PERFORMANCE OF WEANER PIGS FED *75% MUSARPOMS GRADE* AS A REPLACEMENT FOR MAIZE IN THEIR DIETS

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UNIVERSTY OF BENIN
BENIN CITY, NIGERIA

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A PROJECT SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE AWARD OF THE DEGREE OF BACHELOR OF AGRICULTURE (B. Agric) DEGREE IN ANIMAL SCIENCE

NOVEMBER, 2025

CERTIFICATION

This is to certify that this project work was carried out by Godwin OAMHEN with Matriculation Number AGR2000096 of the Department of Animal Science, Faculty of Agriculture, University of Benin-City, Nigeria.

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Dr. N.C. Akaeze **Head of Department**	**Date**

DEDICATION

This work is dedicated to God Almighty for His Blessings and faithfulness in my life, throughout my program in the University of Benin, and for enabling me to do this work.

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TABLE OF CONTENTS

		Page
TITLE	- - - - - - - -	i
CERTIFICATION	- - - - - - -	ii
DEDICATION	- - - - - - -	iii
ACKNOWLEDGEMENTS	- - - - - -	iv
TABLE OFCONTENTS	- - - - - -	vi
LIST OF TABLES	- - - - - - -	ix
LIST OF FIGURES	- - - - - - -	x
ABSTRACT	- - - - - - - -	xi

CHAPTER ONE

			Page
1.0	**INTRODUCTION**	**- - - - - -**	1
1.1	Background of the Study	- - - - -	1
1.2	Problem Statement	- - - - -	3
1.3	Justification of the Study	- - - - -	4
1.4	Objective of the Study	- - - - -	5

CHAPTER TWO

			Page
2.0	**LITERATURE REVIEW**	**- - - - -**	**6**
2.1	Concept of Swine Production and Weaner Pig Performance	-	**6**
2.2	Maize as a Conventional Energy Source in Pig Diets	-	7
2.3	Unconventional Feed Ingredients for Swine Nutrition	-	7
2.4	Overview of the *75% MUSARPOMS Grade*	- - -	8
2.5	Combined Effects of Plantain Peels and POMS in Pig Diets	-	9
2.6	Growth Performance of Pigs Fed Unconventional Diets	-	9
2.7	Functional properties and bioactive in palm oil	- -	10
2.8	Processing of crude palm oil	- - - - -	11
2.9	Composition of Palm Oil Slurry	- - - -	12

Page

2.10	Proximate and mineral composition of Plantain peels -	13
2.10.1	Proximate Composition - - - - -	13
2.10.2	Mineral composition - - - - - -	15
2.10.3	Mineral composition of banana and plantain peels - -	16
2.10.4	Proximate and Mineral Composition of Palm Oil Mill Slurry (POMS) - - - - - -	17
2.10.5	Crude Protein - - - - - -	18
2.10.6	Crude Fat - - - - - - -	18
2.10.7	Ash - - - - - - - -	19
2.11	Mineral Composition of Palm Oil Mill Slurry (POMS) -	19
2.12	Origin of *MUSARPOMS* - - - - -	22
2.13	Operational Definition of Terms - - - -	22
2.14	Feed efficiency of *MUSARPOMS* - - - -	24
CHAPTER THREE		
3.0	**MATERIALS AND METHODS** - - - -	**25**
3.1	Location of Experiment - - - - -	25
3.2	Housing and Experimental Design - - - -	25
3.3	Adaptation, Management and Data Collection - -	26
3.4	*MUSARPOMS* Development - - - - -	26
3.4.1	Collection and Preparation of Plantain Peels - - -	26
3.4.2	Collection of Palm Oil Slurry: - - - -	27
3.4.3	Development - - - - - - -	27
3.5	The *75% MUSARPOMS Grade*: - - - -	27
3.6	Statistical Analysis - - - - - -	28
3.7	Experimental diet - - - - - -	28
CHAPTER FOUR		
4.0	**RESULTS** - - - - - - -	30

		Page
CHAPTER FIVE		
5.0	**DISCUSSION - - - - - -**	34
CHAPTER SIX		
6.0	**CONCLUSION AND RECOMMENDATIONS - -**	37
6.1	Conclusion - - - - - - -	37
6.2	Recommendations - - - - - -	37
REFERENCES	- - - - - - -	39
APPENDIX	- - - - - - - -	46

LIST OF TABLES

		Page
Table 1:	Bioactive compounds present in palm oil and their potential health benefits - - - -	10
Table 2:	Phospholipids present in palm oil and their functions	11
Table 3:	Proximate and mineral composition of banana and plantain peels - - - - -	14
Table 4:	Mineral composition of banana and plantain peels -	16
Table 5:	Proximate and some Mineral Composition of Musarpoms Feedstuff Grades (25 %, 50 % and 75 %)	23
Table 6:	Gross composition of experimental diets (percent) -	30
Table 4.1:	Performance of Weaner Pigs Fed Diets Containing Graded Levels of 75% "MUSARPOMS" Grade as Replacement for Maize - - - -	33

LIST OF FIGURES

Figure 1: Cross section of palm oil fruit - - - - 12

ABSTRACT

This study investigated the growth performance of weaner pigs fed diets in which yellow maize was partially replaced with a novel feed ingredient, designated *75% MUSARPOMS Grade*, at inclusion levels of 0%, 30%, 40%, 50%, and 60%. MUSARPOMS is an unconventional feed resource composed of 75% ground dried ripe plantain peels and 25% palm oil mill slurry. The ten-week feeding trial, including a two-week adaptation period on the control diet, aimed to evaluate the potential of this feed as a cost-effective and environmentally sustainable alternative for swine production by utilizing locally available agro-industrial by-products. A total of twenty-five weaner pigs, with initial body weights ranging from 13.30 to 14.40 kg, were randomly assigned to five dietary treatments, with each treatment replicated five times in a Completely Randomized Design (CRD). Pigs were offered the experimental diets and water ad libitum throughout the study. Initial body weights were statistically similar across treatments, confirming uniformity of experimental animals at the onset of the trial. While final body weights and overall feed intake were not significantly affected by the dietary treatments, parameters such as total weight gain, average weekly weight gain, average daily weight gain, feed conversion ratio, and feed efficiency demonstrated significant responses to maize replacement levels. The highest growth performance and feed utilization efficiency were observed in pigs receiving the control diet. Among the MUSARPOMS-based diets, the 50% maize replacement level yielded growth and feed efficiency values most comparable to the control, whereas higher inclusion levels (60%) resulted in reduced performance and poorer feed utilization. These findings indicate that *75% MUSARPOMS Grade* can replace up to 50% of maize in weaner pig diets without substantially compromising growth, offering a viable, cost-reducing, and environmentally sustainable alternative feed ingredient for swine production.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Pig production is a rapidly expanding livestock enterprise in many tropical regions due to its high reproductive rate, short generation interval, and strong market demand for pork (Ajayi & Akinola, 2022; Banjo *et al*., 2021). However, the sustainability and profitability of pig farming are constrained largely by feed cost, which constitutes about 60–75% of the total production cost (Agboola *et al*., 2021; Amaefule & Onwudike, 2020). Maize remains the major energy source in pig diets globally and is the primary cereal used in Nigeria due to its high energy content, availability, and digestibility (Bolarinwa *et al*., 2021; FAO, 2022). However, rising demand for maize for human consumption, industrial processing, and livestock feeding has consistently resulted in scarcity and price inflation (FAO, 2023; Ojo *et al*., 2022). This has pushed researchers toward alternative, non-conventional feed ingredients capable of partially or wholly replacing maize without compromising animal performance (Adesehinwa & Adewumi, 2019; Omole *et al*., 2021).

Agro-industrial wastes represent one of the most promising categories of energy-rich alternative feedstocks. Plantain (Musa spp.) peels constitute about 30–40% of processed fruit weight and are frequently discarded as waste despite their nutritional potential (Adeoye *et al*., 2020; Hassan & Ahmed, 2021). Studies have revealed that dried ripe plantain peels contain appreciable energy, carbohydrates, crude fiber, and minerals, and can be used as feed when properly processed (Akinfemi *et al*., 2020; Aro *et al*., 2021). Palm oil mill slurry (POMS), a residue of crude palm-oil extraction, is also abundant in West Africa and contains residual oil, fiber, protein, and soluble nutrients that can improve dietary energy when incorporated properly into livestock diets (FAO, 2022; Ezenduka *et al*., 2023; Ogbuewu *et al*., 2021). Both residues are underutilized and often cause pollution when discarded indiscriminately (Chin & Abdullah, 2020; Ogunjimi & Alade, 2022).

Earlier studies have shown that plantain peel meal can partially replace maize without significantly compromising growth and feed conversion ratios (Hassan & Ahmed, 2021; Adeoye *et al*., 2020), while palm oil mill slurry has been used to enhance diet energy with variable effects depending on processing level and diet composition (Kuma *et al*., 2021; Ogbuewu *et al*., 2021). However, there is limited documented scientific evaluation of the combined use of plantain peel and palm oil mill slurry in pig diets. This study therefore evaluates weaner pigs' performance fed diets containing *75% MUSARPOMS Grade*, at 0%, 30%, 40%, 50%, and 60% replacement levels for maize. The findings will contribute to sustainable livestock feeding strategies.

1.2 Problem Statement

The continuous escalation in maize cost due to competition from human food systems, industrial demand, and climate-related production instability has heightened the cost of pig production in Nigeria and other tropical regions (FAO, 2022; Agboola *et al*., 2021; Ojo *et al*., 2022). Many farmers are forced to reduce herd size or abandon swine production due to insufficient cost margins (Amaefule & Onwudike, 2020). Meanwhile, large quantities of plantain peels and palm oil mill slurry remain underutilized despite their nutritive potential (Adeoye *et al*., 2020; Ogbuewu *et al*., 2021). Their disposal poses environmental challenges, contributing to water and soil contamination (Chin & Abdullah, 2020; Ogunjimi & Alade, 2022).

Although individual assessment of plantain peel meal and palm oil mill slurry has shown potential for livestock feeding (Akinfemi *et al*., 2020; Ogbuewu *et al*., 2021), the combined formulation *75% MUSARPOMS Grade* has not been critically evaluated for use in weaner pig diets. Consequently, farmers lack evidence-based guidelines regarding the effectiveness and safety of its inclusion at different dietary levels. Experimental evaluation is therefore necessary to determine whether *75% MUSARPOMS Grade* can partially replace maize without compromising growth performance, feed conversion, health, and economic return.

1.3 Justification of the Study

The development of *MUSARPOMS* as a substitute for maize in pig diets offers a promising option for feed formulation, yet there is still limited evidence on how weaner pigs respond to diets containing the *75% MUSARPOMS Grade* at various inclusion levels of replacement for maize. This gap in knowledge poses a challenge for the livestock sector, especially as farmers continue to grapple with the rising cost of maize. Important questions remain regarding the most effective inclusion level of *75% MUSARPOMS Grade* and its potential influence on growth rate, feed conversion, and the general health of weaner pigs. Therefore, it is essential to assess whether and to what extent *75% MUSARPOMS Grade* can reliably replace maize in weaner pig diets without compromising their growth performance or feed efficiency.

Feed constitutes the major cost component in pig production, thus alternative low-cost feed resources can significantly improve profitability. This study suggests a practical solution to curb the soaring costs of conventional animal feed using locally available agricultural byproducts.

The use of plantain peels and palm oil mill slurry helps minimize environmental pollution associated with improper disposal of these residues (Chin & Abdullah, 2020; Ogunjimi & Alade, 2022). Converting agro-wastes into feed aligns with circular bioeconomy and sustainable development goals (FAO, 2023; Ezenduka *et al*., 2023).

Diversifying animal feed sources reduces pressure on cereal grains for livestock consumption, safeguarding maize availability for human food and industry (FAO, 2023; Banjo *et al*., 2021). This enhances national food security.

1.4 Objective of the Study

The general objective of this study is to evaluate the performance of weaner pigs fed the *75% MUSARPOMS Grade* as a replacement for maize at graded dietary levels (0%, 30%, 40%, 50%, and 60%) over a period of ten weeks.

The specific objectives are to:

- develope the *75% MUSARPOMS Grade*
- determine the performance characteristics of weaner pigs fed the *75% MUSARPOMS Grade* at 0%, 30%, 40%, 50% and 60% replacement levels of maize

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concept of Swine Production and Weaner Pig Performance

Swine production is an important livestock enterprise for sustainable protein supply and economic development in many tropical countries, including Nigeria (Adebayo *et al*., 2022). Pigs are valued for their fast growth rate, short generation interval, high fecundity, and ability to convert feed into meat effectively (Bai *et al*., 2023). Weaner pigs, typically between 6–10 weeks of age, require diets with high energy and balanced nutrients to support growth and immune development (Chung *et al*., 2022). Performance indices used in evaluating weaner pigs include feed intake, body weight gain, feed conversion ratio (FCR), nutrient digestibility, and health status (Santos *et al*., 2024).

Feed constitutes 60–80% of pig production cost (Osei & Boateng, 2021), with maize being the major component of conventional energy sources. However, current price instability and competition between livestock industries and humans for maize grains have intensified the search for alternative, affordable feed resources (Okoro *et al*., 2023). Utilizing low-cost unconventional feedstuffs can reduce production expenses, improve profitability, and enhance sustainability (Akinmoladun *et al*., 2024).

2.2 Maize as a Conventional Energy Source in Pig Diets

Maize is the most widely used cereal grain in pig feed due to its high energy density and palatability (Adeyemi *et al*., 2021). It provides metabolizable energy ranging from 3,300–3,600 kcal/kg and is relatively low in crude protein (8–10%) (FAO, 2022). Despite its advantages, maize production has been challenged by adverse climatic conditions, rising input costs, and competition from biofuel industries (Chukwu *et al*., 2023). These factors have caused significant fluctuations in maize availability and prices, thereby making swine production less profitable.

As the price of maize increases, feed manufacturers explore cheaper alternatives to reduce feed cost without compromising performance indices (Tetteh & Opoku, 2024). Several studies have evaluated nonconventional feed materials as partial substitutes for maize, including cassava peels, plantain peels, palm kernel cake, and spent grain, with varied results (Olabode *et al*., 2022; Oyedele *et al*., 2023)

2.3 Unconventional Feed Ingredients for Swine Nutrition

Unconventional feed ingredients are materials not commonly used in standard feed formulations but can supply essential nutrients when properly processed (Adesina *et al*., 2023). Their application is driven by the need to minimize feed cost, reduce competition with humans for conventional cereals, and promote sustainable livestock systems. Most are by-products of agricultural processing such as peels, husks, seeds, fermented residues, and slurries (Akinyele *et al*., 2024).

Such ingredients may require detoxification, drying, or other treatments to improve palatability and digestibility (Adepoju *et al*., 2022). Previous research shows that properly processed unconventional feed ingredients can support satisfactory growth in pigs when included as partial maize replacements (Adebayo *et al*., 2022).

2.4 Overview of the *75% MUSARPOMS Grade*

The *75% MUSARPOMS Grade* is a coded unconventional feed composite consisting of 75% ground dried ripe plantain peels (MUSAR) and 25% palm oil mill slurry (POMS) based on the research done by Ekhorutomwen and Nwokoro (2022). It is proposed as a partial maize replacement to reduce feed cost and promote circular bioeconomy by utilizing organic wastes.

Plantain processing generates high volumes of peels, which are often discarded and can cause environmental problems (Thompson *et al*., 2021). Palm oil mill slurry, another waste product, is underutilized and contributes to environmental pollution (Roslan *et al*., 2022). Utilizing these wastes helps reduce environmental burden and supports sustainable livestock practices (Kim *et al*., 2022).

The formulation of the *75% MUSARPOMS Grade* aligns with circular waste utilization principles, reducing reliance on maize and thereby addressing the rising cost of energy feed ingredients in pig production (Azeez *et al*., 2024).

2.5 Combined Effects of Plantain Peels and POMS in Pig Diets

The synergy between moderate energy content from plantain peels and lipid contribution from POMS provides a balanced alternative to maize. Fiber improves gut health, while fat supports energy supply for growth and maintenance (Osei & Boateng, 2021).

Studies combining plantain peels with palm by-products report enhanced feed efficiency and satisfactory growth performance in weaner pigs (Shuaib *et al*., 2024). However, optimal inclusion rates are critical to avoiding over-dilution of energy density and ensuring adequate nutrient supply (Bai *et al*., 2023).

2.6 Growth Performance of Pigs Fed Unconventional Diets

Growth response depends on nutrient adequacy and ingredient digestibility. Several studies affirm that unconventional waste-derived diets, when properly formulated, can support performance comparable to maize-based diets (Tetteh & Opoku, 2024). Performance traits monitored include body weight gain, average daily gain, and feed conversion ratio.

Plantain-peel diets at moderate inclusion support satisfactory growth (Olabode *et al*., 2022), while palm oil residues serve as energy contributors that support weight gain (Abdullah *et al*., 2023).

2.7 Functional properties and bioactive in palm oil

The main bioactive constituents of palm oil and their associated health benefits are summarized in Table 1. Palm oil is widely consumed globally as a source of dietary fat within balanced nutritional patterns (Odia *et al*., 2015). Historically, palm oil has been utilized for cooking for several millennia, particularly across regions of Africa and Asia (Odia *et al*., 2015).

Table 1: Bioactive compounds present in palm oil and their potential health benefits (Kumar *et al.,* 2009; Eggersdorfer and Wyss 2018; Trautwein *et al.,* 2007; McIntyre *et al.,* 2000; Neo *et al.,* 2008)

Bioactive Compounds	Health Benefits
Tocopherols	Tocopherols reduce the likelihood of cancer,neurological disorders such as Parkinson’s and Alzheimer’s disease, heart disease and boost immunity
Carotenoids	Carotenoids protect against certain types of cancer by decreasing aberrant cell development and improving gap junctional communication. Carotenoids also aids in preventing heart disease by inhibiting the development and oxidation of LDL
Phytosterols	Phytosterols can lower LDL cholesterol concentrations
Tocotrienols	Tocotrienols can lower the influence of other cardiac risk factors, such as excessive cholesterol, on cardiovascular health. It can also prevent free radical damage and reverse inflammation
Phenolic acids	Phenolics acids have anti-inflammatory properties

There are several phospholipids present in palm oil that enhance brain functioning and nutrient absorption, which are shown in Table 2**.**

Table 2: Phospholipids present in palm oil and their functions

Phospholipids	**Functions**
Phosphatidylcholine	Improves cognitive functioning, prevents fat formation in the liver, and regulates the body's energy metabolism (van der Veen *et al.,* 2017).
Phosphatidylethanolamine	Regulates body energy metabolism and works as a chaperone (Samarasinghe and Viduranga 2023)
Phosphatidylglycerol	Regulates enzymes (Morita and Terada *et al*., 2015)
Phosphatidylinositol	Phosphatidylinositol has the potential to increase reverse cholesterol transport by increasing cholesterol flow into high-density lipids (Burgess *et al*., 2005)

Tsado *et al*, (2021)

2.8 Processing of crude palm oil

Crude palm oil is extracted from the fleshy mesocarp of the fruit, whereas palm kernel oil is produced by crushing the kernel located at the center of the fruit. Figure 1 illustrates a cross-sectional view of the palm oil fruit.

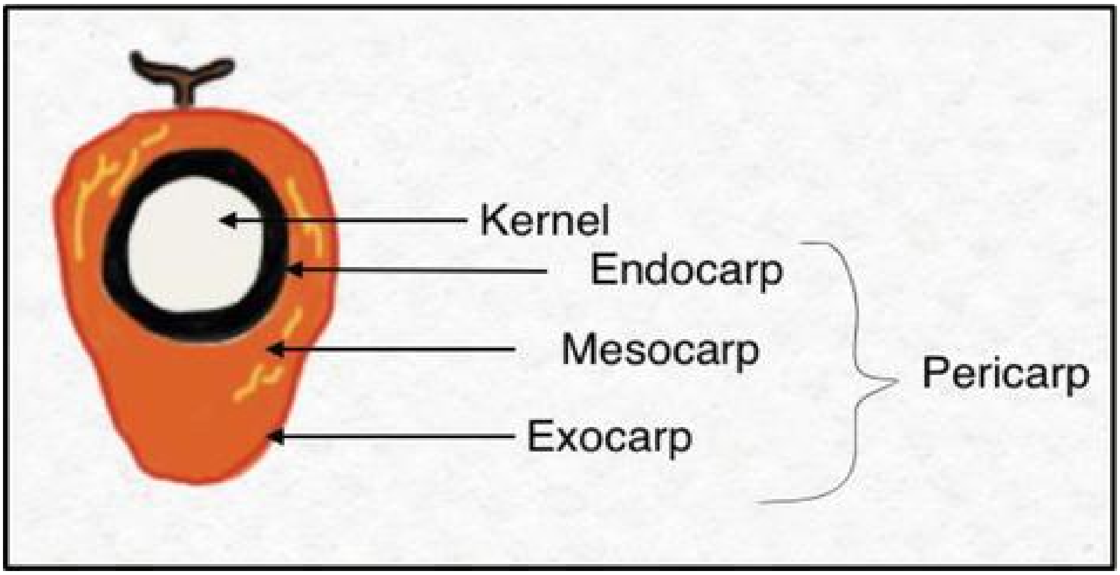

Figure 1. Cross section of palm oil fruit(Samarasinghe and Viduranga 2023).

2.9 Composition of Palm Oil Slurry

Palm oil slurry is generated as a secondary product during the clarification stage of crude palm oil processing in palm oil mills. It is a semi-solid residual material composed of palm oil, water, and particulate matter, including fibers, soil particles, and other contaminants (Saelor *et al*., 2008). The exact makeup of palm oil slurry is influenced by factors such as mill operating parameters and the quality of the fresh fruit bunches (FFB) being processed.

In general, palm oil slurry is made up of the following constituents (Kittikun *et al*., 2000):

- Oil: The oil fraction typically accounts for approximately 4–15% of the total weight and consists mainly of palm oil, along with small amounts of other oils such as palm kernel oil and free fatty acids.
- Water: Moisture content usually falls within the range of 50–70% by weight.
- Suspended solids: Solid particles represent about 15–40% of the slurry and include fibrous materials, dirt, and various other impurities.

2.10 Proximate and mineral composition of Plantain peels

2.10.1 Proximate Composition

Parameters	Composition
Dry matter (%)	93.41
Crude protein (%)	10.50
Crude fat (%)	23.84
Crude fibre (%)	10.66
Ash (%)	11.00
NFE (%)	37.15
Ca (mg/kg)	62.15
Mg (mg/kg)	9.39
Na (mg/kg)	7.92
K (mg/kg)	179.46
P (mg/kg)	32.69
Pb (mg/kg)	0.42
Fe (mg/kg)	19.98

Source : Ekhorurtomwen and Nwokoro (2022).

Ekhorutomwen and Nwokoro (2022) reported the proximate composition of ripe plantain peels in Benin City. The proximate composition of ripe plantain peels obtained from Benin City showed that Crude protein (CP) was 10.50; crude fiber 10.66; ether extract 23.84; Ash 11.00; and NFE 37.15.

Table 3: Proximate and mineral composition of banana and plantain peels

	Plantain peel (%)	Banana peel (%)
Moisture	4.48±0.03	9.83±0.03
Ash	6.17±0.05	9.56±0.06
Protein	3.96±0.07	3.23±0.05
Crude fibre	8.36±0.04	12.67±0.08
Fat	3.01±0.06	0.89±0.04
Carbohydrate	74.12±0.56	63.82±0.32

Data are Mean ±SEM of triplicate determination

Proximate and mineral composition of banana and plantain peels (Tsado *et al.,* 2021).

The proximate composition analysis conducted by Tsado *et al*. (2021) revealed that plantain peels possess notable nutritional value. Carbohydrates were identified as the dominant constituent, making up 74.12 ± 0.565% of the total content. This substantial carbohydrate level indicates that plantain peels have strong potential as an energy-rich material for both human consumption and animal feed.

Crude fiber ranked as the second highest component, constituting 8.36 ± 0.04% of the peel. According to Tsado *et al*. (2021), elevated fiber levels are associated with important health advantages, such as enhanced digestive function and the possible elimination of harmful substances, including mutagens and xenobiotics (Haslinda *et al*., 2009).

The moisture content was relatively low (4.38 ± 0.03%), a characteristic that, as reported by Adepoju and Onasanya (2006), may contribute to extended storage stability and lower risk of microbial deterioration. Protein was present in moderate amounts (3.97 ± 0.07%), while the crude fat content was comparatively low at 3.01 ± 0.06%.

2.10.2 Mineral composition

Parameters	**Composition**
Dry matter (%)	93.41
Crude protein (%)	10.50
Crude fat (%)	23.84
Crude fibre (%)	10.66
Ash (%)	11.00
NFE (%)	37.15
Ca (mg/kg)	62.15
Mg (mg/kg)	9.39
Na (mg/kg)	7.92
K (mg/kg)	179.46
P (mg/kg)	32.69
Pb (mg/kg)	0.42
Fe (mg/kg)	19.98

Source : Ekhorurtomwen and Nwokoro (2022).

Table 4: Mineral composition of banana and plantain peels

	Banana peel (Mg/100g)	Plantain peel (Mg/100g)
Copper	1.35±0.05	0.59±0.83
Iron	5.06±0.07	7.89±0.79
Manganese	10.38±0.04	1.25±0.39
Zinc	11.60±0.03	13.30±0.37
Calcium	17.85±0.25	14.70±0.35
Magnesium	49.32±0.74	45.21±4.36
Sodium	58.16±2.73	76.88±0.89
Potassium	38.22±0.16	26.14±2.68
Phosphorus	22.64±0.38	28.95±0.94

Data are Mean ± SEM of triplicate determination

2.10.3 Mineral composition of banana and plantain peels (Tsado *et al.,*2021)

The findings reported by Tsado *et al*. (2021) indicate that banana and plantain peels contain a wide range of essential minerals. Sodium was identified as the predominant element, occurring at a concentration of 76.88 ± 0.89 mg/100 g. Magnesium and potassium were also present in appreciable amounts, with values of 45.21 ± 4.36 mg/100 g and 26.14 ± 2.68 mg/100 g, respectively.

The study emphasized the functional significance of these minerals, explaining that calcium and phosphorus play key roles in the development of bones and teeth, blood coagulation, and cellular metabolic processes (Rolfe *et al*., 2009). In addition, potassium was noted for its usefulness in industrial applications such as soap manufacture and in agricultural practices for soil pH adjustment (Adeolu and Enesi, 2013).

2.10.4 Proximate and Mineral Composition of Palm Oil Mill Slurry (POMS)

Parameters	Composition
Moisture content (%)	71.96
Crude protein (%)	3.21
Crude fibre(%)	17.62
Ash(%)	4.66
NFE(%)	2.56
Ca(mg/kg)	176.04
Mg (mg/kg)	156.16
Na (mg/kg)	21.39
K (mg/kg)	363.57
P (mg/kg)	9.86
Pb (mg/kg)	0.36
Fe (mg/kg)	29.93

Source : Ekhorurtomwen and NWOKORO (2022).

Palm oil production plays a significant role in supporting the economic growth and livelihoods of many palm oil-producing communities in Nigeria. However, alongside these economic benefits, the processing of palm fruits generates large volumes of residues that pose serious environmental challenges (Imo & Ihejirika, 2021). One such residue is palm oil mill slurry (POMS), which is produced as a leftover material after the efficient extraction of palm oil during processing (Ekhorutomwen & Nwokoro, 2023).

The chemical and nutritional (proximate) characteristics of POMS are not constant but are influenced by factors such as geographical location and the type of processing system employed, whether small-scale local methods or industrial processing techniques (Abiola-Olagunji *et al*., 2014; Ekhorutomwen & Nwokoro, 2023).

2.10.5 Crude Protein

The crude protein content of palm oil mill slurry (POMS) has been reported to differ across geographical locations, with values ranging between 2.04% and 3.79% (Ekhorutomwen & Nwokoro, 2023). Evidence also indicates that POMS obtained from local processing units contains a higher crude protein level (3.50%) compared with samples sourced from industrial processors (2.33%) (Ekhorutomwen & Nwokoro, 2023). These observed variations are likely associated with differences in processing efficiency, equipment, and methods employed by industrial and small-scale palm oil processing operations (Ekhorutomwen & Nwokoro, 2023; Abiola-Olagunji *et al*., 2014).

2.10.6 Crude Fat

Studies have shown that the crude protein content of palm oil mill slurry (POMS) differs across locations, with reported values ranging from 2.04% to 3.79% (Ekhorutomwen & Nwokoro, 2023). Comparatively, samples obtained from locally operated processing units contain higher crude protein levels (3.50%) than those sourced from industrial processing plants (2.33%) (Ekhorutomwen & Nwokoro, 2023). These differences may be attributed to variations in processing efficiency, equipment type, and operational methods used in industrial and small-scale palm oil processing systems (Ekhorutomwen & Nwokoro, 2023; Abiola-Olagunji *et al*., 2014).

2.10.7 Ash

The mineral (ash) content of palm oil mill slurry (POMS) has been reported to vary between 4.16% and 5.16% depending on the sampling location (Ekhorutomwen & Nwokoro, 2023). Findings further indicate that ash levels in POMS obtained from industrial processing plants are comparable to those from locally operated processors, with no statistically significant variation observed between the two sources (Ekhorutomwen & Nwokoro, 2023).

2.11 Mineral Composition of Palm Oil Mill Slurry (POMS)

Famurewa *et al*. (2013) examined the mineral profile of palm oil mill effluent (POME) slurry produced using two processing techniques—mechanical pressing and water displacement—with the objective of assessing the suitability of dried POME as a feed resource based on its chemical and mineral composition. Their findings indicated that the method of processing had a marked influence on mineral content. Specifically, POME obtained through the water displacement method (PEW) contained higher concentrations of several essential minerals than that derived from the pressed method (PEP).

Notably, potassium levels were substantially greater in the PEW sample (835 mg/100 g) compared with the PEP sample (495 mg/100 g) (Famurewa *et al*., 2013). Potassium is a vital element involved in nerve impulse transmission, muscle contraction, and the regulation of fluid and electrolyte balance (Weaver, 2013). Similarly, phosphorus concentration was significantly higher in the PEW sample (1042 mg/100 g) than in the PEP sample (655 mg/100 g) (Famurewa *et al*., 2013). Phosphorus plays a key role in bone development, energy metabolism, and the structural integrity of nucleic acids and cell membranes (Soetan *et al*., 2010).

Higher levels of magnesium (750 mg/100 g), iron (100 mg/100 g), and sodium (485 mg/100 g) were also recorded in the PEW sample relative to the PEP sample, which contained 680 mg/100 g magnesium, 80 mg/100 g iron, and 235 mg/100 g sodium (Famurewa *et al*., 2013). Magnesium is essential for enzymatic reactions, protein synthesis, and neuromuscular function, while sodium is critical for maintaining fluid balance and nerve transmission (Camaschella, 2015). Iron, on the other hand, is a key component of hemoglobin and is necessary for oxygen transport in the body (Gropper *et al*., 2009).

Conversely, zinc concentration was higher in the PEP sample (50 mg/100 g) than in the PEW sample (30 mg/100 g) (Famurewa *et al*., 2013). Zinc is required for immune function, cell division, and numerous metabolic processes. Both samples exhibited relatively low calcium contents, with values of 1.14 mg/100 g for PEW and 0.80 mg/100 g for PEP, although calcium remains important for skeletal development, muscle contraction, and enzyme activity (Weaver, 2015). Importantly, toxic heavy metals such as lead and arsenic were not detected in either sample, an encouraging finding given their carcinogenic nature (Famurewa *et al*., 2013).

In a related context, Donough *et al*. (2016) evaluated the nutrient composition of crude palm oil (CPO) obtained through bunch analysis (BA CPO) and conventional industrial milling (Mill CPO). Their results demonstrated that BA CPO consistently contained higher concentrations of nutrients than Mill CPO. The BA CPO recorded 93 g/t nitrogen (N), 145 g/t phosphorus (P), 20 g/t potassium (K), 58 g/t magnesium (Mg), 42 g/t calcium (Ca), and 37 g/t sulfur (S), whereas Mill CPO contained considerably lower levels of these nutrients. These differences were attributed to the extraction techniques employed, with solvent extraction in bunch analysis preserving more nutrients than the mechanical pressing, cooking, and clarification processes used in industrial milling, which tend to promote nutrient losses (Donough *et al*., 2016).

Further analysis by Donough *et al*. (2014) showed that fertilizer management practices also influenced nutrient concentrations in BA CPO. Reducing fertilizer application from 100% to 80% of the recommended rate increased nitrogen and calcium contents, while fertilizer use generally enhanced phosphorus, potassium, and magnesium levels in the oil, suggesting partial transfer of applied nutrients into the oil fraction. Sulfur content, however, remained largely unaffected by fertilizer treatments.

Using nutrient data from fresh fruit bunches (FFB), Donough *et al*. (2014) estimated nutrient removal rates at a yield of 25 t/ha, reporting values of 75 kg N/ha, 10 kg P/ha, 95 kg K/ha, 15 kg Mg/ha, 12.5 kg Ca/ha, and 7.5 kg S/ha. In contrast, nutrient removal through CPO at the same yield level was minimal. These findings highlight substantial nutrient retention in the FFB relative to the final oil product and underscore the importance of efficient nutrient management strategies to reduce losses during palm oil processing (Donough *et al*., 2016).

2.12 Origin of *MUSARPOMS*

According to the research done by Ekhorutomwen and Nwokoro (2022) *MUSARPOMS* is a feed stock formulated from locally-derived non-conventional feed-stuffs for animal production. The major ingredients for *MUSARPOMS* are ripe plantain peels and palm oil mill slurry**.**

2.13 Operational Definition of Terms

75% MUSARPOMS Grade (MSP75%): A formulated feed stock consisting majorly of 75% ground dried ripe plantain peels and 25% palm oil mill slurry designed for partial maize replacement in pig's diet (Ekhorutomwen and Nwokoro, 2022).

Weaner pig: A young pig recently separated from the sow, transitioning into independent feeding.

Average Daily Gain (ADG): Mean daily body-weight increase within the experiment duration.

Feed Conversion Ratio (FCR): Quantity of feed consumed per unit of body weight gained.

Palm oil mill slurry (POMS): A residue derived from palm oil processing, containing water, fiber, and residual oil.

Table 5: Proximate and some Mineral Composition of Musarpoms Feedstuff Grades (25 %, 50 % and 75 %)

COMPOSITION	MUSARSPOMS GRADES			±SEM
	25 %	50 %	75%	
Dry Matter (%)	91.98[a]	89.46[b]	89.15[b]	0.37
Crude Protein (%)	22.17[a]	20.42[ab]	19.25[b]	0.75
Crude Fat (%)	28.41[a]	27.86[ab]	27.20[b]	0.29
Crude Fiber (%)	18.95[a]	18.71[a]	19.13[a]	0.31
Ash (%)	19.31[a]	17.39[b]	15.30[c]	0.05
NFE (%)	3.32[a]	4.99[b]	8.28[c]	0.39
Ca (mg/kg)	474.20	497.70	515.60	13.71
Mg (mg/kg)	272.5	335.2	196.8	56.80
Na (mg/kg)	0.10	0.14	111.02	64.10
K (mg/kg)	1136.0[a]	1275.0[b]	984.0[c]	28.60
P (mg/kg)	631.8	924.3	591.5	170.70
Pb (mg/kg)	0.02	0.02	0.02	0.001
Fe (mg/kg)	535.1	427.0	569.8	134.9

[abc] means with different superscripts in the same row differ significantly ($P<0.05$). SEM - Standard Error of Mean, MP25%- 25 % MUSARPOMS, MP50% -50 % MUSARPOMS, MP75% - 75 % MUSARPOMS

Source: Ekhorutomwen and Nwokoro, 2022

2.14 Feed efficiency of *MUSARPOMS*

Findings reported by Ekhorutomwen and Nwokoro (2022) indicated that the *25% MUSARPOMS Grade* (MSP25%) has the highest crude protein content, reaching 22.17%, which was markedly greater than the crude protein level of untreated plantain peels (10.50%). This improvement in protein content was closely followed by the *50% MUSARPORMS Grade* (MSP50%) and the *75% MUSARPORMS Grade* (MSP75%), which recorded crude protein values of 20.42% and 19.25%, respectively.

The observed enhancement in nutritional quality was largely attributed to the fermentation process, which has been widely reported to improve feed utilization by lowering crude fiber levels while simultaneously increasing crude protein content in feed ingredients (Adebiyi, 2006; Okpako *et al*., 2008; Babayemi *et al*., 2010; Abiola-Olagunji *et al*., 2014).

In addition, the mineral profile of MUSARPOMS demonstrated considerable nutritional potential. Potassium concentrations were notably high, ranging from 984.00 to 1275.00 mg/kg across the various grades, suggesting that MUSARPOMS could contribute meaningfully to meeting the mineral requirements of livestock (Ekhorutomwen & Nwokoro, 2022).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of Experiment

The experiment was conducted at the Piggery Unit of the University of Benin Teaching and Research Farm located on the Ugbowo Campus, Benin City, Edo State, Nigeria. Benin City lies within the rainforest ecological zone and is geographically situated between latitudes 6° and 3°01′ N of the Equator and longitudes 5°40′ and 6° E of the Greenwich Meridian. The area is characterized by a mean monthly temperature of approximately 27.6 °C. In addition, the locality records an average annual rainfall of about 2162 mm and a mean relative humidity of 72.5% (Meteorological Section of the Nigerian Airport Authority, Benin City, Edo State, Nigeria, 2021).

3.2 Housing and Experimental Design

The experimental animals were randomly assigned to treatments using a Completely Randomized Design (CRD). A total of five dietary treatments were formulated, consisting of a control diet with 0% replacement and diets in which maize was substituted with 75% MUSARPOMS Grade at 30%, 40%, 50%, and 60% inclusion levels. Each dietary treatment was replicated five times, with one pig representing a replicate, resulting in five pigs per treatment. The pigs were kept in pens with concrete flooring and roofing made of metal sheets, partitioned using rods. The housing arrangement was designed to allow adequate cross-ventilation.

3.3 Adaptation, Management and Data Collection

A total of twenty-five (25) weaner pigs with initial body weights ranging from 13.30 to 14.40 kg were utilized for the experiment. Throughout the study period, the animals had unrestricted access to feed and water. The experiment lasted for ten weeks, beginning with a two-week preliminary acclimatization phase during which the pigs were medically treated to prevent diseases and allowed to adjust to their new housing and management conditions. Body weights were recorded at the end of the adaptation period and subsequently measured on a weekly basis until the conclusion of the trial.

3.4 *MUSARPOMS* Development

3.4.1 Collection and Preparation of Plantain Peels:

Fresh ripe plantain peels were sourced from Benin City, Edo State, Nigeria. The peels were thoroughly sun-dried at temperatures ranging from 30–35 °C, milled into a fine form, and subsequently subjected to proximate and mineral composition analyses.

3.4.2 Collection of Palm Oil Slurry:

Fresh palm oil mill slurry (POMS) was obtained in plastic containers from both an industrial and a local processor in Edo South, Nigeria. The chemical composition of the freshly collected POMS samples—including dry matter, crude protein, crude fiber, ash, ether extract, nitrogen-free extract, calcium, and phosphorus—was determined following the procedures outlined by AOAC (2010).

3.4.3 Development:

Following the procedure of Ekhorutomwen and Nwokoro (2022), fresh palm oil mill slurry was thoroughly combined with ground ripe plantain peels. The mixture was weighed and mixed in varying proportions to formulate the *75% MUSARPOMS Grade.* The blended material was then evenly spread on flat trays and left to ferment for a period before being sun-dried. Once dried, the MUSARPOMS grades were milled into a fine form and stored in bags for use.

3.5 The *75% MUSARPOMS Grade*:

Using the method of Ekhorutomwen and Nwokoro (2022), the formulation consisted of 75% ripe plantain peels and 25% palm oil mill slurry (POMS). Fresh POMS was collected in plastic containers. To prepare the mixture, 750g of milled ripe plantain peels was placed in a wide plastic bowl, after which 250g of POMS was added while stirring continuously to ensure thorough blending. The mixture was then transferred into containers for a three-day ageing period, during which it was intermittently turned to promote uniform fermentation. After complete drying, the *75% MUSARPOMS Grade* was milled into a fine form and packed into bags for storage.

3.6 Statistical Analysis

The data obtained from the experiment were analyzed using analysis of variance (ANOVA) with the GENSTAT 2009 (12th Edition) software. Differences among treatment means were further separated using Duncan's Multiple Range Test (DMRT) at a 5% probability level.

3.7 Experimental diet

Five experimental diets were formulated in which maize was replaced with the *75% MUSARPOMS Grade* at inclusion levels of 0%, 30%, 40%, 50%, and 60%. The ingredient composition of these diets, which were used for feeding the weaner pigs during the trial, is presented in Table 1.

Table 6: Gross composition of experimental diets (percent)

	Control	MSP75%			
INGREDIENTS	**Diet 1 (0 %)**	**Diet 2 (30 %)**	**Diet 3 (40 %)**	**Diet 4 (50 %)**	**Diet 5 (60%)**
Yellow maize	55.00	38.5	33.0	27.5	22.0
MUSARPOMS	0.00	16.5	22.0	27.5	33.0
Soya bean meal	20.00	20.0	20.0	20.0	20.0
Fish meal	2.00	2.0	2.0	2.0	2.0
Wheat bran	19.50	19.5	19.5	19.5	19.5
Bone meal	2.30	2.30	2.30	2.30	2.30
Limestone	0.50	0.50	0.50	0.50	0.50
Salt (NaCl)	0.35	0.35	0.35	0.35	0.35
Pig Premix*	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
TOTAL	**100**	**100**	**100**	**100**	**100**

Composition of vitamin – mineral premix per kg of diet: vit A., 5,000 IU; Vit. D, 800IU; Vit E. 12mg; vit. B, 1.5mg; Niacin, 12mg; pantothenic acid, 5mg; Biotin, 0.02mg; vit. B12, 0.01mg; Folic acid, 0.3mg; choline chloride, 150mg; manganese, 60mg; iron, 10mg;

CHAPTER FOUR

4.0 RESULTS

The results of the performance of weaner pigs fed diets in which maize was replaced with the *75% MUSARPOMS Grade* at inclusion levels of 0%, 30%, 40%, 50%, and 60% are presented in Table 4.1.

The initial body weights of the weaner pigs did not differ significantly ($P > 0.05$) among the dietary treatments. Mean initial weights ranged from 13.30 to 14.40 kg per pig, indicating that the animals were of comparable weight at the start of the experiment.

There were no significant differences ($P > 0.05$) in the final body weights of pigs across all treatments. Pigs fed the control diet recorded a mean final weight of 35.10 kg per pig, while pigs fed diets containing 30%, 40%, 50%, and 60% MUSARPOMS recorded mean final weights of 32.60, 30.28, 33.47, and 30.62 kg per pig, respectively.

The total weight gain over the 10-week experimental period showed differences among treatments. Pigs fed the control diet recorded the highest total weight gain (21.80 kg/pig), which differed significantly ($P < 0.05$) from pigs fed the 40% (16.88 kg/pig) and 60% (16.22 kg/pig) MUSARPOMS diets. Pigs fed the 30%

and 50% inclusion diets recorded total weight gains of 18.80 and 19.17 kg per pig, respectively.

The average weekly weight gain followed a similar pattern. Pigs fed the control diet recorded the highest average weekly weight gain of 2.18 kg per pig per week, which was significantly higher ($P < 0.05$) than values obtained for pigs fed the 40% (1.69 kg/pig/week) and 60% (1.62 kg/pig/week) MUSARPOMS diets. The 30% and 50% diets recorded average weekly weight gains of 1.88 and 1.92 kg per pig per week, respectively.

Likewise, the average daily weight gain was highest in pigs fed the control diet (0.31 kg/pig/day). This value differed significantly ($P < 0.05$) from those obtained for pigs fed the 40% (0.24 kg/pig/day) and 60% (0.23 kg/pig/day) MUSARPOMS diets, while pigs fed the 30% and 50% diets recorded 0.27 kg/pig/day each.

The total feed intake and average daily feed intake were not significantly affected ($P > 0.05$) by the dietary treatments. Total feed intake ranged from 51.24 to 53.76 kg per pig over the 10-week period, while average daily feed intake ranged from 0.73 to 0.77 kg per pig per day.

Significant differences ($P < 0.05$) were observed in the feed conversion ratio. The lowest feed conversion ratio was recorded for pigs fed the control diet (2.40), while pigs fed the 40% and 60% MUSARPOMS diets recorded higher values of

3.19 and 3.32, respectively. Pigs fed the 30% and 50% diets recorded feed conversion ratios of 2.95 and 2.81, respectively.

The feed efficiency differed among treatments. Pigs fed the control diet recorded the highest feed efficiency value of 0.43, which was significantly higher ($P < 0.05$) than the values recorded for pigs fed the 40% (0.32) and 60% (0.31) MUSARPOMS diets. Pigs fed the 30% and 50% diets recorded feed efficiency values of 0.36 and 0.37, respectively.

Overall, based strictly on the results obtained, a 50% replacement of maize with the *75% MUSARPOMS Grade* produced growth performance values closest to the control diet among the MUSARPOMS-based diets.

Table 4.1: Performance of Weaner Pigs Fed Diets Containing Graded Levels of 75% "MUSARPOMS" Grade as Replacement for Maize

Parameters	Treatments					P-value	±SEM
	Diet 1 (0%) Control	Diet 2 (30%)	Diet 3 (40%)	Diet 4 (50%)	Diet 5 (60%)		
Initial Weight (kg/pig)	13.30[a]	13.80[a]	13.40[a]	14.30[a]	14.40[a]	0.962	1.32
Final Weight (kg/pig)	35.10[a]	32.60[a]	30.28[a]	33.47[a]	30.62[a]	0.502	2.16
Total Weight gained (kg/pig/10wks)	21.80[a]	18.80[ab]	16.88[b]	19.17[ab]	16.22[b]	0.110	1.49
Ave. Weekly Weight gained (kg/pig/wk)	2.18[a]	1.88[ab]	1.69[b]	1.92[ab]	1.62[b]	0.110	0.15
Ave. Daily Weight gained (kg/pig/day)	0.31[a]	0.27[ab]	0.24[b]	0.27[ab]	0.23[b]	0.110	0.02
Total Feed Intake (kg/pig/10wks)	51.24[a]	52.92[a]	53.76[a]	52.36[a]	53.62[a]	0.798	1.60
Ave. Daily Feed Intake (kg/pig/day)	0.73[a]	0.76[a]	0.77[a]	0.75[a]	0.77[a]	0.798	0.02
Feed Conversion Ratio	2.40[b]	2.95[ab]	3.19[a]	2.81[ab]	3.32[a]	0.047	0.21
Feed Efficiency	0.43[a]	0.36[ab]	0.32[b]	0.37[ab]	0.31[b]	0.054	0.03

[abcd] Means with different superscript within the same parametric row differ significantly ($P<0.05$). SEM - Standard Error of Mean

CHAPTER FIVE

5.0 DISCUSSION

The present study evaluated the performance of weaner pigs fed *75% MUSARPOMS Grade* as a replacement for maize in their diets. The lack of significant differences in initial body weight across treatments confirms effective randomization of experimental animals and ensures that subsequent differences in performance were primarily attributable to dietary treatments. This aligns with standard feeding trial requirements reported in recent pig nutrition studies (Adeola & Cowieson, 2021).

Despite the absence of statistically significant differences in final body weight, pigs fed the control diet consistently recorded higher numerical values than those fed MUSARPOMS-based diets. This observation is expected, as maize is a conventional high-energy feed ingredient with superior digestibility and metabolizable energy content for weaner pigs (NRC, 2021). However, the relatively comparable final body weight obtained at moderate levels of MUSARPOMS inclusion suggests that the test ingredient was able to support acceptable growth when properly balanced within the diet.

The significant reductions observed in total weight gain, average weekly weight gain, and average daily weight gain at higher inclusion levels of MUSARPOMS may be attributed to the increased dietary fibre content associated with dried plantain peels. High fibre diets are known to reduce nutrient digestibility and energy utilization in young pigs, whose digestive systems are still developing (Kerr *et al*., 2022). This is consistent with earlier reports that excessive replacement of maize with fibrous agro-industrial by-products often leads to reduced growth performance in weaner pigs (Oluwafemi *et al*., 2021).

Feed intake was not significantly influenced by dietary treatments, indicating that MUSARPOMS-based diets were readily consumed by the pigs. This suggests good palatability, possibly enhanced by the inclusion of palm oil mill slurry, which may have improved diet aroma and texture. Similar findings have been reported where palm oil by-products were incorporated into pig diets without negatively affecting voluntary feed intake (Santos *et al*., 2023). The similarity in feed intake across treatments implies that growth depression at higher inclusion levels was not due to reduced feed consumption but rather to nutrient utilization efficiency.

The significant increase in feed conversion ratio observed in pigs fed higher levels of *75% MUSARPOMS Grade* indicates poorer feed utilization efficiency. This trend is consistent with the observed reduction in feed efficiency values. Increased fibre levels in plant-based by-products can lead to higher gut fill, reduced nutrient absorption, and increased maintenance energy requirements, thereby reducing feed efficiency (Montoya *et al*., 2021). These factors collectively explain the inferior feed conversion ratios recorded at 40% and 60% maize replacement levels.

Among the MUSARPOMS-based diets, the 50% replacement level produced growth and feed efficiency values closest to the control diet. This suggests that at this inclusion level, the energy contribution from palm oil mill slurry was sufficient to partially offset the reduced energy availability associated with plantain peels. This finding supports recent literature emphasizing the importance of balancing energy-dense by-products with fibrous feed materials to improve nutrient utilization in pig diets (Li *et al*., 2022).

Overall, the study demonstrates that the *75% MUSARPOMS Grade* can be effectively utilized as a partial replacement for maize in weaner pig diets. However, increasing inclusion levels beyond a threshold compromises growth performance and feed utilization efficiency. These findings reinforce the growing body of evidence supporting the strategic use of locally sourced agro-industrial by-products as cost-effective and environmentally sustainable alternatives to conventional feed ingredients, provided that inclusion levels are carefully optimized (FAO, 2022).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study demonstrated that replacing maize with *75% MUSARPOMS Grade* in the diets of weaner pigs did not significantly affect feed intake, indicating good acceptability of the diets. Growth performance and feed utilization declined with increasing levels of maize replacement. However, among the test diets, 50% replacement of maize with *75% MUSARPOMS Grade* produced growth performance and feed efficiency values closest to the control diet. Based on the findings of this study, it can be concluded that *75% MUSARPOMS Grade* can successfully replace maize at a level of up to 50% in the diets of weaner pigs without severe adverse effects on growth performance and feed intake, while also offering reduction in feed cost and contributing to environmental sustainability through the utilization of agro-industrial waste materials.

6.2 Recommendations

- Optimum Inclusion Level: The *75% MUSARPOMS Grade* should be included at 50% replacement of maize in the diets of weaner pigs for optimal growth performance and feed utilization among the tested inclusion levels.

- Feed Cost Reduction: Farmers are encouraged to adopt MUSARPOMS as a partial substitute for maize to minimize feed costs and improve profitability.
- Nutrient Profiling: Further studies should explore the chemical analysis to determine the amino acid balance, and anti-nutritional factors in *75% MUSARPOMS Grade.*
- Long-Term Studies: Future trials should investigate the long-term effects of MUSARPOMS inclusion on carcass quality, nutrient retention, and blood biochemical parameters of pigs.
- Policy Support: Extension services and livestock policy programs should promote the use of agro-waste-based feed resources like MUSARPOMS as part of sustainable livestock production strategies.

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APPENDIX

Plate 1: During a weight taking session

Plate 2: Weaner Pigs in their pen

Plate 3: Feeding of the pigs

Plate 4: Feed formulation

Plate 5: Inspection of the pigs

Plate 6: Taking the weights of the pigs