs in bran - thus middling supplies 15% more TDN (Morrison, 1961).

Wheat bran has unique nutritional properties. Its light, bulky mature; its 16% of high quality protein (a chemical score equal to that of beef muscle) and its high phosphorus content; give bran a unique place in livestock feeding. About 40% of the wheat germ is in the bran which account for its high quality protein. None of the other wheat milling by-products - shorts, middling, feed flour - have any of the special properties of wheat bran. They are basal feeds useful largely in proportion to their energy and nutrient values (Crampton and Harris, 1969).

Utilization of Fibre by the Pigs

Woodman and Evans (1947) remarked that the pig is less able to use crude fibre than other farm livestock because of its simple stomach of relatively small capacity which is in contrast with complex stomach of cattle and sheep and the large caecum of the horses where a great deal of microbial activity break down a large part of crude fibre consumed. Thus the pig is limited in the amount of crude fibre it can use in the diet.

There is however, no agreement as to how much crude fibre pigs can use (Axelsson and Eriksson, 1953). This lack of agreement is probably due to difference in source of fibre fed, level of fib in the diet, level of other nutrients in the diet, plane of nutrition, age and weight of the pigs, character of the non-fibrous part of the diet, as well as other factors (Cunha, 1977). Teague and Hanson (1954) observed that the heavier the pigs, the more fibre it can use in the diet.

One of the reasons for the use of fiber in the diet of pigs is the assumption that it helps facilitate the passage of residue through the digestive tract and the level considered to be adequate for this purpose are 2 and 5%. (Cunha, 1977).

Farrel and Johnson (1970) showed that some cellulose is digested by the pigs. They estimated the volatile fatty acids (VFA) produced and obsorbed from caccum and colon of pigs in diets containing 8 and 26% cellulose to be 1.9 and 2.7% of the apparent digestible energy respectively came from the acids. However, they cited Friend, Cunningham and Nicholson (1964) who suggested that 15 to 28% of the maintenance energy requirement of a 30kg. pig could be contributed from VFA absorbed from the alimentary tract. Keys and Debarthe (1974) stated that most of the cellulose digestion occurs in the large intestines of the pigs. The end products of microbial digestion of the cellulose in the alimentary tract of the pigs are mainly the steam-volatile fatty acids which are produced in and absorbed from the caecum and the colon (Farrel and Johnson, 1970). Baker et. al. (1965) showed that cellulose added to the diet in the concentration of up to 60% causes a linear decrease in average daily gain, average non-cellulose feed intake and gain per unit of non-cellulose feed intake. Farrel (1973) showed that the pig was able to digest 53% of the dry matter on all-alfalfa diet.

Cunha (1977) stated that in breeding stock, diets for sow can contain more fibre than those for growing-finishing pigs. Many scientists agree on 10 - 12% fibre ... of high quality alfalfa meal and oats.

Cunha (1977), further stated that the use of high fibre levels will also tend to prevent sow from becoming too fat, a condition that can lead to poor results in reproduction.

There is disagreement as to what level of fibre should be recommended for growing-finishing pigs (15 kg. up) when no effort is made to add extra energy to compensate for the higher level in the diet. However, some researchers agree on a figure of 5 - 6% fibre as the maximum level to include in the diet. Cunha (1977) suggested 6 - 8% fibre in the diets of pigs. Of considerable importance in determining the fibre level to use is the quality of the fibrous feeds. Higher quality alfalfa meal and oats can be tolerated at higher levels than corn cob meal, poor quality roughage and other fillers which might be used. This means that any increase in fibre levels allowed in swine diets depends on the quality of fibrous feeds and the level of energy in the diet (Cunha, 1977). Crampton and Harris (1969) observed that amount of fibre and of available energy of basal feeds are negatively correlated.

Higher levels of fibre in swine diets have been used during the latter part of the finishing period ... to reduce backfat deposition and improve carcass quality. According to Cunha (1977) the introduction of higher

crude-fibre-content feeds in the U.S. during the latter part of the finishing period (by self-feeding the animals) was to produce hogs with more meat and less fat.

Crampton (1954) observed that lean meat production could be achieved by the use of nutrient adequate ration about 65 - 70% TDN, instead of 75 - 80% TDN content. According to him, 45kg pigs could then be self-fed to the finished weight of 90kg and still yield an acceptably lean carcasses. He further stated that suitable low energy rations are prepared in North America either by selection of feeds naturally low in energy concentration, or by dilution of fattening ration with high fibre feeds such as alfalfa or wheat bran.

As Braude (1963) observed, the major incentive for the inclusion of high fibre feeds especially in the ration of finishing pigs is the need to produce lean pigs to meet consumer preference. The present trend of pork preference is toward lean meat. Pig fat is very costly to produce and not competitive with other fats abundantly available in the market. According to him, production methods must be geared towards the production of lean pigs, and the animals slaughtered before they start laying down fat.

The effects of including wheat bran in non-ruminants diets has been studied by several workers. In human beings

by Cowgill and Anderson (1932), Fantus and Frankl (1941), Olmsted et. al. (1935); in laboratory animals by Bell (1960); and in swine by Sheehy, (1935) and Cooper and Tyler, (1959). The growth-simulating action which was observed in some studies, was associated with increased rate of passage of ingesta. The laxative nature of wheat bran has been attributed to various factors, foremost among which is the ability of the bran to absorb and hold large quantities of water at all stages of digestion. In this respect, peristalsis appears to be stimulated by increased ingesta volume. Sheehy (1935) regarded wheat bran as a valuable feed ingredient for the establishment of optimum mechanical condition in the digestive tract because of its favourable influence on the activity of the lower gut and by promoting rapid digestion of the diet in the stomach. The flaky nature of bran was believed to alter the physical condition of the ingesta, thus making it more favourable to enzymatic action.

Fantus and Frankl (1941) suggested that bran residues stimulate bacterial action in the lower gut with the resultant increase in production of volatile fatty acids and gases. Both products are believed to stimulate peristalsis and hence, facilitate faecal elimination. Cooper and Tyler (1959) observed extensive gas production as a result of feeding rations containing bran to swine.

Utilization of Wheat Bran by Laboratory Animals

Bell (1960) made a comparative study of fibrous feed-stuffs in weanling mice. Wheat bran along with wheat straw, alfalfa, oat hulls, beet pulp, corn cobs and cellulose were added to basal diets at levels of 8, 16, 24 and 32% and it was found that wheat bran in comparison with other feedstuffs resulted in no reduction in gains at these levels. He also noted increased feed intakes as levels of energy declined in the diets.

In a corollary experiment, Bell (1960) tested the effects on growth rates of the various fibrous feeds when incorporated at predetermined graded levels of digestible energy per unit weight of feed. He showed that there were marked differences between bulk additives. At 2.2 and 2.4 DE cal/gr. levels of energy, mice failed to survive on wheat straw, did poorly on best pulp and cellulose ration; but, gained at about 70% of the normal rates on wheat bran and on oat hull rations. He also observed that wheat bran passed through the gastro-intestinal tract most rapidly. Those with the slowest rates of passage were found to have the smallest apparent volume when wet; were less capable of swelling in water and occupied less space per unit weight of the stomach, and retained their physical forms or volumes throughout digestion. Wheat bran has the outstanding single exception which permitted good growth

at a faecal volume of 200 and a stomach volume of 550 ml. per 100 gram dry matter fed.

Utilization of Wheat Bran by Poultry

In India, several workers have adopted unconventional approaches in formulating chick diets with the use of wheat bran-groundnut cake as major components of the ration - Wheat bran had been studied as major energy source, and groundnut cake as major protein source. Efforts have been made to improve further on the performance of the chicks by various processing methods like autoclaving, pelleting or by addition of fat and lard to elevate energy content of rations or by addition of higher levels of fishmeal and addition of essential amino acids lysine or methionine.

Qazi and Netke (1975) conducted experiments to improve the nutritive value of unprocessed wheat bran in a wheat bran-groundnut cake basal ration for chicks. The proportion used was 55.8% wheat bran to 39.66% groundnut cake. Wheat bran was either atoclaved, milled and milled and autoclaved or with addition of DCP to the diets. They found that autoclaving wheat bran at 0.35 kg/cm^2 for 2 minutes significantly increased weight gains, improved nitrogen and energy retention but only in one out of three experiments. Milling variously autoclaved wheat bran was not helpful.

Also, the beneficial effects due to processing of wheat bran could not be detected even when such diets were supplemented with di-calcium phosphate, lard or meat meal.

Hete et. al. (1975) also conducted experiments using wheat bran-groundnut cake basal diet (56.4% wheat bran and 40% groundnut cake) supplemented with energy (addition of lard and starch). Lysine and methionine or various levels of fishmeal were added to the diets. They found that increasing caloric density of the diet by supplementing with fat did not improve the weight gain. On the contrary, it depressed the protein intake of the chicks, which correspondingly depressed gains. Supplementation of the diet with 2% fat plus lysine and methionine improved gain to a limited extent, indicating that lysine and methionine were deficient in the diet. Supplementing the basal diet with 2% lard and 5% fishmeal gave maximum growth rate.

Utilization of Wheat Bran by Growing Pigs

Hochstetler et. al. (1959) in experiment with growing pigs (under 45kg) fed wheat bran 0, 20 or 40% of the diet. They reported significantly slower rate of growth at the 40% level compared to those given a basal ration without bran. Feed efficiency was also significantly poorer in pigs fed 20 and 40% wheat bran diets.

Dhudapker et. al. (1971), however, fed growing pigs (11.8kg to 70kg) diets containing 0, 23, or 43% wheat bran and observed no significant differences in feed consumed and feed utilization. All animals in the treatments reached 70kg at 126 days of feeding and gained 460 grams daily.

Ranjhan et. al. (1971) studied the replacement value of wheat bran in the rations of growing pigs (15-45kg). Wheat bran was at 10%, 40, 60 or 70½ of the basal diet. They reported that rate of growth was depressed at 60 and 70% wheat bran. Feed to gain ratio, was however, not significantly affected. Feed consumption significantly dropped at 60 and 70% levels.

Ranjhan et. al. (1972) fed growing pigs 30% wheat bran in a basal ration (33Mcal/kg. DE; 20% CP) against 60% wheat bran (28Mcal/kg. DE 20% CP) and found a significant reduction in daily gain in weight and feed: gain ratio in pigs fed 60% level of wheat bran. No significant difference was observed in daily feed and the number of days taken to attain 50kg. live weight.

Neufville et. al. (1973) found that wheat bran fed to pigs (33.9 - 100kg) at 39% of the diet decreased daily gain of growing-finishing pigs. There was a consistent decrease in feed efficiency which was, however, not significant.

Babatunde et. al. (1976) fed growing pigs (25.56kg) with graded levels (0, 5, 10 or 15) of wheat offals and groundnut shells and found no significant difference in rate of gain and in feed: again ratio in wheat offals diets.

Sharda et. al. (1977) reported an average daily gain of 458 and 424 grams respectively, in growing pigs fed diets containing wheat bran at 5 or 25% levels. The difference in weight grain was significant but the respective feed to gain ratio of 3.63 and 3.57 were, however, not significantly different.

In a similar study, Sharda et. al. (1979) observed a significantly depressed growth rate in growing pigs (13.8kg.) fed 25% wheat bran. Also gain to feed ratio was significantly lower for growing pigs fed 25% wheat bran in the diet than at 5% level.

Hines (1980) studied the effects of fiber sources on weaned pigs performance (11.5kg) at fixed crude fibre contents of 3.9% against 2.2% crude fibreeof basal ration and found that at 21.2% level of wheat bran, average daily gain, feed consumption, feed to gain ratio were not significantly different compared to a basal ration.

Utilization of Wheat Bran by Finishing Pigs

Hochstetler et. al. (1959) obtained a significant decrease in rate of gain and in feed efficiency in pigs (from 45kg) fed a ration containing 40% wheat bran than those fed at 0 and 20% levels.

Ranjhan et. al.(1972) showed that pigs of 50 - 70kg weight fed 60% wheat offals in the diet compensate for the initial set-back during the growing period and gained as fast as those given the basal ration containing 30% wheat bran. Pigs fed 72 and 83% wheat offals in the diet showed significant depression in their growth rate. Feed efficiency was significantly depressed at 60, 72 and 83% levels. For Finishing pigs weighing between 70 to 90kg average daily gains and feed efficiency were also significantly depressed at 72 and 83% levels of wheat bran in the diet. They observed that feed efficiency was uneconomical when the pigs reached 90kg than when they were at 50kg or 70kg. They also observed no significant differences in feed intakes.

Babatunde et. al. (1976) studied the effects of feeding finishing pigs (45 - 92kg) 0, 5, 10, 15% levels of wheat offals in the diet and did not obtain significant differences in growth parameters (daily gain, feed intakes and feed efficiency).

Sharda et. al. (1979) found that the inclusion of 37.5% wheat bran in the ration did not adversely affect both the average daily gain and gain to feed ratio when fed to finishing pigs (50kg.) compared to those fed 7.5% wheat bran in the diet.

Hines (1980) showed that pigs of weight 60 - 98kg fed finishing diets containing 40% wheat bran had significantly slower rate of growth and lower feed efficiency compared to pigs given basal rations, while those fed diets containing 10 and 20% wheat bran were the most efficient in feed utilization.

Hines (1980) fed various levels of wheat bran (0, 5, 10, 15 and 20%) in a milo-soybean diet, and found no significant differences in average daily gain in weight of finishing pigs; but feed utilization was 4% more efficient for pigs fed 10 or 15% wheat bran than those given the basal diet without bran. He also found that wheat bran costing more than milo would not merit its use in swine finishing ration.

Effects of Wheat Bran on Carcass Quality of Pigs

Hochstetler et. al. (1959) feeding different levels of (0, 20 and 40%) wheat bran to pigs found significantly less backfat, lower percentage fat trim, larger lean and primal cuts and lower dressing percentage in pigs fed 40% wheat bran. There was also significantly more fill in

large intestines of pigs fed 40% wheat bran compared to pigs given basal ration, or 20% wheat bran. No differences were observed in weights of stomach, small intestines, empty large intestines, carcass length and loin eye area in all the pigs.

Ranjihan et. al. (1972) observed a significant reduction in backfat of pigs fed levels of 60, 72 and 83% wheat bran compared to 30%. There was also a significant increase in percentage lean.

Neufville et. al. (1973) also observed that only dressing per cent was significantly decreased at 39% level of wheat bran in the diet compared to pigs fed 0, 7.5, 19.5 and 27%; other parameters were not significantly affected. There was however, a tendency towards increase in percentage lean cuts and thinner backfat as level of dietary wheat bran increased.

However, Babatunde et. al. (1976) feeding graded levels of 5, 10, and 15% wheat offals to pigs observed no significant influence on pig carcass quality. A aignificant increase in gut weights was reported for pigs given ration containing 15% wheat bran.

Sharda et. al. (1977) observed that pigs fed 37.5% level of wheat bran compared to pigs fed 7.5% showed no significant difference in carcass length and dressing

percentage. However, backfat was significantly reduced; lean cut %, ham + loin and loin eye area were much larger. Fat trim was reduced and lean trim increased. Weights of belly, spare ribs, and jowls were not influenced by dietary treatment. The carcass of pigs fed the 37.5% dietary wheat bran were reportedly brighter, less firm and had less marbling than that of pigs fed 7.5% wheat bran.

Nutrient Utilization of Various Levels of Wheat Bran by Pigs

The utilization of nutrients in different diets containing wheat bran has been reported by several workers. Ranjihan et. al. (1971) in a digestibility trial using rations containing 10, 40, 60 and 70% wheat bran in the diets observed that dry matter and nitrogen-free extract digestibility decreased significantly at 60 and 70% levels. They observed significant differences among treatment means for crude protein, crude fibre, and ether-extract digestibility. Nitrogen retention was significantly less at 60 and 70% levels and calcium retention significantly higher at 10 and 40 than in 60 and 70% levels.

Similarly, Dhudapker et. al. (1971) in a digestibility trial, fed rations containing 0, 23 and 43% wheat bran to pigs and observed that digestibility of dry matter and nitrogen-free extract were much higher in diet without wheat bran compared to 23 and 43% wheat bran. Crude fibre digestibility was significantly higher at 43% level and

ether-extract lower in diet without wheat bran. Nitrogen and energy intake were lower for the control diet and the utilization of nitrogen and energy were significantly better for diets with 23 and 43% wheat bran.

Ranjhan et al. (1972) reported that crude protein and dry matter digestibility were significantly depressed at levels 72 and 83% wheat bran in the diets; crude fibre digestibility was quite high at 60, 72 and 83% levels; ether-extract was significantly higher at 72 and 83% levels.

Babatunde et al (1976) studied the apparent digestibility and retention of nutrients by pigs fed 0, 5, 10, and 15% wheat offals in the diet. They found no significant differences in the digestibility of dry matter, crude protein, nitrogen-free extract and energy. However, there was a significant depression of crude fibre digestibility at 15% level. Crude fibre was best digested at 5% level. However, ether-extract was significantly depressed with 15% wheat offal in the diet, and nitrogen retention at this level was lowest.

In digestibility trials using two levels of wheat bran (7.5 and 37.5%), Sharda et al. (1979) found no significant difference in the digestibility of crude protein, ether-extract, nitrogen-free extract and dry matter. The digestibility of crude fibre was significantly higher in pigs fed 37.5% wheat bran.

CHAPTER III

EXPERIMENTAL PROCEDURE

General Objective

This research was designed to study the effects of wheat offals in the diets on the performance and carcass characteristics of pigs. The performance of pigs was evaluated in terms of gain, feed intake and efficiency of feed utilization. The effects of feeding graded levels of wheat offals on nutrient digestion and utilization were also studied. Wheat offals replaced sorghum in the diets on weight for weight basis in experiments 1 and 2; and at fixed ratio in experiment 3.

General Procedure

The research was conducted at the Agricultural Complex of the Ahmadu Bello University, Zaria. The units comprising the Agricultural Complex are the Faculty of Agriculture, Meat Laboratory, Samaru College of Agriculture, University Far, National Animal Production Research Institute (NAPRI) and the Institute for Agricultural Research. The study was divided into three (experiments 1, 2, and 3).

Experiments 1 and 2 were conducted at the Piggery Farm of the Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria. The piggery farm has twenty-two concrete pens each

measuring 5m x 4.5m and provided with waterers and feeders. Carcass evaluation was conducted at the Animal Products Laboratory of the Department of Animal Science.

The digestibility trial, Experiment 3, was carried out in the metabolism house located at the University Farm, Ahmadu Bello University. The metabolism house is equipped with twelve metal crates. Each crate measuring 71.5cm x 131.5cm has slatted metal floor and is provided with feed and water trough. Directly below the crate is a metal sheet with perforations to catch faecal excretions, below which is another metal funnel (71.5cm x 131.5cm) to collect urine in a bucket. Waste feeds were collected and placed on a newspaper to dry.

Proximate chemical analyses of experimental diets, feed ingredients, faecal and urine samples were conducted at the Biochemistry Laboratory of the National Animal Production Research Institute. Statistical analysis of data were done at the Computer Centre of the Institute of Agricultural Research.

Experimental Animals

A total of one hundred and thirty (130) (Landrace x Large White) pigs were used for experiment 1 and 2. Before being put to experiments, all pigs were earmarked, dewormed with piperazine wormer - 17 (5 grams piperazine base equivalent to 17% W/V piperazine). Pigs were treated for mange and lice with Tic-Tac and all male pigs were castrated

All the experimental pigs were fed a commercial grower's ration (Liverstock Feeds, Pfizer Kaduna) and allowed unlimited access to clean water prior to being put on the experiment. The pigs were weighed before being assigned to treatments and thereafter were weighed every two weeks.

Twelve (12) pigs (Landrace x Large White) used for the digestibility trial (Experiment 3) were obtained from the National Animal Production Research Institute, Shika.

Feeding Regimen

In experiments 1 and 2, pigs were fed ad-libitum and had free access to water. Feeds consumed were measured every two weeks and all pigs weighed every two weeks. In experiment 3, pigs were fed at 4% of body weight daily during the first adjustment and collection period and 6% of body weight daily during the second adjustment and collection period. Each daily feed allotment was divided into two: one-half offered at 8:00 a.m. and the other half at 4:00 p.m. Refused feed were oven-dried at 52°C and allowed to cool down to room temperature and the weight recorded.

Experimental Procedures

Experiment 1: The Replacement Value of Wheat Offals for Sorghum in Grower Pigs Diet

Purpose:

The experiment was designed to investigate whether wheat offals can adequately and economically replace

sorghum as a major energy source in grower pigs diets. Performance of pigs was monitored in terms of average daily gain (ADG), average daily feed intake (ADF), Feed: gain ratio (F:G ratio), cost of feed/kg weight gain, digestible energy (DE) consumed and DE:gain ratio.

Procedure:

Seventy (70) crossbred (Landrance x Large White) barrows and gilts with an initial average weight of 11.67 kgs. were randomly allocated on the basis of sex and weight to pens. Treatments were randomly assigned to pens in two replications of seven pigs per pen. The pigs were fed ad-libitum and water available throughout the experimental period. Feeds consumed and weights of pigs were measured every two weeks in a 60-day feeding trial. The experimental diet (Appendix I.a.) fed throughout the trial period were:

a. A 19% crude protein basal diet in which sorghum was the sole energy source.

b. Wheat offals replaced 25% of the sorghum in the basal diet and constituted 18.75% of the rations; while sorghum was 56.25%.

c. Wheat offals replaced 50% of the sorghum in the basal diet and was 37.5% of the diet; while sorghum was also 37.5%

d. Wheat offals replaced 75% of the sorghum in the basal diet and was 56.25% of the diet; while sorghum was 18.75%.

e. Wheat offals replaced all of the sorghum in the basal diet and was 75% of the diet.

Experiment 2: The Replacement Value of Wheat Offals for Sorghum on Performance and Carcass Characteristics of Finishing Pigs.

Purpose

Sixty (60) crossbred (Landrance x Large White) barrows and gilts with an initial average weight of 40kg. were randomly alloted on the basis of sex and weights to pens. Treatments were randomly assigned to pens in two replications of six pigs per pen. Pigs had unlimited access to experimental diets and water. Feeds consumed and weight of pigs were measured every two weeks in a 30-day trial period. The experimental diets (Appendix 11.a.) were as follows:

a. A 16% crude protein basal ration in which sorghum was the major source of energy in the diet and devoid of wheat offals.

b. Wheat offals replaced 25% of the sorghum in the basal diet and constitutes 20.55% of the diet; while sorghum was 61.65%.

c. Wheat offals replaced 50% of the sorghum in the basal diet and was 41.10% of the diet: Sorghum was 41.10% of the diet.

d. Wheat offals replaced 75% of the sorghum in the basal diet and was 61.65% of the diet, while sorghum was 20.55%.

e. 100% by weight of the sorghum in the basal ration was replaced by wheat offals and was 82.2% of the diet.

Carcass Study:

This aspect of the trial evaluated the effects of feeding wheat offals on carcass quality of finisher pigs, in terms of dressing percent, backfat thickness, carcass length, loin eye area, % ham and % shoulder.

Fifty (50) crossbred barrows and gilts out of the 60 pigs used in the finishing study, with average live weights of 63.80 kg. (5 pigs for each replicate of each treatment group) were selected for carcass evaluation. Pigs were slaughtered and carcasses chilled for 24 hours at a temperature of 2 - 4°C before carcass quality parameters were measured, according to Argoñosa (1972), as follows:

1. Carcass length was measured in centimetres from the anterior edge of the aitchbone to the forward edge of the first rib.

2. Backfat thickness was measured at three different points of the left side of the carcass - at the first rib, the last rib last lumbar vertebra level. The mean of the three measurements was taken as the backfat thickness in centimeters.

3. Loin eye area is the area in square centimeters of the cross-section of the longissiumus dorsi muscle at the tenth rib level. After cutting the loin between the tenth and eleventh ribs, the muscle area was carefully traced on an acetate paper and area determined by using a planimeter.

4. Ham weights - the ham was separated from the loin and side by a cut made 4-5cm. anterior to the aitchbone and perpendicular to the hindlegs. To obtain % of ham, the weight of the ham was divided by the chilled carcass weight and multiplied by 100.

5. Shoulder weight - the shoulder was separated from the loin and side by a cut between the second and third rib and perpendicular to the topline. To

obtain % of shoulder, shoulder weight was divided by the chilled carcass weight and multiplied by 100.

6. Dressing percentage is the weight of the chilled carcass divided by the live-weight of the pigs at slaughter multiplied by 100. Pigs were not fasted prior to slaughter.

Experiment 3: The Digestibility and Utilization Nutrients of Wheat Offals Diets by Young Pigs.

Purpose

The aim of the experiment was to determine the digestibility and utilization of nutrients of wheat offals diets by young pigs. Apparent digestibilities were determined for dry matter, energy, nitrogen, crude protein, crude ether-extract, crude fibre, and nitrogen-free-extract; including biological values.

Procedure

Twelve pigs with an initial average weight of 26.43 kg. were randomly allotted invdividually to four treatment groups of 3 replicates. Dietary treatments were randomly alloted to pens. Pigs were kept in metabolism crates and fed the experimental diets containing 0, 15, 30 and 45% wheat offals at 4% and 6% of the

body weights during the first and second periods respectively. Each period (Period I and Period II) consisted of a 7-day adjustment period followed by a 7-day collection period. Pigs were weighed at the beginning and at the end of each of the adjustment and collection periods. The pigs were fed twice daily - one-half of the ration at 8:00 a.m. and the other half at 4:00 p.m. Ration was fed dry and water supplied to the pigs as needed. Refused feeds were collected and weighed each day and pooled for each of the 7-day collection periods. Total collection of faeces and urine was done during the two collection periods.

Faeces were collected and weighed twice daily after the morning and evenings feedings. Faecal collection for each day was pooled for the 7-day collection period and put in the freezer. The urine was collected for the 7-day period in buckets containing 25ml. of toluence and 25ml. of concentrated HCl. A 10% aliquot solution of urine was taken at the end of each collection period and kept in the freezer for later analyses.

Chemical Analysis

Experimental diets, faecal samples and feed ingredients were analyzed for dry matter, nitrogen, crude fibre and ether-extract according to AOAC (1970) Urine also analysed for nitrogen according to AOAC (1970).

Gross energy values of diets, feed ingredients and faccal samples were obtained with the Parr Adiabatic Bomb Calorimeter.

Statistical Analysis:

Data were subjected to statistical analysis procedures explained by Cochran and Snedecor (1967). Analysis of variance procedures as well as Duncan's Multiple Range (DMRT) analysis were followed collectively or separately as the case may be (Cochran and Cox, 1957).

CHAPTER IV

RESULTS

Experiment 1:

Table 1 is a summary of the performance of growing pigs in terms of average daily gains (ADG), average daily feed intake (ADF), Feed:gain (F:G) ratio, feed cost per kilogram gain in weight, Digestible energy (DE) consumed and digestible energy:gain ratio (DE: Gain) in a 60-day trial period.

Pigs fed treatment diets containing 18.75, 37.5, 56.25 and 75% levels of wheat offals respectively gained as much as those fed the control diet. No significant differences was also observed among the treatment means for feed intakes. Calculated DE intakes among treatment means were also the same.

In terms of feed:gain ratio (F:G) results showed that the treatment means of pigs fed 75% wheat offals was significantly better ($P<0.05$) than those of the basal diet. In terms of DE: gain ratio, significantly less ($P<0.05$) digestible energy was required to gain a kg, weight for pigs fed 75%, wheat offals compared to pigs fed the control diet and those fed 56.25%, 37.5% and 18.75% wheat offals diets. Also, pigs fed 56.25% wheat offals had a significantly ($P<0.05$) better DE:gain ratio compared to those fed the control diet and 18.75%, but similar to those fed 37.5% level.

In terms of feed cost per unit gain in weight, 75% level of wheat offals was significantly cheaper than the basal ration and other wheat offals in the diet ($P<0.05$). Cost of feed per unit gain in weight s significantly ($P<0.05$) decreased as levels of wheat offals were increased in the diets. The most expensive diet per unit weight gain was the control ration.

Table 1. Experiment 1. Average Daily Gain, Average Daily Feed, Feed:Gain Ratio, DE:Gain Ratio, DE Consumed, Feed Cost/Gain.

Rep	Level of Wheat Offals, % 0%	18.75%	37.5%	56.25%	75%	Mean	S.E.
			Total Average Gain in Weight, kg				
I	22.80	21.60	26.40	24.00	29.40	24.84	
II	18.60	25.60	35.80	25.20	25.20	24.24	
Ave.	20.70	23.10	26.10	24.60	27.30	24.54	±2.94
			Average Daily Gain in Weight, g				
I	380.0	360.0	440.0	400.0	490.0	414.0	
II	310.0	440.0	430.0	420.0	420.0	404.0	
Ave.	345.0	400.0	435.0	410.0	455.0	409.0	±28.90

Row means with different superscripts are significantly different ($P<0.05$)

Table 1 (continued)

Rep	Level of Wheat Offals, % 0%	18.75%	37.5%	56.25%	75%	Mean	S.E
	Total Average Gain in Weight, kg						
I	60.00	54.00	64.20	64.80	66.00	61.80	
II	51.60	61.80	65.40	59.40	57.00	59.04	
Ave.	55.80	57.90	64.80	62.10	61.50	60.42	±4.9
	Average Daily Feed Intake, g						
I	1000.0	900.0	1070.0	1080.0	1100.0	1030.0	
II	860.0	1050.0	1090.0	990.0	950.0	984.0	
Ave.	930.0	965.0	1080.0	1045.0	1025.0	1007.0	±58.
	Feed: Gain Ratio						
I	2.63	2.50	2.43	2.70	2.24	2.50	
II	2.77	2.34	2.53	2.35	2.26	2.45	
Ave.	2.70^{a}	2.42^{ab}	2.48^{ab}	2.53^{ab}	2.25^{b}	2.48	±0.0

Row means with different superscripts are significantly different ($P<0.05$).

Table 1 (continued)

Rep	Level of Wheat Offals, % 0%	18.75	37.5%	56.25	75%	Mean	S.E.
	Feed cost per kg. Gain in Weight (₦)						
I	0.97	0.80	0.66	0.58	0.36	0.67	
II	1.02	0.75	0.72	0.50	0.36	0.67	
Ave.	1.00[a]	0.78[b]	0.69[b]	0.54[c]	0.36[d]	0.67	±0.03
	Daily Digestible Energy Consumption, Mcal						
I	3.40	2.91	3.27	3.13	2.80	3.10	
II	2.90	3.33	3.33	2.87	2.59	3.10	
Ave.	3.16	3.12	3.30	3.16	3.00	2.79	±0.16
	DE: Gain Ratio, Mcal/kg. Gain						
I	8.89	8.13	7.43	7.22	6.12	7.56	
II	9.42	7.59	7.70	6.86	6.21	7.56	
Ave.	9.16[a]	7.86[b]	7.57[bc]	7.04[c]	6.17[d]	7.56	±0.20

Row means with different superscripts are significantly different ($P<0.05$)

Experiment 2: Effects of Various Levels of Wheat Offals on Performance of Finishing Pigs

Table 2 gives the summary of the performance of finishing pigs in terms of average daily gain (ADG), average daily feed intake (ADF) digestible energy consumed (DE), DE:gain ratio and cost of feed per kg. gain in weight.

Pigs fed wheat offals at 20.55, 41.10 and 61.65% of the diet showed significantly faster rates of gain than those in the control diets ($P<0.05$). Pigs of the control diet had similar rate of gain as those fed 82.2% wheat offals. No significant difference was observed between treatments for feed intake. But, in terms of DE intake, it was noted that pigs fed 20.55% wheat offals had significantly higher ($P<0.05$) DE intake than those fed 41.10, 69.65 and 82.2% levels and similar to those in the control diet. At 41.1% wheat offal, DE intake was similar to those fed the control diet and those at 69.65 and 82.2% wheat offal diet.

Feed:gain ratio of the pigs fed 41.10% wheat offals was significantly better than those of the control ration ($P<0.05$) but was similar to those fed the other wheat offal diets. The pigs fed the control diet significantly ate more to gain a unit weight ($P<0.05$); but were also similar to those that were fed 20.55, 69.65 and 82.2% wheat offals in the diets. In terms of DE/kg.

gain in weight, treatment means of pigs showed that all those fed different levels of wheat offals significantly consumed less digestible energy per unit weight gain ($P<0.05$).

In terms of feed cost/unit gain in weight, treatment means of pigs showed that it significantly ($P<0.05$) cost less to gain a unit weight as level of wheat offals was increased in the diets compared to the basal ration. The cost of feed/unit output of the product was significantly cheapest when wheat offals was included in diet at 82.2% and this was similar to those fed 69.65% wheat offals. The most expensive were those at the control diets ($P<0.05$).

Table 2. Experiment 2. Average Daily Gain, Average Daily Feed, Feed:Gain Ratio, DE:Gain Ratio, DE Consumed, Feed Cost/Gain

Rep	Level of Wheat Offals, % 0%	20.55%	41.10%	61.65%	82.2%	Mean	S.E.
			Total Average Gain Weight, kg.				
I	20.40	30.30	26.40	27.00	27.90	26.40	
II	22.20	27.00	30.30	29.70	22.50	26.34	
Ave.	21.30	28.65	28.35	28.35	25.20	26.37	±3.55
			Average Daily Gain Weight, g.				
I	680.0	1000.0	880.0	900.0	930.0	880.0	
II	740.0	900.0	1010.0	900.0	750.0	878.0	
Ave.	710.0^{b}	855.0^{a}	945.0^{a}	945.0^{a}	840.0^{ab}	879.0	±60.4
			Total Average Feed Consumed, kg.				
I	80.10	83.40	75.00	75.90	75.30	77.94	
II	69.90	80.70	71.40	75.90	64.80	72.54	
Ave.	75.00	82.05	73.20	75.90	70.05	75.24	±5.51

Row means with different superscripts are significantly different ($P<0.05$).

Table 2. (continued)

Rep	Level of Wheat Offals, % 0%	20.55%	41.10%	69.65%	82.2%	Mean	S.E.
			Average Daily Feed Consumed				
I	2670.0	2780.0	2500.0	2530.0	2510.0	2598.0	
II	2330.0	2690.0	2380.0	2530.0	2100.0	2418.0	
Ave.	2500.0	2735.0	2440.0	2530.0	2335.0	2508.0	±114.14
			Feed: Gain Ratio (As Fed Basis)				
I	3.92	2.75	2.84	2.81	2.69	3.00	
II	3.14	2.99	2.36	2.56	2.88	2.79	
Ave.	3.53^{a}	2.87^{ab}	2.60^{b}	2.69^{ab}	2.79^{ab}	2.89	±0.22
			Cost of Feed per kg. Gain in Weight, ₦				
I	1.32	9.77	0.58	0.44	0.30	0.68	
II	1.06	0.84	0.52	0.42	0.31	0.63	
Ave.	1.19^{a}	0.51^{b}	0.55^{c}	0.43^{cd}	0.31^{d}	0.66	±.06

Row means with different superscripts are significantly different ($P<0.05$)

Table 2 (continued)

Rep	Level of Wheat Offals, %						
	Daily Digestible Energy Consumption, Mcal						
I	8.93	8.78	7.44	7.06	6.53	7.75	
II	7.79	8.50	7.08	7.06	5.62	7.21	
Ave.	8.36^{ab}	8.64^{a}	7.26^{bc}	7.06^{c}	6.08^{c}	7.48	±0.34
	DE: Gain Ratio, Mcal/Kg. Gain						
I	13.13	8.70	8.45	7.84	7.02	9.03	
II	10.53	9.44	7.01	7.13	7.50	8.32	
Ave.	11.83^{a}	9.07^{b}	7.73^{b}	7.49^{b}	7.26^{b}	8.68	±0.71

Row means with different superscripts are significantly different ($P<0.05$).

Summary of carcass evaluation data (Experiment 2) is presented in Table 3. The addition of various levels of wheat offals did not affect the dressing percentage significantly. However, it appeared there was a slightly better dressing percentage for carcasses of pigs fed the control diets than those fed various levels of wheat offals.

Significantly ($P<0.05$) longer carcasses were obtained from pigs fed 20.55, and 82.2% levels of wheat offals than those of the control ration; but were similar to those fed 41.10 and 61.65% wheat offals in the ration. Pigs fed the control ration had the shortest carcass length among the treatments ($P<0.05$).

The backfat thickness of pigs fed the control ration was significantly higher compared to all those fed various levels of wheat offals in the diet ($P<0.05$). Pigs fed wheat offal diets had less backfat and thickness decreased with increasing levels of wheat offals in the diet, but the decreases were not significant between treatments.

For loin eye area, pigs fed the basal ration, and those fed 61.65% and 82.2% had significantly larger loin eye area ($P<0.05$) than those fed 41.10% wheat offals; but were similar to those fed 20.55% levels.

Significantly higher ($P<0.05$) ham percent were obtained in pigs fed 82.2% and 61.65% wheat offals compared to those

fed the control diet. However, % ham for the control pigs was similar to those fed 20.55 and 41.10% wheat offals. The percent ham of carcasses of pigs fed the control diet, although similar to those of pigs fed 20.55 and 41.10 wheat offal, was relatively smaller.

In terms of percent shoulder, treatment means of pigs were smaller. However, there was a non-significant trend for higher percent shoulder in all carcasses fed various levels of wheat offals than those of the control diet.

Table 3: Experiment 2. Carcass Evaluation of Pigs Fed Different Levels of Wheat Offals

Rep	Level of Wheat Offals, % 0%	20.55%	41.10%	61.65%	82.2%	Mean	S.E.
			Carcass Weights, kg				
I	41.36	40.73	40.50	41.18	42.09	41.47	
II	43.82	41.41	37.95	39.23	38.04	40.09	
Ave.	42.59	41.07	39.22	40.21	40.70	40.63	±1.29
			Dressing Percent, %				
I	64.99	59.08	63.64	64.64	65.76	63.62	
II	72.85	62.64	61.47	61.50	61.24	63.92	±2.61
Ave.	68.92	60.81	62.56	63.07	63.50	63.77	
			Carcass Length, cm.				
I	73.40	77.20	76.70	76.55	78.05	76.38	
II	76.10	78.00	75.60	77.70	77.20	76.92	
Ave.	74.75^{b}	77.60^{a}	76.15^{ab}	77.12^{ab}	77.62^{a}	76.65	±0.75
			Backfat Thickness, cm.				
I	3.10	2.24	2.40	1.98	2.23	2.39	
II	2.61	2.28	2.10	2.11	1.82	2.18	
Ave.	2.86^{a}	2.26^{b}	2.25^{b}	2.05^{b}	2.02^{b}	2.29	±0.27

Row means with different superscripts are significantly different ($P<0.05$)

Table 3 (continued)

Rep	Level of Wheat Offals, % 0%	20.55%	41.10%	61.65%	82.2%	Mean	S.E.
	Loin Eye Area (LEA), sq. cm						
I	22.43	17.91	17.42	22.42	21.03	20.24	
II	21.22	18.28	15.30	18.77	19.92	18.70	
Ave.	21.82[a]	18.10[ab]	16.30[b]	20.59[a]	20.48[a]	19.47	±1.02
	Ham Weights (Percent of Chilled Carcass), %						
I	21.42	23.28	22.02	24.09	23.71	23.70	
II	16.80	24.73	24.87	25.44	26.39	23.65	
Ave.	19.11[b]	24.01[ab]	23.44[ab]	24.77[a]	25.05[a]	23.68	±1.42
	Shoulder Weights (Percent of Chilled Carcass), %						
I	13.68	14.53	13.63	15.19	13.97	14.20	
II	13.26	15.55	16.39	15.91	16.30	15.48	
Ave.	13.47	15.04	15.01	15.55	15.14	14.84	±0.86

Row means with different superscripts are significantly different ($P<0.05$).

Experiment 3: Nutrient Utilization by Pigs Fed Various Levels of Wheat Offals.

Table 4 summarizes data on average daily gain (ADG), average daily feed (ADF), Feed: gain (F:G) ratio on as - fed and dry matter (DM) basis, for the combined period.

In the combined period, pigs fed 45% wheat offals significantly gained less ($P<0.05$) than the control pigs. However, gain of the pigs fed 45% wheat offal was similar to those fed 15 and 30% wheat offals. Rate of gain of those on the control diet was the fastest; but was similar to those on 15 and 30% levels.

The average daily feed intake (ADF), DM intake and F:G ratio were similar for all the treatments. There is however, a general tendency for lower ADF for pigs as levels of wheat offals increased in the diets: and a general tendency for poorer feed efficiency as levels of the wheat offal increased in the diets.

Faecal DM (Table 5.1) was significantly higher ($P<0.05$) for pigs fed 45% wheat offals than the control and those fed 15% levels in period I. In period II, treatment means were similar for all the treatments. In the combined period, treatment mean for faecal DM of pigs fed 45% wheat offals was again significantly higher than both the control and 15% level ($P<0.05$). At 30% level of wheat offals, treatment mean was the same with all the treatments.

The amount of dry matter digested was not significantly different between treatments in period I and II and in the combined periods.

Treatment means of apparent dry matter digestibility coefficient in period I was significantly smaller for pigs fed 45% wheat offals than those at 0 and 15% ($P<0.05$). At 30% level, DM digestibility was similar to all the other treatments. Highest digestibility of the dry matter was observed at the control diets, followed by those at 15% wheat offals. There was a trend of decreasing digestibility as wheat offals increased in the ration. During the second period treatment means were similar for all the treatments. For the combined periods, the trend observed was similar to that observed in period I. The lowest digestibility of DM was obtained in pigs fed 45% wheat offals than those of the control and 15% level. At 30% level, treatment mean was the same with all the other treatments. There was a general tendency for lower DM digestibility as levels for wheat offals increased in the diets.

Table 4: Experiment 3. Average Gaily Gain, Average Daily Feed, Feed: Gain Ratio.

Items	Level of Wheat Offals, % 0%	15%	30%	45%	Mean	S.E.
Total Ave.Gain in Weight, kg.	6.21	5.54	5.55	4.89	5.55	±0.54
Ave. Daily Gain, g.	888.0[a]	791.8[ab]	792.7[ab]	697.7[b]	792.0	±48.50
Ave. Daily Feed Consumed, g.	1673.4	1620.0	1593.4	1566.9	1613.3	±62.23
Feed:Gain Ratio (as fed basis)	1.87	2.00	1.98	2.26	2.03	±0.15
Feed:Gain Ratio (DM basis)	1.67	1.84	1.82	2.09	1.86	±0.14

Row means with different superscripts are significantly different(P<.05)

Table 5:1. Experiment 3 - Digestibility of Dry Matter of Wheat Offal Diets by Pigs.

Period	Level of Wheat Offals, % 0%	15%	30%	45%	Mean	S.E.
	Ave. Daily Dry Matter Consumption, g.					
I	993.3	1010.0	976.7	1000.0	995.0	±52.00
II	1990.0	1983.3	1970.0	1893.3	1959.2	±100.81
Ave.	1491.7	1496.7	1473.4	1446.7	1477.1	±56.73
	Ave. Daily Faecal Dry Matter, g					
I	158.3^{b}	184.7^{b}	208.3^{ab}	262.0^{a}	203.3	±16.58
II	388.3	385.0	462.3	467.3	425.5	±35.53
Ave.	273.3^{b}	284.9^{b}	334.8^{ab}	364.7^{a}	314.4	±19.60
	Ave. Daily Dry Matter Digested, g					
I	835.0	825.3	768.3	738.0	791.1	±52.92
II	1000.0	1600.0	1443.3	1427.7	1542.5	±111.45
Ave.	1217.5	1212.7	1155.8	1082.9	1167.1	±61.68
	Apparent Dry Matter Digestibility, %					
I	83.72^{a}	81.68^{a}	78.70^{ab}	73.78^{b}	79.47	±1.79
II	80.01	80.57	77.98	75.33	78.47	±2.03
Ave.	81.87^{a}	81.12^{a}	78.34^{ab}	74.55^{b}	78.97	±1.35

Row means with different superscripts are significantly different (P<0.05).

Table 5.2. summarizes data on energy utilization by pigs fed a control diet and those fed 15, 30 and 45% wheat offals in the diets.

In terms of gross energy intake, treatment means of pigs fed 0, 15, 30 and 45% wheat offals were not significantly different from each other, during period I and II and at the combined periods. There was, however, a relatively lower gross energy intakes at 30 and 45% levels of wheat offals.

Treatment mean of faecal energy from pigs fed the 45% wheat offals was significantly greater ($P<0.05$) during period I compared to those fed the control diet and 15% wheat offals. At 30% level, faecal energy was not different from those of other treatments. In period II, treatment means of faecal energy were similar for all the treatments. In the combined period, as in period I, energy lost in the faeces was significantly higher at 45% wheat offals ($P<0.05$) compared to those of the control and those at 15% level of wheat offals. At 30% level, faecal energy was similar to all the other treatments.

The digestible energy during periods I and II and combined periods, were similar on all the treatments.

In period I, digestibility coefficients for energy of pigs fed 45% level of wheat offals was significantly lower

than those of the control and 15% wheat offals ($P<0.05$). At 30% level, energy digestibility was similar to those of the other treatments. There was a decreasing apparent digestibility of energy as wheat offals was increased in the diets during period I. In period II, apparent energy digestibility were similar for pigs fed the various diets.

In the combined periods, treatment mean of pigs fed 45% wheat offals was significantly lower than those of the control and 15% level of wheat offals ($P<0.05$). The highest apparent energy digestibility was observed for the control diet. There was a general tendency for decreased apparent energy digestibility coefficient with increasing wheat offals in the diets.

In terms of digestible energy:gain ratio (DE:gain) treatments means in period I and II and at the combined periods did not show any significant differences.

Table 5.2 Experiment 3. Energy Digestibility of Wheat Offal Diets by Pigs.

Period	Level of Wheat Offals, % 0%	15%	30%	45%	Means	S.E.
			Daily Gross Energy Intake, Mcal			
I	4.10	4.25	3.96	4.14	4.11	±0.21
II	8.35	8.30	8.47	7.94	8.27	±0.43
Ave.	6.22	6.28	6.22	6.04	6.19	±0.24
			Faecal Gross Energy, Mcal			
I	0.69^{b}	0.80^{b}	0.89^{ab}	1.12^{a}	0.88	±0.07
II	1.67	1.61	1.82	1.95	1.76	±0.12
Ave.	1.18^{b}	1.21^{b}	1.36^{ab}	1.54^{a}	1.32	±0.07
			Energy Digested, Mcal			
I	3.42	3.45	3.06	3.01	3.24	±0.22
II	6.68	6.69	6.65	5.99	6.50	±0.47
Ave.	5.05	5.07	4.86	4.50	4.87	±0.26
			Apparent Energy Digestibility, %			
I	82.83^{a}	81.24^{a}	77.45^{ab}	72.84	78.59	±1.85
II	97.49	80.57	78.42	75.47	78.49	±2.08
Ave.	81.16^{a}	80.91^{a}	77.94^{ab}	74.16^{b}	78.54	±1.39
			Digestible Energy:Gain Ratio			
I	4.55	5.00	4.29	5.37	4.80	±0.46
II	6.73	7.51	7.69	7.56	7.37	±0.76
Ave.	5.64	6.26	5.99	6.47	6.09	±0.44

Row means with different superscripts are significantly different ($P \leq 0.05$).

Table 5.3. shows the results of nitrogen utilization by pigs fed graded levels of wheat offals in the diet. In periods I and II and in the combined periods, treatment means for nitrogen consumption, faecal nitrogen, nitrogen digested and apparent nitrogen digestibility were not significantly different from each other, and were not to any degree affected by wheat offals in the diet.

Likewise, treatment means of urinary nitrogen, nitrogen balance (NB), NB as % of nitrogen consumed and NB as % of nitrogen digested (Table 5.4) were not significantly different from each other in period I and II and for the combined periods.

Table 5.5 summarizes the data on crude protein utilization by pigs fed 0, 15, 30 and 45% wheat offals in the diets. The treatment means for crude protein consumed, faecal rude protein, crude protein, digested and apparent crude protein digestibility were all not significantly different from one another, in periods I and II and in the combined periods.

Table 5.3. Experiment 3. Nitrogen Digestibility of Wh. + Offal Diets by Young Pig

Period	Level of Wheat Offals, % 0%	15%	30%	45%	Mean	S.E.
			Ave. Daily Nitrogen Consumption, g			
I	35.83	33.40	36.77	38.10	36.02	±1.69
II	76.10	73.23	78.27	69.47	74.27	±3.75
Ave.	55.97	53.32	57.52	53.79	55.15	±2.06
			Ave. Daily Faecal Nitrogen, g			
I	5.90	4.14	6.47	7.57	6.52	±0.62
II	13.62	12.95	14.14	14.61	13.83	±0.84
Ave.	9.76	9.55	10.31	11.09	10.18	±0.53
			Ave. Daily Nitrogen Digested, g			
I	30.11	27.24	30.29	30.53	29.54	±1.81
II	62.48	60.29	64.16	54.86	60.43	±4.04
Ave.	46.30	43.77	47.20	42.70	44.99	±2.21
			Apparent Nitrogen Digestibility, %			
I	83.16	81.53	82.41	80.12	81.81	±1.98
II	81.82	82.26	81.78	78.96	81.21	±1.61
Ave.	82.49	81.90	82.10	79.54	81.51	±1.28

Row means with different superscripts are significantly different ($P<0.05$).

Table 5.4. Experiment 3. Nitrogen Balance[1], NB as % of N Consumption[2] and Biological Value[3] of Wheat Offal Diets by Pigs.

Period	Levels of Wheat Offals, % 0%	15%	30%	45%	Means	S.E.
			Ave. Daily Urinary Nitrogen, g			
I	8.90	8.62	7.86	7.19	8.14	±1.10
II	12.76	16.71	14.00	11.29	13.69	±2.96
Ave.	10.83	12.67	10.93	9.24	10.92	±1.58
			Ave. Daily Nitrogen Balance (NB), g			
I	21.00	18.62	22.43	23.33	21.34	±1.55
II	49.71	43.57	50.10	43.57	46.74	±3.17
Ave.	35.36	31.10	36.27	33.45	34.00	±1.76
			NB as % of Consumption			
I	58.31	55.50	61.30	61.30	59.12	±3.12
II	65.23	59.48	64.08	63.02	62.95	±3.26
Ave.	61.77	57.49	62.72	62.16	61.03	±2.25
			NB as % of N Digested (Biological Value)			
I	70.03	60.00	74.53	76.53	72.27	±3.29
II	79.78	72.33	78.49	79.79	77.60	±4.26
Ave.	74.91	70.17	76.51	78.16	74.90	±2.69

Row means with different superscripts are significantly different ($P<0.05$).

1. Nitrogen intake less faecal and urinary nitrogen
2. Nitrogen balance as % of nitrogen consumed = NPU (Net Protein Utilization).
3. Nitrogen balance as a percentage of nitrogen consumed less faecal nitrogen.

Table 5.5. Experiment 3. Crude Protein Digestibility of Wheat Offal Diets by Pigs

Period	Levels of Wheat Offals, % 0%	15%	30%	45%	Mean	S.E.
			Ave. Daily Crude Protein Consumption, g			
I		198.3	221.7	225.7	213.1	±11.90
II	414.7	416.7	447.0	393.3	417.9	±21.50
Ave.	310.7	307.5	334.4	309.1	315.5	±12.29
			Ave. Daily Faecal Crude Protein, g			
I	37.0	38.3	40.7	47.7	40.9	±3.25
II	85.3	81.3	88.7	91.3	86.7	±5.40
Ave.	61.2	59.8	64.7	69.5	63.8	±3.54
			Ave. Daily Crude Protein Digested, g			
I	169.7	160.0	181.0	178.0	172.2	±12.42
II	329.3	335.3	358.3	302.0	331.2	±23.27
Ave.	247.5	247.7	269.7	240.0	251.2	±13.20
			Apparent Crude Protein Digestibility, %			
I	81.73	80.58	81.60	78.89	80.70	±2.09
II	79.05	80.42	80.00	76.77	79.06	±1.85
Ave.	80.39	80.50	80.80	77.83	79.88	±1.39

Row means with different superscripts are significantly different ($P<0.05$).

Table 5.6. is the summary of data obtained from results of ether-extract utilization by pigs fed wheat offals diets.

In period I, treatment means of ether-extract consumption were not significantly different from each other. In period II, however, significantly more ether-extract ($P<0.05$) was consumed by pigs fed level of 30% wheat offals than those the control diet ; but was not different from the others. Treatment mean of the control diet showed the lowest intake of ether-extract, but was similar to those on 15% level of wheat offals. Those fed 30% level consumed significantly more ($P<0.05$) ether-extract compared to those fed 0, and 15% but, similar to those fed 45% wheat offals. Ether-extract consumed at 15% wheat offal was similar to those fed the control diet and 45% level of wheat offals. The peak of ether-extract consumed was therefore obtained at 30% level of wheat offals in period II and the combined periods and the lowest were those fed the control diet.

Treatment means of faecal ether-extract in the periods I and II and the combined period did not show significant differences between treatments.

Treatment means of ether-extract digested in the period I showed no significant difference between the treatments. However, in period II, significantly more

ether-extract was digested (P<0.05) by pigs at 30 and 45% levels of wheat offals than those in the control, but were similar to those at 15% level. In the combined periods, all the treatment means of those fed 15, 30 and 45% wheat offals were significantly higher than those of the control diet (P<0.05).

In terms of apparent ether-extract digestibility, in period I, treatment means did not show any significant differences between each other. During the second period, ether-extract digestibility improved significantly (P<0.05) with the addition of wheat offals. For the combined period, treatment means of pigs fed 15 and 30% levels of wheat offals was significantly better (P<0.05) compared to the control. Ether-extract digestibility of the control diet was however, similar to that of 45% wheat offal diet.

Table 5.6. Experiment 3. Ether-Extract Digestibility of Wheat Offal Diets by Pigs

Period	Level of Wheat Offals, % 0%	15%	30%	45%	Means	S.E.
	Ave. Daily Ether-Extract Consumption, g					
I	52.3	54.7	57.3	57.3	55.6	±2.89
II	104.7^{b}	114.7^{ab}	135.0^{a}	123.3^{ab}	119.3	±6.12
Ave.	78.5^{c}	84.7^{bc}	96.2^{a}	90.7^{ab}	87.5	±3.36
	Ave. Daily Faecal Ether-Extract, g					
I	20.3	17.0	17.7	21.3	19.1	±2.04
II	37.7	31.7	34.3	35.3	34.7	±2.04
Ave.	29.0	24.4	26.0	28.3	26.9	±1.58
	Ave. Daily Ether-Extract Digested, g					
I	32.0	37.7	39.7	36.7	26.5	±2.89
II	67.0^{b}	83.0^{ab}	100.7^{a}	88.0^{a}	84.7	±5.77
Ave.	49.5^{b}	60.4^{a}	70.2^{a}	62.4^{a}	60.6	±3.24
	Apparent Ether-Extract Digestibility, %					
I	60.63	68.70	69.49	63.20	65.50	±3.94
II	63.56^{b}	72.42^{a}	74.57^{a}	71.30^{a}	70.46	±2.31
Ave.	62.10^{b}	70.56^{a}	72.03^{a}	67.25^{ab}	67.98	±2.29

Row means with different superscripts are significantly different ($P<0.05$).

Table 5.7. summarizes the data on crude fibre utilization by pigs fed 0, 15, 30 and 45% wheat offals in the diets, in terms of crude fibre consumption, faecal crude fibre, crude fibre digested and apparent crude fibre digestibility.

Crude fibre consumption data in period I show that treatment means of pigs fed 45% was significantly higher than those at 15 and 30 and those of the control diet ($P<0.05$). Treatment means of those at 15 and 30% were also significantly different from those fed at the control diet ($P<0.05$). Crude fibre consumption increased significantly as levels of wheat offals increased in the diet. In period II, more pronounced differences were obtained. Crude fibre consumption increased significantly with increasing levels of wheat offals in the diet. Treatment means of pigs fed 45% wheat offals in the diet was significantly higher ($P<0.05$) than either those at 30%, 15% on control diet. For the combined period, similar trend as in period II was observed. Pigs fed 45% wheat offals consumed significantly higher ($P<0.05$) crude fibre than either those at 30, 15 or the control diets. Those fed 30% wheat offals consumed significantly higher ($P<0.05$) crude fibre than those fed 15% on the control diets and those at the 15% were significantly higher ($P<0.05$) than the control diet.

Faecal crude fibre data show that during period I pigs fed 45% wheat offals excreted significantly higher ($P<0.05$) crude fibre compared to other treatments. Similarly, those fed 30% wheat offal were significantly different ($P<0.05$) from either 15% or the control diet. For the combined periods, pigs fed 45% wheat offals excreted more crude fibre compared to pigs in other treatments. There was an increase in faecal crude fibre as levels of wheat offals increased in the diets.

In terms of crude fibre digested, treatment means of pigs in period I showed that there were no significant differences between treatments. Similar amount of crude fibre was digested by pigs on all the treatments. However, during period II pigs fed 45% wheat offals significantly ($P<0.05$) digested more of the crude fibre than those on the control diet but was similar to those fed 15 and 30% wheat offals diets. For the combined periods, pigs fed 45% wheat offals diet digested more ($P<0.05$) than those fed the control and 15% wheat offal diet, but was similar to those fed 30%.

In terms of apparent crude fibre digestibility, in period I treatment means of pigs fed the 45% wheat offals showed significantly lower digestibility ($P<0.05$) of the crude fibre than either those fed the control or 15% wheat offals diets; but was similar to those fed 30% level.

Those fed the control diet had the highest crude fibre digestibility. No significant differences between treatments were observed during period II. For the combined periods, treatment means of pigs fed 45 and 30% wheat offals were significantly lower ($P<0.05$) than those fed the control diet or 15% level of wheat offals.

Table 5.7. Experiment 3. Crude Fibre Digestibility of Wheat Offal Diets by Pigs.

Period	Level of Wheat Offals, % 0%	15%	30%	45%	Mean	S.E.
	Ave. Daily Crude Fibre Consumption, g					
I	36.0^{c}	49.0^{b}	55.0^{b}	71.3^{a}	53.3	±2.89
II	72.3^{d}	92.3^{c}	122.0^{b}	142.0^{a}	107.2	±5.00
Ave.	55.2^{d}	70.7^{c}	88.5^{b}	107.2^{a}	80.3	±2.91
	Ave. Daily Faecal Crude Fibre, g					
I	14.7^{d}	24.0^{c}	32.0^{b}	45.7^{a}	29.1	±1.34
II	36.0^{b}	43.3^{b}	66.3^{a}	78.7^{a}	56.2	±2.88
Ave.	25.5^{d}	33.6^{c}	49.2^{b}	62.2^{a}	42.2	±1.59
	Ave. Daily Crude Fibre Digested, g					
I	24.7^{a}	25.0^{a}	23.0^{a}	25.7^{a}	24.6	±2.89
II	36.0^{b}	48.7^{ab}	55.7^{ab}	66.7^{a}	51.8	±4.59
Ave.	30.4^{c}	36.9^{bc}	39.40^{b}	46.2	38.2	±2.62
	Apparent Crude Fibre Digestibility					
I	63.95^{a}	50.69^{b}	41.57^{bc}	35.97^{c}	48.04	±3.23
II	48.32	52.88	45.41	47.00	48.65	±3.26
Ave.	56.64^{a}	51.79^{a}	43.49^{b}	41.49^{b}	48.65	±2.30

Row means with different superscripts are significantly different ($P<0.05$).

Table 5.8 shows the data on the utilization of the nitrogen-free extract (NFE) of pigs fed a control diet (0% wheat offals), 15, 30 and 45% wheat offals in the diets.

There were no significant differences among treatment means for NFE consumption during period I. In period II however, pigs fed the 45% wheat offals consumed significantly less ($P<0.05$) NFE than those of the control diet; but were similar to those fed diets containing 15 and 30% wheat offals. The highest NFE consumption was for pigs fed the control diet, but this was not significantly different from those fed 15 and 30% of wheat offals. In the combined periods, as it was in period II treatment mean of pigs fed 45% wheat offals was significantly lower ($P<0.05$) compared to those fed the control diet and 15% wheat offals but was similar to that of pigs fed 30%.

In period I, treatment mean of faccal NFE of pigs fed 45% wheat offals was significantly more ($P<0.05$) than those on control and 15% wheat offals diet; but, was similar to those fed 30% wheat offals. In period II, however, no significant difference was observed between treatments for faecal NFE. Likewise, no significant differences were observed among treatments for faecal NFE for the combined periods, although pigs on wheat offal diets excreted more NFE in the faeces compared to control pigs.

During the first period pigs fed 45% wheat offal digested a significantly less ($P<0.05$) amount of NFE than those on the control diet; but was similar to those fed 15 and 30% levels. The amount of NFE digested was not significantly different between treatments in period II, although less NFE was digested with increasing level of wheat offals in the diets. This was also the trend for the combined periods.

In terms of apparent NFE digestibility coefficient in period I, treatment means of pigs fed 45% level of wheat was significantly lower ($P<0.05$) than those fed the control and 15% wheat offal diets; but was similar to those of pigs fed 30% wheat Offals. During the second period, no significant differences were observed between the treatments. For the combined periods, treatment mean of pigs fed 45% level of wheat offals was significantly lower ($P<0.05$) than those of the control or 15% levels; but, was similar to those fed 30% wheat offals.

Table 5.8. Experiment 3. Nitrogen-Free Extract Digestibility of Wheat Offals Diets by Pigs

Period	Level of Wheat Offal, % 0%	15%	30%	45%	Mean	S.E.
	Ave. Daily Nitrogen-Free Extract Consumption, g					
I	632.7	635.3	572.0	559.3	599.8	±31.62
II	1294.0^{a}	1212.7^{ab}	1121.3^{ab}	1038.4^{b}	1156.0	±59.41
Ave.	963.4^{a}	924.0^{a}	846.7^{ab}	798.8^{b}	878.3	±33.65
	Ave. Daily Faecal NFE, g					
I	58.7^{b}	75.3^{b}	85.3^{ab}	107.7^{a}	81.7	±8.42
II	176.7	171.3	179.7	181.1	177.2	±4.30
Ave.	117.7	123.3	132.5	152.2	131.4	±10.99
	Ave. Daily NFE Digested, g					
I	574.0^{a}	559.0^{ab}	487.0^{ab}	451.7^{b}	517.9	±31.82
II	1077.3	1041.3	941.7	841.7	975.5	±71.15
Ave.	825.7	800.2	714.4	646.7	764.7	±38.98
	Apparent NFE Digestibility, %					
I	90.47^{a}	88.17^{ab}	85.13^{bc}	80.73^{c}	86.12	±1.36
II	85.38	85.97	83.87	81.05	84.08	±2.15
Ave.	87.93^{a}	87.02^{a}	84.50^{ab}	80.91^{b}	85.09	±1.27

Row means with different superscripts are significantly different ($P<.05$).

CHAPTER V

GENERAL DISCUSSION

In experiment 1, wheat offals substituted for sorghum in the diets of growing pigs. Feed intakes and gains of pigs fed diets in which wheat offals replaced sorghum at the rate of 0, 25, 50, 75 and 100% on weight for weight basis were similar to those of pigs fed the control diet (Table 1). There was an apparent tendency for pigs to eat more and gain more weights on the diets containing wheat offals. For instance, the percentage increase of feed intake over the control diets were 4.3, 16.13, 11.83 and 9.68 percent more for diets containing wheat offals at levels of 18.75, 37.5, 56.25 and 75% respectively. The calculated mean digestible energy (DE) intakes of pigs on all treatments also showed no significant differences and that DE was not the critical factor even at the highest level of wheat offals in growing pigs diet. The increased feed and DE intakes of the rations containing wheat offals although insignificant maybe attributed to homeostatic mechanism in pigs to compensate and equate the low-energy density of the diets (Merkel, 1958; Axelsson and Eriksson, 1953).

With regards to increasing feed intakes to compensate for low energy density of the diets, results suggest that there is a limit to which growing pigs fed ad lib. could continue to eat more of a bulky ration, as indicated by

gradual decline in feed intake at 56.25 and 75% wheat offals in the diet (8.22 and 9.71% crude fibre respectively). This agrees with the finding of Ranjhan (1972) who observed no compensatory increase in feed intake in pigs fed 60% wheat bran compared to a basal ration containing 30% wheat bran.

In this trial, weight gains of pigs fed diets containing various levels of wheat offals equaled, if not, slightly surpassed those of pigs fed the basal ration, in spite of the increasing crude fibre content of the wheat offal diets (3.71, 5.21, 6.72, 8.22 and 9.71% at levels of wheat offals of 0, 18.75, 37.5, 56.25 and 75% respectively). Tolerance limit to these levels of crude fibre using wheat offals may not have been reached. (Cunha, 1977; Merkel, 1958a). Age and early adjustments may also be factors to these results.

Other factors in bran as source of fibre may have influenced intake and gains of the growing pigs. Level of intake plays a large part in influencing growth (Cole, 1962) which could make it more an important measure of the nutritive value than digestibility or chemical composition. Likewise, of considerable importance in determining the fibre level to use is the quality of the fibrous feed according to Cunha (1977). Foremost among the characteristics of bran in the diet is its ability to influence the physical behaviour of the

ingesta throughout the length of the gastro-intential tract that modifies enzymatic, microbial and nutrient absorption. Wheat bran is laxative in nature (Pond and Maner, 1974). By its water-holding capacity (Bell, 1960) it is able to hold large quantities of water at all stages of digestion, thus stimulating peristaltic activity by way of increased volume of the ingesta. He also found that wheat bran passed most rapidly than cellulose, oat hulls, corn cobs, wheat straw, Alfalfa and beet pulp. Payler et al (1975) observed that the transit time of wheat bran was significantly reduced compared to oatmeal and ordinary diet.

The flaky nature of the bran was also believed to render the physical condition of the ingesta more favourable to enzymatic action and rapid digestion of the diet in the stomach, as well as, favourable activity in the lower gut. Fantus and Frankl (1941) suggested that bran residues stimulate bacterial action in the lower gut with the resultant increase in the production of volatile fatty acids and gases. Both products are believed to stimulate peristalsis, hence, faecal elimination. Cooper and Tyler (1959) also observed extensive gas production as a result of feeding wheat bran to swine.

The comparatively higher rates of growth responses of growing pigs fed various levels of wheat offals may also be due to the higher protein content of the diets

containing wheat offals. It should be noted that weight for weight replacement of sorghum in the diet with wheat offals increased protein content from 19% in the basal ration to 20.54, 22.11, 23.66 and 25.21 at levels of 18.75, 37.5, 56.25 and 75% wheat offals respectively. From the foregoing explanation, it may be logical to assume that there was better and enhanced assimilation of amino acids for tissue development of the growing pigs with addition of wheat offals.

The feed:gain ratio revealed that pigs fed 75% wheat offals were the most efficient converters of feed to body gain. The pigs ate less per unit gain in weight ($P<0.05$) than those on the basal ration. The feed:gain ratios were however, not significantly different between the control and the other treatments. Ranjhan et al. (1971a) reported no significant differences in feed efficiency of pigs fed 10, 40, 60 and 70% wheat bran diets. Other workers using bran on growing pigs did not find significant difference in feed efficiency, although the levels used were lower than those used in this experiment. Hines (1980) reported that feed efficiency of weaned pigs fed 21.2% wheat bran was similar to those fed a standard basal ration. Babatunde et al. (1975) found similar feed efficiency in pigs fed 0, 5, 10, and 15% wheat offals, Dhudapker et al. (1971) did not observe significant differences in feed efficiency in pigs fed 0, 23 and 43% wheat bran. Neufville et al. (1973) found no significant

difference in efficiency of feed conversion of pigs fed 0, 7.5, 19.5, 27 and 39% wheat bran. On the contrary, Sharda et al. (1979) found significant difference in feed efficiency of pigs fed 25% wheat bran compared to 5% level. Ranjhan (1972b) found significantly lower feed efficiency in pigs fed 60% wheat bran compared to 30%. Hochstetler (1958) also observed poorer feed efficiency in pigs fed 20 and 40% compared to a basal ration.

Feed conversion efficiency is a parameter of performance in growing pigs of great economic value. Feed constitutes a large proportion of production cost. A diet that will allow the pigs its maximum growth potential at lesser amounts is a factor of importance in raising the profit margin in pig production in the tropics and an incentive for expanded production. The over-all better feed efficiency of pigs fed the wheat offal diets may be partly attributed to lower energy requirements for maintenance and growth of the pigs raised in a tropical environment like Nigeria. Likewise, a basal ration whose energy contents are based on NRC (1971) requirements and recommended for use in the temperate region may prove to be a liability in the tropical region, as shown in these results. Calculated DE:gain ratio also indicate the greater energetic efficiency of the pigs fed the various levels of wheat offals. There is a need to further investigate and re-assess energy requirements of pigs in

terms of energy levels in the diets in various geographic and climatic conditions in Nigeria with the use of cheap and locally available by-products like wheat offals.

The cost of feed per unit weight gain is the outstanding feature of the addition of wheat offals in growing pigs' diets, which was lowered significantly at each level of replacing sorghum with wheat offals ($P<0.05$). It is well-known that feed cost represents the major cost of producing pigs (Goodwin, 1974). Lowering the cost of producing a unit of the product will create the major impetus and incentive for increased production of pork in the country, especially with use of cheap and abundant agro-industrial by-products. The percentage decrease in the cost of feed per kilogram gain by each level of replacement were 22, 31, 46 and 64% of the cost of basal ration. This will undoubtedly contribute to lowered cost of production and at the same time relieve competition that exist between man and animals in the use of the scarce grains. The unit cost of wheat offals is relatively lower than sorghum (6.7 k vs 35 k per kilogram). Moreover, historical trends in Nigeria indicate that sorghum will always be higher-priced than wheat offals and valued as human staple food. Recurrent shortages of grains aggravated by drought will no doubt prohibit the critical use of grains for pig production in Nigeria.

In general, there was nothing in the results of this study which points to any deleterious effects on growth and general well-being and health of the pigs when wheat offals replaced sorghum even at the highest levels.

In experiment 2, overall results of feeding trial in finishing pigs and carcass study showed some significant and favourable responses to diets contining various levels wheat offals. With similar feed intakes for all the treatments, significantly higher ($P<0.05$) average daily gains were however, obtained in pigs fed 20.55, 41.10 and 61.65% wheat offals in the diets. These results tend to show that neither the crude fibre contents nor the energy-diluting effects on gains of finishing pigs in this study. Other factors may be involved in these results.

That feed intake did not decline as levels of wheat offals increased but maintained at similar levels with those of the basal diet may suggest better accommodation of a bulky feed by way of enlargement of the gastro-intestinal tract (McCormick and Kidwell, 1953). It was also noted that there was a slight increase in feed intake at the level of 20.55% wheat offals, but beyond this, bulkiness of the diet with increasing levels of wheat offals did not allow further increase in feed intake.

That pigs fed a basal ration that is nutritionally adequate in energy significantly grew slower than those

fed 20.55, 41.10 and 61.65, but similar only in gains with pigs fed 82.2% wheat offals may indicate liability of a high energy diet in a tropical environment. Superior growth of the pigs fed the wheat offals, in spite of the lowered total DE intake suggests that energy requirements for maintenance is much lower in conditions prevailing in Nigeria, than those recommend for temperate conditions.

Furthermore, it should be noted that protein content increased as levels of wheat offals increased in the diets. As such there may have been maximum opportunity for lean tissue development of the pigs, because of higher availability and assimilation of some essential acids. It may also be assumed that the higher levels of protein in diets containing increasing levels of wheat offals may have ameliorating effects on lowered energy intakes.

Finally, the inherent unique physical and chemical properties of wheat offals as feed ingredient may also have some bearing in the results obtained in this study. Due to its flaky nature, wheat offals is known to enhance proteolytic enzymes; thus, enhancing assimilation of amino acid for muscle development (Gorril, 1960). Bran is also known to stimulate peristalsis and passes through the gastro-intestinal tract more rapidly than other fibrous feeds (Bell, 1960). Likewise, bran stimulates bacterial action in the lower gut (Fantus and Frankl, 1941)

with resultant increase in production of volatile fatty acids and gases (Cooper and Tyler, 1959; Friend et al. 1964; Farrel and Johnson, 1970).

Findings in this study agree with those of Babatunde et al. (1976) who found no significant differences in intake and gains of pigs when fed 0, 10, and 15% wheat offals and also of Sharda et al. (1979) who found no significant differences in rate of growth of finishing pigs when fed 7.5 and 37.5% wheat bran.

However, Ranjhan (1972) found depressed rate of growth in pigs fed 72 and 83% wheat bran; and Hines (1980) obser observed significantly slower rate of growth in pigs (60 - 98 kg) fed 40% wheat bran. Hochstetler (1959) also found significant decrease in rate of gain in pigs (from 45 kg) when fed 40% wheat bran compared to 0 and 20%.

In terms of feed efficiency, it took significantly less feed ($P<0.05$) to gain a kilogram weight for pigs fed 41.10% wheat offal diet compared to the basal ration. This is due to higher daily gains of pigs at this level. This also compared well with efficiency of pigs fed 20.55, 69.65 and 82.20% levels of wheat offals in the diets. It may be important to note that weight range of finishing pigs used in the finishing study was between 40 and 64kg and it is at this stage of development that, the pigs are expected to lay down fat, as an inevitable accompaniment

of growth. Energy intake in excess of maintenance requirement would invariably be stored as fat (as evidenced by backfat measurements). Since fat contains much more energy than protein, it is evident that the energy requirement per unit of body gain increases in accordance with its fat content (Maynard, 1979). Babatunde et al. (1976) found no significant difference in efficiency of pigs fed 0, 10, and 15% wheat offals. Likewise Sharda et al. (1979) who observed no adverse effect in feed efficiency of pigs when fed 37.5% wheat bran compared to 7.5%. Hines (1980b) also obtained no significant differences in feed efficiency of pigs fed 0, 5, 10, 15 and 20% levels of wheat bran. On the other hand, Ranjhan et al. (1972) obtained depressed feed efficiency in pigs fed 72 and 83% wheat bran at both 50-70 and 70-90 kilogram weight ranges.

In terms of feed cost per unit gain in weight, diets in which wheat offals replaced sorghum showed significantly reduced ($P<0.05$) cost per kilogram gain in weight of the finishing pigs from 31, 54, 64 and 74% of what it cost to feed the finishing pigs a basal ration without wheat offals. The significantly cheaper cost of gains is due to the relatively cheaper cost per kilogram of the wheat offals as a by-product of the flour mills compared to sorghum which is a major human staple in Nigeria. The need to reduce cost is an over-riding factor in pig production in Nigeria. As results show, wheat offals can be used

extensively in finishing pig rations without deleterious effects and at cheaper rate than what could be obtained with sorghum. Hines (1980), however, found that in the United States, wheat bran costing more than milo would not merit its use in swine finishing rations.

Significantly ($P<0.05$) reduced backfat thickness was obtained from pigs fed all the wheat offal diets compared to the basal diets. This may be due in part to the energy-diluting effect of the wheat offals in the diets. Even at the lowest level of wheat offals (20.55%) in the diet, significantly reduced ($P<0.05$) backfat thickness was observed. This implies that less energy is available for fat deposition and there was further reduction in backfat as levels of wheat offals increased in the diet. Reduced backfat thickness may also be due to the increasing levels of protein concentration as wheat offals increased in the diets. It was noted that protein levels increased from the basal diet containing 16% CP to 22.97% CP at the highest levels of inclusion. At higher levels of protein, excess of amino acid which are provided, not only encouraged near maximum lean tissue development, but, depressed fatty tissue development as obtained by Fetuga et al. (1977) who observed significantly reduced backfat as protein levels increased from 12 to 20% in LW X LD pigs. These results also agree with findings of Ranjhan et al. (1972) who found reduced backfat in pigs fed levels of 60, 72 and 83%

wheat bran. Likewise, Hochstetler et al. (1959) observed less thick backfat in pigs fed 40% wheat bran compared to those fed 0, or 20% wheat bran. Sharda et al. (1977) also found significantly reduced backfat in pigs fed 37.5% wheat bran compared to those fed 7.5%. On the contrary, Neufville (1973) observed no differences in backfat thickness of pigs fed 0, 7.5, 19.5, 27 and 39% wheat bran in the diets.

While no significant differences were observed between treatments for dressing percentage, pigs fed the basal diet tended to have a higher dressing percentage compared to all the other pigs fed diets containing wheat offals. Ranjhan et al. (1972) observed lower dressing percentage on pigs fed 72 and 83% wheat bran. Hochstetler et al. (1959) also, observed significantly lower dressing percentage in pigs fed 40% wheat bran compared to pigs on the basal diet.

Although no attempt was made to measure gut weight or gut fill, relatively lower dressing percentage of pigs fed wheat offals may be due to increased gut weights. Babatunde et al. (1975) found significantly increased gut weights in pigs fed 15% wheat offals compared to those fed 0, 5 and 10%. Other workers also observed that the amount of fill influences carcass yield (Arganosa, 1972; Hochstetler et al. 1959; Neufville et al. 1973).

Carcass length of pigs fed dietary wheat offals were in general much longer ($P<0.05$) than those of pigs fed the control diet. Merkel et al. (1958), also, reported significantly longer carcass in pigs fed low TDN diets and hand-fed pigs. On the other hand, Ranjhan et al. (1972) did not find any difference in the carcass length of pigs fed 30, 60, 72 and 83% wheat bran.

Significantly (P 0.05) larger loin eye area (Longissimus dorsi muscle) were obtained in carcass of pigs fed the basal ration and those fed 61.65 and 82.2% wheat offals than those fed 41.10% wheat offals diet. It is known that loin eye area is highly correlated with all the measures of meatiness (ham loin and shoulder weight) individually or as lean cut yield. This trait has a high but negative association with backfat thickness. When backfat is thick, the area is small (Arganosa, 1972). However, result in this study did not follow this trend. Hochstetler et al. (1959) reported that loin eye area was not measurably affected in pigs fed 0, 20 and 40% wheat bran.

The shoulder weight results indicate that there were no significant differences between treatments; although there was consistently high percentage shoulder between treatment means of carcass of pigs fed the various levels of wheat offals than those on the control diet. This implies that finishing rations containing various levels

of wheat offals yield equal, if not better percentage shoulder than those of the control diet. The percentage increases of % shoulder of pigs fed 20.55, 41.10, 61.65 and 82.2% wheat offals were 10.44, 10.26, 13.38 and 11.03% respectively over those of the control diet. These increases in % shoulder of wheat offal fed pigs is indication of greater lean tissue development brought about by higher availability of protein in diets containing wheat offals.

Significantly higher ($P<0.05$) ham percent were obtained in carcass of pigs fed 61.65 and 82.2% wheat offals compared to pigs fed the control diet. The ham percent of the pig fed 20.55 and 41.10% wheat offals diets although similar to those of the basal diet, were relatively higher. These results may be directly a result of higher crude protein content of the rations containing wheat offals which could have encouraged lean tissue development especially the ham. It should be noted that percentage of protein in the diets increased from 16% in the basal diet to up to 22.97 in the highest inclusion of wheat offals. This is in consonance with the findings of Fetuga et al. (1977). This may be due to amino acid availability for lean tissue development in the pigs.

In summary, based from the over-all results of lean cut yield - % ham, % shoulder and loin, including that of carcass length, it could be reasonably deduced that

pigs fed the wheat offal diets even at the highest rate of replacement of sorghum in the diet, gave generally superior lean meat yield than those fed the basal ration. Lean cut yield - individually or collectively - represent an important measure of carcass value, since they constitute about 65% of the carcass value (Arganosa 1972).

In experiment 3, the digestibility of nutrients of diets containing wheat offals was studied. There was no significant difference observed between treatments for feed intake, although there was a general trend for decreased feed intake as levels of wheat offals increased from 15 to 45% of the diets. Relatively less intake may be due to bulkiness of rations containing higher levels of wheat levels of wheat offals. It should be noted that the method of feeding the pigs at 4 and 6% of their body weights means that pigs were given equal amounts of feed per unit of weight; as such, the pigs may have been challenged to take in feeds that were bulky as wheat offals were given at fixed rates of 15, 30 and 45% in the rations. It was noted that there were more left-over feeds as levels of wheat offals increased in the diet, indicating that full distention of GIT (gastro-intestinal tract) was achieved when given at this fixed percentages of body weight.

The contrasting differences in the phenomenon observed in the digestibility trial and that of experiments 1 and 2 may be attributed to one or all of the following:

a. Method of feeding - In experiment I and II, the animals were group-fed ad libitum, while those in the digestibility study the animals were allotted feed at individually fixed rates of 4 and 6% of body weights, given a two intervals (8 A.M. and 4 P.M.). In ad libitum feeding, the animals were given the full benefit to express their full potential for growth. As was observed in experiments I and II, a homeostatic mechanism is at play at certain point or limit where the animals tend to equate their energy needs when rations are deficient in energy due to the inclusion of a diluent like wheat offals. In contrast, when given a fixed amount per kilogram body weight, the variable factor in play is that of bulk. Thus, it could be presumed that method of feeding may have influenced results in these experiments.

b. Composition of the diets - Differences in the phenomenon observed between experiments 1 and 2 and that of the digestibility trial could also be due to differences in composition of the rations for each experiment. In experiments 1 and 2, wheat offals replaced sorghum in the diet at the rate of 25, 50, 75 and 100% on a weight for weight basis (non-isocaloric and non-isonitrogenous) on the presumption that wheat offals could economically and nutritionally replace the expensive grain in the pig ration. Except for the proportionate changes between sorghum and wheat offals in the diets, all other ingredients were held constant across the treatments. In experiment 1 and 2,

with the economic viewpoint in mind, wheat offals was accorded the same nutritional status as sorghum unless proved otherwise. While in the digestibility trial, wheat offals was added at fixed amounts in the rations on iso-nitrogenous (20% CP) basis. As such the only variable factor involved is the level of energy in the diets.

c. Level of other nutrients in the diets - In experiment 1 and 2, protein content of the rations increased as energy decreases with increasing levels of wheat offals. From a basal diet containing 19% CP in the growing phase and 16% CP in the finishing phase, protein content of the rations increased to a maximum of 25.21 and 22.97% CP respectively with the highest inclusion of wheat offals. Compensatory effects of protein for energy in the diet may have influenced results in this studies. Up take of other nutrients likewise increased with increasing level of wheat offals. On the other hand, for rations in the digestibility study, crude protein content was held constant across the treatment and energy level is the only limiting nutrient with increasing level of wheat offals.

The over-all net effects of reduced feed intake (although not statistically significant) and the low/ energy contents or density of the diets containing higher levels of wheat offals may have been responsible for the reduced ADG at 45% level of wheat offals ($P<0.05$) observed in the combined periods.

It had been documented that reduced growth could be effected by restricting feed intakes by hand feeding (Merkel, 1958a). This can also be accomplished by restricting energy contents of the diets by diluting it with inert or fibrous feeds (Merkel, 1958a; Hochstetler et al. 1959; Bell, 1960; Pond et al. 1962); but at what level is dependent to a large extent, on the quality of the fibrous materials used, age and weights of the pigs, level of other nutrients in the plane of nutrition (Cunha, 1970); and other factors concerning the physical and chemical characteristics of the fibre source (Bell, 1960) which may affect level of feed intake or appetities.

The significantly reduced ADG ($P<0.05$) observed at 45% wheat offals could also be explained by the significantly poor digestibility of energy, DM and NFE, and fibre at this level due to their large losses in the faeces.

Feed:gain ratio of the pigs fed the control ration and those fed 15, 30 and 45%, was similar and was not significantly affected by increased levels of wheat offals. However, there was a slight decrease in the efficiency of feed utilization with the addition of wheat offals to the diet. This may be attibuted to the observed general decline in ADI of pigs fed wheat offal diets.

The digestibility of dry matter was poorest at 45% ($P<0.05$) level compared to those fed 0, 15% wheat offals diets but similar to those fed 30% wheat offals in the diet. More dry matter was excreted in the faeces initially when pigs were on these high fibre diets, although the pigs did adjust with time but the amounts of dry matter digested on wheat offal diets were still relatively smaller. Dhudapker *et al*. (1971) fed wheat bran to pigs at 0, 23, and 23% levels and observed that digestibility of DM was depressed with increased dietary wheat bran.

The apparent energy digestibility coefficient Table 5) decreased ($P<0.05$) with increased dietary wheat offals and followed the same trend as those of the dry matter and NFE digestibility. This is due to large losses of energy and NFE through the faeces with the addition of wheat offals to the diets. This was more pronounced at the highest level of inclusion.

The apparent nitrogen digestibility coefficient was not affected by level of wheat offals in the diet. Likewise, nitrogen balance as percent of consumption, the biological value (BV) and the crude protein (CP) digestibility coefficients of the diets in this experiment were not significantly different between treatments. However, the BV was significantly improved with 30 and 45% wheat offals in the diet. This observation, in contrast to those observed in the digestibilities of DM, Energy

and NFE, may be attributed to two factors due to bran: enhanced functioning of proteolytic enzymes or improved assimilation of amino acids (Gorril, 1960). Extensive proteolytic reactions may have responded to improved physical conditions created by bran in the lower gut (Sheehy, 1935). Dhudapker et al. (971) also observed significantly better nitrogen utilization with 23 and 43% wheat bran in the diets of pigs than the basal diet. However, Babatunde et al. (1976) fed wheat offals at 0, 5, 10 and 15% levels reported that there was no significant difference for digestibility of crude protein.

The apparent ether-extract digestibility coefficient significantly ($P<0.05$) improved with dietary wheat offals at 15 and 30% levels compared to basal ration but, there was a slight depression at the 45% level equal to that of basal ration. This is due to greater up take of ether-extract in the diet and relatively non-significant losses through the faeces. Babatunde et al. (1975), however, observed that thedigestibility of ether-extract was significantly depressed at 15% level of wheat offals in the diet of pigs. The result observed in this trial agreed with the findings of Ranjhan et al. (1972) who reported higher digestibility values for ether-extract in diets containing 72 and 83% wheat bran diets compared to 30 or 60%.

Apparent digestibility coefficient of crude fibre decreased significantly ($P<0.05$) at 30 and 45% levels of wheat offals in the diet of pigs in this experiment. Inspite of large intake of crude fibre, there were large losses in the faeces. Babatunde et al. (1976) also observed that crude fibre digestibility was significantly depressed with 15% wheat offals in the diet. Whereas other workers (Dhudapker et al. 1971; Sharda et al. 1979; Ranjhan et al. 1972) observed significantly higher digestibility for crude fibre in diets containing high levels of wheat bran.

The apparent digestibility coefficient of nitrogen-free extract (NFE) also decreased with increased dietary wheat offals in this experiment particularly at 45%. There were large losses of NFE in the faeces with the addition of wheat offals to the diets and significantly less at NFE was consumed at the highest level of inclusion. This may be due to high fibre content of the diet at this inclusion level. Ranjhan et al. (1972) observed that NFE digestibility was depressed with 72 and 83% wheat bran in pigs diet. Dhudapker et al. (1971) also reported lower NFE digestibility at 23 and 43% wheat bran levels compared to the control diet without wheat bran.

It appears that poor digestibility of DM, energy and NFE, may be directly linked to significantly poor digestibility of crude fibre obtained in both periods and

combined period in diets of pigs containing 30 and 45% wheat offals. Significantly ($P<0.05$) large quantities of crude fibre were lost through the faeces as wheat offals increased in the diets. Also, the pronounced effects of poor fibre digestibility in the first period and not in the second period, indicate that relatively younger pigs have poorer digestibility of the fibre than the older pigs.

The significant decrease in ADG observed in the combined period when wheat offals was added at the level of 45% in the diet may be more a result of the decreased feed intake, combined with significantly lower digestibilities of DM, Energy and NFE and the high fibre of the diet. The method of feeding employed (4 and 6% of feed to body weight) may have challenged the pigs from eating more of a bulkier ration containing wheat offals.

Ether-extract digestibility was enhanced ($P<0.05$) at 15 and 30% levels of feeding wheat offals in the diets compared to the control. Thus, at these levels the ether-extract portion of the diets was digested more while more energy and high fibre NFE were lost in the faeces. It was noted that there were insignificant losses of ether-extract through the faeces even at higher levels of wheat offals, which may be directly associated to increased microbial activity in the lower gut which gives rise to production of volatile fatty acids (Friend et al. 1964).

SUMMARY

Three experiments including carcass evaluation aimed at evaluating wheat offals as an energy source to replace sorghum grain in the diets of pigs were conducted. Wheat offals was fed on weight-for-weight (non-isocaloric, non-isonitrogenous) basis in the growing and finishing trials at replacement rates of 25, 50, 75 and 100% of sorghum in the rations. In the digestibility trial, wheat offals was fed at 0, 15, 30 and 45% levels (iso-nitrogenous at 20% crude protein).

In a growing trial, feed intake and weight gain of growing pigs (11.67kg) fed 0, 18.75, 37.5, 56.25 and 75% wheat offals in the diets were similar between treatments. Feed:gain ratio was, however, significantly better in pigs fed the 75% wheat offals compared to those fed the control diet. Cost of feed/kg. weight gain was significantly ($P<0.05$) lower at each level where wheat offals replaced sorghum in the diet of growing pigs compared to basal ration.

In a finishing trial, pigs (40.08kg.) were fed wheat offals at levels of 0, 20.55, 41.10, 61.65 and 82.2% in the diets (weight-for-weight basis). Results showed that feed intake between treatments were similar; but, weight gains were significantly ($P<0.05$) higher in pigs fed 20.55, 41.10 and 61.65% wheat offals compared to those fed the control diet. With 82.2% wheat offals in the diet rate of

gain was similar to those of the control diet. Feed:gain ratio of pigs fed 41.10% wheat offals was significantly better ($P<0.05$) compared to those fed the control diet. Cost of feed/kg. weight gain was significantly lower ($P<0.05$) where wheat offals replaced sorghum at each level in the diets of inishing pigs.

Carcass data showed that finishing pigs fed 0, 25.55, 41.10, 61.65 and 82.2% wheat offals had similar dressing percentage and percent shoulder. However, significantly ($P<0.05$) longer carcass was obtained in pigs fed diets containing 20.55 and 75% wheat offals compared to those fed the control diet. Significantly ($P<0.05$) smaller loin eye area was obtained in the carcass of pigs fed 41.10 wheat offals compared to the control diet which was similar to the other treatments. Carcass of pigs fed 61.65 and 82,2% wheat offals showed significantly ($P<0.05$) higher percent ham compared to pigs fed the basal ration which had the smallest percent ham. Pigs fed the diets containing wheat offals had significantly ($P<0.05$) less backfat compared to those fed the control diet.

In a digestibility trial with pigs (26.42kg) fed 0, 15, 30 and 45% wheat offals (iso-nitrogenous at 20% CP) data revealed that feed intakes and feed:gain ratio were not significant different between treatments. Weight gain was, however, significantly ($P<0.05$) depressed in pigs

fed the 45% wheat offals diet compared to those fed the control diet.

Apparent digestibility coefficients of dry matter energy and NFE significantly depressed ($P<0.05$) with 45% wheat offals in the diet. No significant differences were observed between treatments for apparent digestibility coefficients of nitrogen, crude protein, nitrogen balance as percent of nitrogen consumed and the biological value. Apparent digestibility of ether-extract was significantly lower ($P<0.05$) in pigs fed the control diets than those fed 15 and 30% wheat offals. Significantly higher ($P<0.05$) crude fibre digestibility coefficient was obtained in pigs fed the control diet and 15% wheat offals compared to those fed 30 and 45% wheat offals diets.

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Appendix Ia

Experiment 1: Composition of Growing Diets

Ingredients	Level of Wheat Offals, %				
	0	18.75	37.5	56.25	75
1. Sorghum	75.00	56.25	37.50	18.75	0
2. Wheat Offals	0	18.75	37.50	56.25	75.00
3. Groundnut Cake	19.75	19.75	19.75	19.75	19.75
4. Fishmeal	3.00	3.00	3.00	3.00	3.00
5. Bonemeal	0.50	0.50	0.50	0.50	0.50
6. Oyster Shells	1.00	1.00	1.00	1.00	1.00
7. Salt	0.25	0.25	0.25	0.25	0.25
8. Min-Vit Premix	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

Mino-Vit Super contains (per 1000 gr.) the following vitamins and minerals: Vitamin A-7,500,000 I.U., Vitamin D3-1,500,000 I.U., Vitamin B1-100 mg., B2-2,750 mg., B12-5 mg., D-Ca Pantothenate-5,000 mg., Vitamin E-2,500 mg., Vitamin K-1,500 mg., Niacin-12,500 mg., Choline Chloride-60,000 mg., Ethoxyquin - 5,000 mg., Manganese Oxide-16,130 mg., Potasium Iodide-353 mg., Cobalt Sulphate-286 mg., Zinc Oxide-12,500 mg., Copper Oxide-1283 mg., Ferro-Carbonate-20,323 mg., Milo-Corn Ad-1000 gr.

Appendix Ib

Experiment 1: Calculated Analyses of Grower Diets

Ingredients	Level of Wheat Offals, %				
	0	18.75	37.5	56.25	75
Crude Protein %	19.00	20.54	22.11	23.66	25.21
Digestible Energy Kcal/kg	3402	3233	3059	2895	2725
Calcium %	0.81	0.80	0.79	0.79	0.78
Phosphorous %	0.53	0.48	0.42	0.36	0.30
Lysine %	0.68	0.74	0.80	0.86	0.93
Methionine	0.44	0.47	0.50	0.53	0.71
Crude Fibre %	3.71	5.21	6.72	8.22	9.71
Cost of Ration per kilogram ₦	0.37	0.32	0.27	0.21	0.16
DE:CP Ratio (Kcal/g)	17.9	15.7	13.8	12.2	10.8

Appendix IIa

Experiment 2: Composition of Finishing Diets

Ingredients	Level of Wheat Offals, %				
	0	20.55	41.10	61.65	82.2
1. Sorghum	82.20	61.65	41.10	20.55	0
2. Wheat Offals	0	20.55	41.10	61.65	82.2
3. Groundnut Cake	12.05	12.05	12.05	12.05	12.05
4. Bloodmeal	3.00	3.00	3.00	3.00	3.00
5. Bonemeal	1.50	1.50	1.50	1.50	1.50
6. Oyster Shell	0.50	0.50	0.50	0.50	0.50
7. Salt	0.50	0.50	0.50	0.50	0.50
8. Min-Vit Premix	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00

Mino-Vit Super contains (per 1000 gr.) the following vitamins and minerals: Vitamin A-7,500,000 I.U., vitamin D3-1,500,000 I.U., Vitamin B1-100 mg., B2-2,750 mg., B12-5mg., D-Ca Panthothenate - 5,000mg., Vitamin E-2,500mg., Vitamin K - 1,500mg., Niacin - 12,500mg., Choline Chloride -60,000mg., Ethoxyquine -5,000mg., Manganese Oxide - 16,130 mg., Potassium Iodide-353mg., Cobalt Sulphate - 286mg., Zinc Oxide - 12,500mg., Copper Oxide 1283mg., Ferrocarbonate 20,323mg., and Milo-Corn Ad-1,000 grams.

Appendix IIb

Experiment 2: Calculated Analyses of Finishing Diets

Ingredients	Level of Wheat Offals, %				
Crude Protein, %	16.18	17.88	19.58	21.28	22.97
Digestible Energy Kcal/kg	3345	3159	2974	2789	2603
Calcium, %	0.78	0.80	0.82	0.84	0.86
Phosphorous, %	0.40	0.58	0.75	0.93	1.11
Lysine, %	0.62	0.69	0.76	0.83	0.89
Methionine, %	0.39	0.43	0.46	0.49	0.52
Crude Fibre, %	3.01	4.65	6.30	7.94	9.59
Cost of Ration per kilogram, ₦	0.34	0.28	0.22	0.17	0.11
DE:Protein Ratio (Kcal/g.)	20.7	17.7	15.2	13.1	11.3

Appendix IIIa

Experiment 3: Composition of Rations

Ingredients	Level of Wheat Offals, %			
	0	15	30	45
1. Sorghum	63.30	50.96	38.67	26.38
2. Groundnut Cake	30.90	28.24	25.52	22.82
3. Wheat Offals	0	15.00	30.00	45.00
4. Soybean Oil	2.00	2.00	2.00	2.00
5. Bonemeal	2.50	2.50	2.50	2.50
6. Salt	0.50	0.50	0.50	0.50
7. Lysine	0.35	0.35	0.35	0.35
8. Methionine	0.30	0.30	0.30	0.30
9. Mineral - Vitamin Premix	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00

Mino-Vit Super contains (per 1000 gr.) the following vitamins and minerals: Vitamin A-7,500,000 I.U., vitamin D3-1,500,000 I.U., Vitamin B1-100 mg., B2-2,750mg.,B12-5mg.,D-ca Panthothenate - 5,000mg., Vitamin E-2,500mg., Vitamin K - 1,500mg., Niacin - 12,500mg., Choline Chloride-60,000mg., Ethoxyquine - 5,000mg., Manganese Oxide-16,130mg., Potassium Iodide-353mg., Cobalt Sulphate-286mg., Zinc Oxide-12,500mg., Copper Oxide 1283mg., Ferrocarbonate 20,323mg., and Milo-Corn Ad-1,000 grams.

Appendix IIIb

Experiment 3: Calculated Analyses of Ration

Ingredients	Level of Wheat Offals, % 0	15	30	45
Crude Protein, %	20.00	20.00	20.00	20.00
Crude Fibre, %	3.79	4.74	5.92	7.34
Metabolizable Energy, Kcal/kg	3106	2984	2861	2739
Calcium, %	0.84	0.85	0.85	0.86
Phosphorous, %	0.73	0.84	0.96	1.07
Lysine, %	1.08	0.99	0.90	0.80
Cys/Methionine, %	0.55	0.55	0.55	0.46
Ether-Extract, %	4.59	4.77	4.93	5.10

Mino-Vit Super contains (per 1000 grams) the following vitamins and minerals: Vitamin A-7,500 I.U., Vitamin D3-1,500,000 I.U., Vitamin B1-100 mg., B2-2,750 mg., B12-5mg., D-Ca Panthothenate - 5,000 mg., Vitamin E - 2,500 mg., Vitamin K - 1,500 mg., Niacin - 12,500 mg., Choline Chloride - 60,000 mg., Ethoxyquine - 5,000 mg., Manganese Oxide - 16,130 mg., Potassium Iodide - 353 mg., Cobalt Sulphate - 286 mg., Zinc Oxide - 12,500 mg., Copper Oxide - 1283 mg., Ferrocarbonate 20,323 mg., and Milo-Corn Ad-1,000 grams.

Appendix IIIc

Experiment 3: Proximate Chemical Analysis of Rations

Ingredients	Level of Wheat Offals, %			
	0	15	30	45
Dry Matter, %	90.00	93.00	92.63	93.75
Nitrogen, %	3.70	3.20	3.92	3.74
Crude Protein, %	20.80	20.34	22.66	21.69
Crude Ash, %	6.87	7.28	7.20	7.94
Crude Ether-Extract, %	5.44	5.58	6.38	6.17
Crude Fibre, %	3.79	4.74	5.92	7.34
Nitrogen-Free Extract, %	63.28	62.06	57.85	55.94
Cross Calorific Value, Kcal/kg	4159.31	4197.56	4182.66	4169.82
Digestible Energy, Kcal/kg	3367.36	3390.03	3259.59	3105.16

Appendix IIId

Experiment 3: Proximate Chemical Analysis of Faeces

	Level of Wheat Offals, %			
	0	15	30	45
Dry Matter, %	45.00	42.05	35.27	33.25
Nitrogen, % g	3.63	3.36	3.19	3.01
Crude Protein, % (N x 6.25)	22.70	20.98	19.91	18.83
Crude Ash, %	15.97	15.77	15.24	15.08
Crude Ether-Extract, %	5.44	5.58	6.38	6.17
Crude Fibre, %	9.52	12.16	15.40	16.72
Nitrogen-Free Extract, %	40.31	42.36	41.27	41.55
Gross Calorific Value, Kcal/kg	4332.95	4247.81	4247.58	4219.26

Appendix IIIe

Experiment 3: Digestibility Coefficients of Rations

	Level of Wheat Offals, %			
	0	15	30	45
Dry Matter, %	81.87^{a}	81.12^{a}	78.34^{ab}	74.55^{b}
Nitrogen, %	82.49^{a}	81.90^{a}	82.10^{a}	79.54^{a}
Crude Protein, %	80.39^{a}	80.50^{a}	80.80^{a}	77.83^{a}
Crude Ether-Extract, %	62.10^{b}	70.56^{a}	72.03^{a}	67.25^{ab}
Crude Fibre, %	56.64^{a}	51.79^{a}	43.49^{b}	41.49^{b}
Nitrogen-Free Extract, %	87.93^{a}	87.02^{a}	84.50^{ab}	80.91^{b}
Energy, %	81.16^{a}	80.91^{a}	77.94^{ab}	74.16^{b}

Treatments with the same superscripts are not significantly different at $P<0.05$ level (DMRT).

Appendix IV

Proximate Analyses of Feed Ingredients

	Sorghum	Fishmeal	Groundnut Cake	Wheat Offals
Dry Matter, %	91.64	94.12	98.66	92.49
Nitrogen, % g	1.61		8.11	3.22
Crude Protein, % (N x 6.25)	10.06	72.75	50.68	20.13
Crude Ash, %	1.92		6.66	6.17
Crude Ether-Extract %	3.27		9.01	3.58
Crude Fibre, %	2.17		7.71	10.80

	Bonemeal	Oyster Shells
Calcium (%)	35.6	39.72
Phosphorous (%)	17.95	0.03
Crude Protein (%)	3.50	-

Appendix V

Amino Acid Content of Fishmeal, Groundnut Cake, Wheat Offals

Amino Acid (%)	Fishmeal	Groundnut Cake	Wheat Offals
1. Lysine	5.54	2.0	0.80
2. Histidine	1.80	1.77	0.62
3. Arginine	3.60	5.37	1.26
4. Asparagine	6.12	5.67	-
5. Threonine	2.79	1.67	0.64
6. Serine	3.00	2.33	0.73
7. Clutamine	8.54	9.11	3.20
8. Proline	2.71	2.08	0.93
9. Glycine	3.40	2.38	1.07
10. Alanine	4.06	2.15	0.88
11. Methionine	1.88	1.16	0.30
12. Isoleucine	2.86	1.80	0.58
13. Leucine	4.70	3.73	1.05
14. Tyrosine	1.87	1.74	0.39
15. Phenylalanine	2.36	2.76	0.37
16. Valine	3.50	2.12	1.01

Analysis from National Animal Production Institute, Shika (13th March, 1979)

Appendix VI

Chemical Composition of Wheat Offals from Various Sources (% DM)

	A[1]	B[2]	C[3]	D[4]
Dry Matter, %	86.4	95.00	90	87.94
Crude Protein, %	16.0	17.88	12.8	15.50
Ether-Extract, %	5.1	4.14	3.2	2.88
NFE, %	10.0	7.70	11.1	-
Calcium, %	0.17	0.10	-	.10
Gross Energy (Kcal/kg)	4386	-	-	-
Digestible Energy (Kcal/kg)	2486	-	2.98*	-
Metabolizable Energy (Kcal/kg)	-	1145 (Poultry)	2.44*	-

A[1] - Babatunde, G.M., Fetuga, B.L., Oyenuga, V.A. and Akpawunam, A. (1976). The effects of feeding graded levels of wheat offals and ground shells to pigs on their performance and carcass characteristics and nutrient utilization. Nigerian J. of Anim. Prod. 2(2) pp. 135-147.

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C[3] Ranjhan, S.K. Animal Nutrition in Tropics. Vikas Publishing House PVT Ltd. New Delhi, 1980.

D[4] Olomu, J.M., Offiong, S.A. and Smulikowaska (1981) Methionine and Lysine in Practical Broiler Rations in the Tropics. J. Anim. Prod. Res. 1(1): 69-88.

*Mcal/kg.