DEVELOPMENT, EVALUATION AND *IN-VIVO* STUDIES OF DOUGH MEAL FROM PLANTAIN, DEFATTED SESAME AND RICE BRAN FLOUR

BY

ADEOTI OLUWATUNMISE DEBORAH

MATRIC NO: 16010501005

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

MOUNTAIN TOP UNIVERSITY

PRAYER CITY, IBAFO, OGUN STATE.

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF SCIENCE DEGREE (B.Sc.) IN FOOD SCIENCE AND TECHNOLOGY.

DECLARATION

I hereby declare this is an original work done by me and is a record of my own research work. It has been not been presented in any previous application of any higher degree of this or any other University. All citations and sources of information are clearly acknowledged by means of reference.

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ADEOTI OLUWATUNMISE DEBORAH

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Date

CERTIFICATION

This is to certify that the content of this project entitled **'Development, Evaluation and In-Vivo Studies of Dough Meal from Plantain, Defatted Sesame and Rice Bran Flour'** was prepared and submitted by **ADEOTI OLUWATUNMISE DEBORAH** in partial requirements for the degree of **BACHELOR OF TECHNOLOGY IN FOOD SCIENCE AND TECHNOLOGY**. The original research work was carried out by her under my supervision and is hereby accepted.

_____(Signature and Date)

Dr. (Mrs.) A.O Idowu

Supervisor

_____(Signature and Date)

Dr. (Mrs.) M. O. Omosebi

Head of Department

DEDICATION

I dedicate this research work to God Almighty for His love, guidance, provision throughout my years of study. Also my parents for always being there to support and encourage me throughout my academic years.

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ABSTRACT

Malnutrition is a problem in Africa, particularly in rural areas, where starchy foods such as maize, cassava, plantain, yam, rice, and others are consumed as staple foods, resulting in a protein deficiency and thus protein malnourishment. Enrichment of this food with protein rich food sources like soybeans and sesame seeds may help to curb these problems.

Diabetes and cardiovascular diseases are prevalent in our world and there are side effect of the orthodox drugs or medication used in their treatment. The use of functional food like rice bran may help to prevent these diseases. The objective of the study therefore is to enrich the plantain flour with defatted sesame seed and rice bran and evaluate its nutritional, functional and sensory properties as well as the ability of the flour blends to lower blood glucose and blood cholesterol using animal experiment.

Flour blends of ratio, 100:0:0, 75:15:10, 70:30, 70:22:8, and 65:30:5 (plantain: defatted sesame: rice bran flour) were used to prepare dough meal. The nutritional, functional, sensory properties and in vivo studies of the flour blends were evaluated and the data obtained from the results were subjected to statistical analysis using Analysis of variance (ANOVA). The values obtained ranged from 4.93% to 16.36%, 0.50 to 3.50%, 10.95% to 12.30%, 2.33% to 5.80%, 1.59% to 3.59%, and 64.09% to 74.92% for protein, fibre, moisture, fat, ash and carbohydrate contents respectively. The 100% plantain flour had the lowest amount of protein and fibre content, the inclusion of defatted sesame and rice bran increased the protein and fibre content significantly ($p < 0.05$). The flour blend showed significant reduction on the blood glucose level and blood cholesterol level of the experimental rats. In conclusion, addition of defatted sesame and rice bran flour by different ratios to plantain flour as used in the developed dough meal did not only improve its nutritional value, but it could also be used in the management of diabetes and cardiovascular diseases associated with blood glucose and blood cholesterol.

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1.0 INTRODUCTION

1.1 Background of the study

Plantains and bananas are economic crops and staple foods cultivated throughout the tropics, and due to their perishable nature, they offer source of carbohydrate for millions of people in Asia, Africa, the Caribbean, and Latin America, it is low in protein and fat but rich in starch and mineral elements especially potassium.

In green unripe finger plantain, the protein content is estimated to be 4g per kg (Kay, 1987). As a starchy staple meal, plantains have about 1 gram of protein per 100 grams of edible portion (USDA, 2009).

The entire fruit of the plantain pulp, whether unripe or half-ripe, is roasted on hot charcoal in Nigeria, Cameroun, Coted' Voire, and other plantain-producing countries in Africa, and eaten with other delicacies such as avocado, roasted fish or meat, and kelat, and sometimes in combination. Plantain can be eaten raw when ripe, but it can as well be processed into plantain chips and plantain flour. Unripe plantains can be ground into flour, which can then be used to make biscuits, baby food, cakes and bread, pudding, and puff puffs. Plantain flour was found to have little effect on customer approval of pasta and snacks, and gives the product a slightly nutty taste (Badejo, *et al*., 2017). When ground into flour, it's been used to make gruel, which is made by combining flour with boiling water to make a thick paste (Badejo, *et al*., 2017). The gruel is known as ‘Amala’ among the Yorubas in Nigeria, and known as ‘Foufou’ in Cameroun. Several research on the production of functional foods for diabetes treatment in the form of dough meal derived from plantains and cereal have recently been reviewed.

As a result of low glycemic response when consumed and its free radical scavenging activity in diabetics, unripe plantain flour has recently been reported to have a potential for lowering blood glucose, which makes it suitable as a beneficial diet for diabetes patients.

Sesame (Sesamum indicum Linn) is an oilseed legume rich in protein and essential amino acids (Idowu et al., 2021). It is categorized as an underused oilseed with regards to protein extraction and food formulation. Sesame is the richest source of most of the inorganic nutrients, it is also consumed for its medicinal qualities. Sesame seed is rich in protein compared to other seed

protein, because of the higher essential amino acids content. Sesame protein is more nutritious compared to all the other oilseed proteins (Pathak *et al*, 2014; Idowu *et al*., 2021).

Rice bran is made up of pericarp, sub aleurone layer, aleurone, and germ, and is the brown outer layer of the rice kernel. Rice bran is a byproduct of rice milling that is produced in excess of 70 million tons per year, either for further use or as waste (Ryan, 2011).Rice bran contain essential amino acids, minerals, dietary fibers, and bioactive substances that may help to lower total blood cholesterol, triglycerides (TG), and low-density lipoproteins while raising high-density lipoproteins (Liang et al., 2014; Ryan, 2011).

Significant levels of protein, fat, and dietary fiber are all present. Protein, fat, and dietary fiber are all present in significant proportions (Sharif et al., 2014). Minerals such as K, Ca, Mg, and Fe are also present in significant amount. The presence of antioxidants such as tocopherols, tocotrienol, and -oryzanol increases the possibility of rice bran being used as a functional ingredient in humans to treat life-threatening diseases (Sharif et al, 2014).

1.2 Statement of Problem

Malnutrition is a problem in Africa, particularly in rural areas, where starchy foods such as maize, cassava, plantain, yam, rice, and others are consumed as staple foods, resulting in a protein deficiency and thus protein malnourishment. However, with a key strength in large-scale plantain production as one of the main starchy crops cultivated across most African countries, it is undeniable that the people of most African countries eat mostly high-energy, low-protein foods.

Plant proteins now play a major role in human nutrition, especially in developing countries where average protein intake falls short of what is needed. Because animal proteins are in short supply, researchers are constantly looking for new protein sources to use as functional food ingredients and nutritional supplement (Daniel et al, 2021)

Plantain, a perishable food product is usually processed into a more stable form as plantain flour to minimize food wastage as well as create another food variety from plantain. Plantain flour is widely consumed in South-western Nigeria, so it is necessary to improve its nutritional composition to avoid the problem of malnutrition.

Some vital nutrients, such as protein, minerals, vitamins, fiber, and phytochemicals, have been found to be lacking in dough meal. Many studies have shown, that adding legumes like soy flour and fiber-rich commodities like whole millet and maize and rice bran flours to dough meals can improve their nutritional content (Idowu, 2015; Famakinwa *et al*., 2016; Badejo, *et al*., 2017; Oluwajuyitan *et al*., 2021).

1.3 Objectives

The general objective of the study is to produce and evaluate plantain flour enriched with rice bran and defatted sesame seed. The specific objectives were to:

1. Improve the nutritional value of plantain flour
2. Assess the functional properties of plantain flour, defatted sesame seed and rice bran flour blends
3. Assessing the sensory quality of the flour
4. To evaluate the ability of the flour blends to lower blood glucose and blood cholesterol using animal experiment

1.4 Scope of the study

This study is an *in vivo* study that involves working on typical animal models such as mice. It involves improving the nutritional component of plantain flour, as well as testing the potential health benefits of the flour blends`. *In vivo* study evaluates the effects of diverse biological entities on entire, living organisms or cells, mainly animals, including humans, and plants

1.5 Significance of the study

Although plantain flour is widely consumed, the literature is sparse on its supplementation with other food products (such as legumes), which make it nutrient-dense and such functional food items like rice bran, thereby increasing its potential health benefits.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Plantain

2.1.1 Origin of Plantain

Plantain (Musa spp.) are edible crops commonly consumed in the tropical regions. Plantain belongs to Musaceae family, with the Genus Musa, and have historically been important crops in human societies. Its common names are Oji-Oko (igbo), Ayaba (Hausa) and Ogede (Yourba).

Plantain is a monocotyledonous perennial crop that grows in tropical and sub-tropical parts of the world (Baiyeri et al., 2011). Plantains are said to have come from Southeast Asia. The horn plantain and the French plantain are two species of plantains that are said to have originated from the same origin. Both types can be found in India, Africa, tropical America, and Egypt.

The French plantains may also be found in Indonesia and the Pacific Islands. Plantains account for around 85% of all banana cultivation worldwide.

Plantains are similar to bananas, except that they are longer, have a thicker skin, and have more starch. In Africa, Latin America, and Asia, they are also a major staple meal. Unless they are quite ripe, they are usually fried and not eaten raw. Plantains are more prevalent in West and Central Africa's humid lowlands. Plantains grow in the African rainforest in a hundred or more distinct kinds. After rice, wheat, and maize, they are the world's fourth most important food crop, and they are used in food, beverages, fermentable sugars, medicines, flavorings, and prepared meals.

2.1.2 Plantain Production in West Africa

West Africa is one of the world's major plantain-producing nations, accounting for around 32% of global production. Nigeria, Guinea, Côte d'Ivoire, and Ghana are among the region's top plantain producers. Nigeria is West Africa's third-largest producer of plantains.

The two major species are (Musa acuminata and Musa balbisiana) the hybrid of the two is Musa paradisiaca.

2.1.3 Plantain Cultivars

In Central and West Africa, at least 116 plantain varieties have been identified. The most important factors for productivity are size of the plant and the type of bunch. The number of leaves produced prior to flowering determines the plant's size: a modest number of foliage leaves (less than 32); a medium number of foliage leaves (between 32 and 38); a large number of leaves on the foliage (more than 38). When the plantains grows, they produce less than 38 foliage leaves, and leaf production ends.

Bunch morphology provides another method of grouping

- French plantains: At maturity, the bunch of French plantains is complete. Many hands have a lot of tiny fingers, followed by a bunch axis covered in male flowers and neutral flowers, with a big and persistent male bud.

- False Horn plantains: at maturity, the bunch is incomplete since there is no male bud. A little neutral flowers follow the large fingers on the hands.

- Horn plantains: at maturity, the bunch is completed. Hands are small and have only a few yet extremely big fingers. There are no neutral flowers or male buds, and the bunch axis is terminated by a malformed glomerule. The False Horn plantain looks similar to the Horn plantain, but it lacks a neutral flower and has large fingers.

2.1.4. Plantain flour

Plantain flour is made by gently removing the greenish skin of mature but unripe plantain fingers. After that, the finger is chopped into regular shapes such as: (chips) and sun - dried. Ovens or mechanical dryers can also be used to dry plantain fingers and pulverized into flour once they have been dried to a safe moisture content of around 13%.

A novel way of utilizing green bananas is to process the fruit into flour. Plantain flour, a principal product of many varieties of plantain, is one of the most common ways to keep bananas and their masses fresh. The shelf life of flour can be prolonged and secure storage

can be provided. It has a high starch content and is commonly used as a source of energy in baby feeding. It also has excellent health advantages, particularly in cases of gastrointestinal infection.

2.1.4.1 Nutritional Composition of Unripe Plantain Flour

Unripe plantain is an excellent fortification component since it's a natural source of resistant starch, which helps to decrease blood glucose levels. Resistant starch has the advantage of influencing the digestive tract's function, blood cholesterol levels, and diabetes control (Fuentes-Zaragoza, Riquelme-Navarrete, Sanchez-Zapata, & Perez-Alvarez, 2010).

Unripe plantain has been discovered to contain antioxidant compounds that aid in disease prevention and provide vitamins. It produces a gradual release of glucose, which can help prevent colon cancer and constipation while also lowering cholesterol and triglycerides in the bloodstream.

According to research analysis carried out on plantain flour; the results of analyses revealed the unripe plantain's nutritional content (Table 1) yielded 128.6 kcal of energy per 100 g sample (Thomas, et al 2017).

The demand for unripe plantain flour has increased as a result of its health benefits. Unripe plantain flour is a good source of carbohydrate, vitamins, and minerals and is high in nutrients.

Table 2.1 Nutritional composition of plantain flour (Thomas *et al*, 2012)

Moisture	59.4 g
crude protein	7.7g
Ash	1.5 g
crude fibre	1.4 g
Carbohydrate	24.4 g
sodium,	80 mg
potassium,	120 mg
calcium,	66.6 mg
magnesium,	275 mg
phosphorus,	195 mg
iron,	2.53 mg
Zinc	3.7 mg

2.1.5 Plantain by products

Plantain by-products are generally available as a raw material supply for industry. These by-products' pectin, cellulose, and starch are utilized in the food sector as gelling agents, thickening agents, and stabilizers. Plantain by-products from postharvest losses can be utilized as a high-nutritive feed to supplement the limited and costly available resources for animal feed production.

2.2.1 Sesame seeds

Sesame seeds (Sesamum indicum Linn), commonly known as benne, are the seeds of a tall annual plant in the Pedaliaceae family that have been grown for their seeds, which have been used as food and flavoring since antiquity and from which a rich oil is generated. Sesame (Sesamum indicum) is an oilseed legume with significant protein content and considerable amounts of essential amino acids. Sesame is the richest source of most of the inorganic nutrients, it is also consumed for its medicinal qualities. According to several studies, seeds not only contain nutritionally essential bio-compounds, but they are also substantial sources of other phyto-compounds with anti-nutritional effects (Gilani et al, 2005).

2.2.2 Application and uses of sesame seeds

Sesame seeds are mainly roasted and used as snack and also used eaten in combination with roasted groundnut. Oil is normally extracted from the seed, and sometimes the remnant is used to make a traditional soup called *Miyartaushe* with its leaves, as well as being utilized as a component in the production of other dishes (Idowu *et al*, 2021).

In food applications, it has a limited application. This might be due to a scarcity of structural and functional knowledge on sesame protein isolate fractions (Idowu *et al*, 2021).

According to several studies, seeds not only contain nutritionally essential bio-compounds, but they are also substantial sources of other phyto-compounds with anti-nutritional effects (Samtiya et al, 2020).

2.2.3 Sesame seeds diversity, cultivar and morphology

Sesame (Sesamum indicum) is a rich source of most of the inorganic nutrients, it is also consumed for its medicinal qualities (Idowu et al, 2021).

The flowering plant Sesame belongs to the Sesamum family. Africa has a significant number of wild relatives, but India has a smaller number. It is grown for its edible seeds, which are produced in pods, and has become widely indigenous in tropical locations around the world. With 6 million tonnes produced globally in 2018, Myanmar, Sudan, and India were the biggest producers.

The white cultivar is mostly cultivated in the states of Benue (Oturkpo), Nassarawa (Doma), Jigawa (Malammadori), and Taraba, whereas the black cultivar is mainly grown in Katsina, Kano (Dawanau), and Jigawa (near Hadejia) (Makinde and Akinoso 2013).

Sesame is an annual or occasionally perennial plant that may reach a height of 50-250 cm (Sun Hwang, 2005). It has a wide range of morphologies. The sesame plant comes in two varieties: branched and unbranched. The leaves can be alternating or opposite, and they come in a range of shapes and sizes (Oplinger et al., 1990). The bell-shaped white to pale-rose flowers appear 6 to 8 weeks after planting on the leaf axils and last for many weeks. Opposite leaves facilitate multiple flowering. Sesame seeds are usually pollinated by insect. The fruit is a deeply grooved capsule (1 to 3 inches long) containing 50 to 100 seeds or more. Sesame's growth is indeterminate, meaning the plant will produce leaves, flowers, and capsules as long as the weather permits. Sesame seeds come in different variety of colors and sizes. The seeds with a lighter color are thought to be of better quality. It grows in subtropical and tropical regions, and is well adjusted to withstand dry conditions. Sesame seed plants thrive on poor soil and in climates that are unfavorable for other crops.

2.2.4 Nutritional composition of sesame seeds

According to several studies, seeds not only contain nutritionally essential bio-compounds, but they are also substantial sources of other phyto-compounds with anti-nutritional effects. The defatted sesame meal contains 16.20 to 26.50% protein content (Vajpeyi et al., 2006). Additionally, the oil has medicinal value as a source of vitamin E, an anti-oxidant, and

has been linked to decrease cholesterol, blood pressure, and cancer-preventive properties (Vidya Shankar et al., 2004).

2.3.1 Rice bran

Rice bran is the outer layer of the rice kernel and a byproduct of rice milling that contributes for around 8% of the total grain weight and is a brownish portion of rice that is removed in grain form during dehusking and milling. Rice bran has a light color, a sweet flavor, toasted nutty flavor and a moderate fat content. Rice bran is also known as the paddy. It is made up of the sub aleurone layer, pericarp, nucellus, aleurone, seed coat, germ, and a little amount of starchy endosperm. The color of the bran varies depending on the variety or race; it may be whitish, brownish, reddish or blackish. The bran contains protein, carbohydrates, fats, dietary fiber, vitamins, and minerals are all present in the bran. It contains a unique blend of phytochemicals with a range of benefits, including oryzanol, phytosterol, tocotrienol, tocopherol, and others that have a variety of properties (Raghav *et al*, 2016).

2.3.2 Origin

Rice (Oryza sativa) is the most commonly consumed staple food, as it is consumed by half of the world's population. It is the world's third most produced agricultural commodity, behind sugarcane and maize. The three continents that produce the most rice are Asia, Africa, and America. Rice is made from the seed of the grass species Oryza sativa (Asian Rice) or Oryza glaberrima (European Rice/African Rice) (Esa et al, 2013). Rice endosperm (70%) is the main product, whereas rice husk (20%), rice bran (8%), and rice germ (2%) are byproducts of the rice milling industry.

2.3.3 Usage of rice bran

Rice bran oil, which was previously utilized mainly as animal feed, has recently become a significant use. In regards of rice bran oil production, India and Thailand have been the most successful.

Rice bran is being more widely used in the food industry, owing to its high dietary fiber content and therapeutic potentials. Many food items, such as pasta, cakes, noodles, bread, cookies, pizza, and ice creams, have bran added to them without affecting their sensory or textural properties (Lavanya *et al*,. 2017).

2.3.4 Nutritional composition of rice bran

Rice bran contains a substantial amount of protein (11-17%), fat (12-22%), dietary fiber (6-14%) such as -glucan, pectin, and gum; moisture (10-15%), and ash (8-17%). It also contains vitamins E, thiamine, and niacin, and also minerals such as chlorine, aluminum, calcium, potassium, manganese, iron, magnesium, phosphorus, zinc, and sodium. It has excellent potentials as functional food components in humans to minimize life-threatening illnesses due to the presence of antioxidants such as tocopherol, tocotrienol, -Sitosterol, and -oryzanol, which can be used as functional components in humans to minimize life-threatening illnesses. Rice bran also contain phytochemicals that have been linked to improved health benefits. Rice bran has a significant amount of oil (12-13%) and very unsaponiable components (4.3%) (Raghav et al, 2019).

Rice bran contains essential amino acids, minerals, dietary fibers, and bioactive substances that may contribute to lower total blood cholesterol, triglycerides (TG), and low-density lipoproteins while enhancing high-density lipoproteins (Jolfaie *et al*, 2016)

Processed rice bran is used to improve nutrient content, textural properties, and shelf life in a variety of foods. (Spaggiar *et al*, 2021).

2.3.5 Stabilization of rice bran

Rice bran require stabilization due to the oxidative and hydrolytic rancidity of the oil (12-19%) found in the bran, it cannot be maintained in its current state for a long period of time. As a result of the presence of lipase, an enzyme that rapidly hydrolyzes oil into free fatty acids (FFA) and glycerol, the rice bran must be stabilized soon after manufacturing, resulting in a severe loss in the rice bran's quality. These free fatty acids produced by the hydrolysis reaction are harmful compounds which make bran unsuitable for edible use (Orthoefer, 2005, Rohman *et al*, 2014).

Rice bran stabilization can aid in overcoming these problems. The enzymes are inactivated and the nutrients are preserved when the food is properly stabilized. The most common way to

stabilize rice bran is through heat stabilization. Several researches have revealed that rice bran contains some components that may help in preventing thermal treatment. High temperatures above 120°C denature the enzyme that causes oil to oxidize in rice bran oil without damaging the rice bran's nutritional value (Orthoefer 2005).

2.3.6 Potential health benefits of rice bran

It is rich in dietary components such as fibre content that helps to keep a healthy bodyweight and prevent overeating by providing a feeling of fullness during consumption. As an effect of its rich fibre content it reduces cholesterol level and lower blood pressure in humans (de munter *et al*, 2007; Most *et al*, 2005; Ravichanthiran *et al*, 2018)

2.4 Blood glucose and Diabetes

3.0 MATERIAL AND METHODOLOGY

2.4.1 Blood glucose

The most essential carbohydrate source in the body is glucose. Majority of circulating glucose comes from the diet in the fed state; in the fasting state, glycogen lysis and gluconeogenesis keep glucose levels stable. The majority of glucose in the diet is found in more complex carbohydrates, which are broken down into monosaccharides throughout the digestive process.

The amount of glucose in the blood is measured by the blood glucose level. Glucose is a sugar that comes from the meals we eat, as well as being generated and stored by our bodies. It is the main source of energy for our body's cells, and it is supplied to each cell through the bloodstream. The intestine absorbs glucose directly into the bloodstream, resulting in a rapid rise in blood glucose.

2.4.2 Diabetes

Diabetes is a disease that develops when your blood glucose (also known as blood sugar) levels are unusually high. Blood glucose, which comes from the food you eat, is your main source of

energy. Insulin, a hormone secreted by the pancreas, aids glucose uptake into cells for energy production.

Diabetes mellitus is a category of metabolic illnesses marked by hyperglycemia caused by insulin production, insulin action, or both. Diabetes-related chronic hyperglycemia is linked to long-term damage, dysfunction, and failure of multiple organs, including the nerves, kidneys, heart, and eyes, blood vessels. Diabetes is characterized by elevated blood sugar levels, but additional symptoms such as increased thirst and hunger, unexplained fatigue, increased urination, blurred vision, and unexpected weight loss should not be disregarded.

Both types of diabetes mellitus (DMT1 and DMT2) are linked to an increased risk of chronic complications like neuropathy, retinopathy, nephropathy, atherosclerosis and endothelial dysfunction, (Femlak et al, 2017)

Regular consumption of plant-based foods containing bioactive compounds such as protein, fiber, and phytochemicals has been linked to fewer digestive disorders, a lower risk of colon cancer, better blood sugar control, and lower blood cholesterol levels, according to studies (Samtiya et al, 2021.)

2.4.3 Type 2 diabetes

Type 2 diabetes also known as non-insulin dependent, is common with individuals with insulin resistance who have a partial (rather than absolute) insulin deficit are included in this category. Type 2 diabetes, the most prevalent type, can be caused by a variety of variables, the most important of which is lifestyle, but it can also be determined by genetic factors (Wu et al, 2014). This type of disease takes years to develop, and the signs sometimes are undetectable; as a result, many people develop diabetes without noticing any unique or unusual symptoms. Type 2 diabetes is frequently linked to obesity or being overweight (American diabetes association, 2015).

2.4.4 Functional food as treatment for type 2 diabetes

Type 2 diabetes is a complex metabolic condition that can have both immediate and long-term consequences. Functional foods and their bioactive compounds may be used as a supplemental treatment for type 2 diabetes mellitus due to their biological properties, according to emerging evidence in recent years (Mimiran *et al,* 2014).

Despite availability of many pharmacological interventions including oral hypoglycemic agents and insulin therapy for diabetes management, recent researches shows an alarming rising trend in the occurrence of undesirable complications among these patients.

Regular consumption of functional foods has been linked to improved anti-inflammatory, anti-oxidant, insulin sensitivity, and anti-cholesterol functions, which may aid in the prevention and management of type 2 diabetes.

Dough meal has been discovered to be deficient in some essential nutrients such as protein, minerals, vitamins, fiber, and phytochemicals. Adding legumes like soy flour and fiber-rich commodities like whole millet, maize, and rice bran flours to dough meals has been demonstrated in numerous studies to boost their nutritional content (Idowu 2015; Famakinwa *et al*., 2016; Badejo, *et al*., 2017; Oluwajuyitan *et al*., 2021).

2.5.1 Lipid profile

A lipid profile, often known as a lipid panel, is a set of blood tests used to detect abnormalities in lipids such as cholesterol and triglycerides. A lipid profile includes the levels of total cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides, the calculated low-density lipoprotein (LDL) 'cholesterol and the very low-density lipoprotein (VLDL) cholesterol (Niva et al. 2019).

2.5.1.1 Cholesterol

Cholesterol is a waxy, fat-like molecule that, in small levels, is necessary for good health. Cholesterol is an unsaturated steroid alcohol present in the cell membranes of all animal cells and is necessary for their normal function. It's also a precursor for essential molecules including steroid hormones from the adrenal and gonadal glands, as well as bile acids. Cholesterol is a crucial component of the human body's lipid fraction (Niva et al. 2019). Cholesterol must be carried in the plasma in association with various lipoprotein particles because it is a nonpolar lipid molecule (insoluble in water). The hydration density, electrophoretic mobility, and size of plasma lipoproteins are used to classify these cholesterols (Niva et al. 2019).

Cholesterol is a fatty substance that is found in all of the body's cells. Cholesterol is carried in the blood via lipoproteins, which are small particles. Low-density lipoproteins (LDL), high-density lipoproteins (HDL), and very low density lipoproteins (VLDL) are three of the most frequent lipoproteins (VLDL). High blood cholesterol is a condition caused by unhealthy cholesterol levels. High levels of LDL cholesterol have been linked to an increased risk of coronary artery blockages, while high levels of HDL cholesterol have been linked to a lower risk.

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2.5.1.2 Triglycerides

Triglycerides are fatty acid esters of glycerol that make up the majority of dietary fat and animal fat stores. Although cholesterol and triglycerides are nonpolar lipids (insoluble in water), they must be carried in the plasma with different lipoprotein particles. They are lipid molecules made up of three varied length and composition fatty acid chains esterified to a glycerol (Niva et al. 2019).

These fatty acid chains can be saturated or unsaturated, and their chemical composition varies. Each chain is made up of carbon and hydrogen atoms with varied single or double-bonded chains, depending on the degree of saturation or unsaturation. The lipid fraction of the human body contains a substantial amount of triglyceride. Triglycerides are fatty acid esters of glycerol that make up the majority of dietary fat and animal fat stores (Niva et al. 2019).

Triglyceride, being a nonpolar lipid substance (insoluble in water), need to be transported in the plasma associated with various lipoprotein particles.

Plasma lipoproteins are separated by hydrated density, electrophretic mobility, and size (Niva et al. 2019).

2.5.1.3 High density lipoprotein cholesterol

High-density lipoprotein (HDL) cholesterol is regarded as the "good" cholesterol because it aids in the removal of other types of cholesterol from the bloodstream HDL cholesterol levels that are higher help to reduce the risk of heart disease (Niva et al. 2019).Thus HDL cholesterol is strongly and inversely associated with the occurrence of cardiovascular events, according to numerous research. HDL cholesterol aids in the removal of cholesterol from the body.

CHAPTER 3

3.0 MATERIAL AND METHOD3.1.1 Sources of Raw Materials and Equipment

Unripe plantain (green colour 1) was obtained from Mowe market, Ogun state, Nigeria. The rice bran was obtained from Royal Siblings rice milling factory in ketu, Lagos state. Sesame seeds (white cultivar) was purchased from Jemeta modern market in Jimeta yola, Adamawa State. Chemicals of analytical grade were used. Wistar rats (150g and above) were obtained from the Central Animal House, Mountain Top University, Ogun state Nigeria. The equipment used were obtained from food science and technology department laboratory (MTU).

3.1.2 Experimental animal

Thirteen healthy Wistar rats (> 180.00g) were obtained from the animal holding unit of the Department of Biological Sciences Mountain Top University, Ogun State, Nigeria. The animals were kept in a well-ventilated house (temperature of 22±3 °C; photoperiod of 12h/12h light/dark cycle) and fed with rat feed (Vital Feeds, Grand Cereals, Lagos, Nigeria) and water.

3.1.3.1 Equipment:

Oven, milling machine, stirrer, weighing balance, warring blender, dicer, spoons, conical flasks, beakers, pipette, burette, retort stand, measuring cylinders, kjeldahl apparatus, kjeldahl tablet, , crucibles, tins, Soxhlet apparatus, micropipette, UV-Visible Spectrophotometer (Jenway 7205), and centrifuge. spatula, nose mask, hand gloves, sample bottle rack, petri dishes, aluminum foil, sample bottles, Eppendorf tubes, distilled water

3.1.3.2 Chemicals and reagents

Sodium hydroxide, boric acid, Hydrochloric acid, sulphuric acid, n hexane, ethanol, diethyl ether, formaldehyde were obtained from dilca ventures, Nigeria.

3.1.3.3 Assays

The assay kits (Cholesterol kit, HDL-cholesterol kit, Triglyceride kit) were products of Randox Laboratory, Co-Atrim, United Kingdom.

3.1.3.4 Glucometer and Test strips

Accu-chek Active strip compact plus glucometer and Accu-chek active test strip glucometer were products of Roche Diagnostic, Mannheim Sandhofer strasse, Germany.

3.2.1. Sample preparation

3.2.1.1 Sample preparation of plantain flour

The plantains fingers were washed to remove adhering soil particles, the unripe plantain were washed to remove sand, dirt and other adhering materials. The plantain peel was removed using a sharp stainless knife (the plantain were kept in water during peeling operation to prevent browning). Using a dicing equipment, the flesh was sliced to obtain a uniform surface area for drying, after which it was oven dried (memmert oven and universal oven) at 70°C a constant weight was obtained indicating that the slices were properly dried. The dried slices will be milled in a disc attrition machine to obtain smooth flour. The milled flour was sieved with 0.25 mm mesh sieve into fine flour and kept in an air tight container, and stored at ambient temperature until when it was to be used. Plantain flour was produced following the method described by (Adeleke and Odedeji, 2010) with slight modification (figure 3.1)

3.2.1.2 Sample preparation of defatted sesame seed flour

The sesame seeds were washed to remove sand, dirt and other smaller particle or material afterwards the seeds were sun dried for 2day due to the intensity of the sun, after which it was milled using the blender to get a nice texture for easy extraction of oil. The paste was extracted using the Soxhlet extractor and hexane to extract the oil and get the flour While the defatted sesame seed flour was obtained by defatting the sesame flour using soxhlet extraction with N-hexane as the solvent (obtained from dilcal ventures).

3.2.1.3 Sample preparation of rice bran flour

Rice bran flour was stabilized before it was blended to flour as recommended by with slight modification at 105^{o}c (Orthoefer 2005).

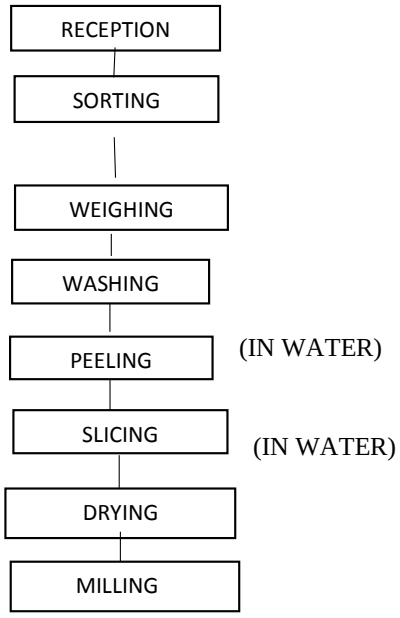


Figure 3.1: Flowchart for plantain flour product

3.2.2 Production of Flour blends of unripe plantain, rice bran and defatted sesame seed flour

The unripe plantain was peeled, sliced, washed with water, and dried in forced air oven at 70 ^{o}C for 8 h as earlier described by Famakinwa et al., 2016). It was then milled and sieved to pass 200 mm mesh size and packaged in polythene bag. Fresh rice bran was cleaned to remove foreign materials before milling and sieving to pass through 200 mm mesh size and packaged in air tight polythene bag. Sesame seeds were milled into flour with a blender, followed by defatting using n-hexane for 8 hr. The wet defatted flour was air-dried in a fume hood and then stored at 4 ^{o}C and sieved through a 200 mm mesh sieve before packaging in a polythene bag.

Table 3.1: Formulation of flour blend

Sample	Plantain flour	Defatted sesame seed flour	Rice bran flour
A	100	0	0
B	75	15	10
C	70	30	0
D	70	22	8
E	65	30	5

3.3 Proximate analysis

Proximate analysis was determined according to the official method of analysis described by the Association of Official Analytical Chemist (AOAC 2012).

3.3.1.1 Determination of protein content

The protein content of the flour samples was determined according to AOAC, (2012). One (1g) of the grinded samples was weighed into a digestion flask and 1 kjeldahl catalyst tablet was added, 12ml of conc.H_2SO_4 was added and digested for 4 hours in a (baker) fume hood with (tecator 1001 digester) until a clear solution was obtained. The digest was cooled, 30ml of 4% boric acid was dispensed into a conical flask with 0.132g of methyl red indicator and 0.198g bromocesol green plus in a 200 ml alcohol.

The digest was diluted with 75ml distilled water and dispensed into Kjedahl distillation flask, the conical and the distillation flask was fixed in place and 50ml of 4% NaOH was added through the glass funnel into the digest, in the kjedahl auto distillation unit . The steam exit was closed and it was stopped when the solution of the boric acid and indicator reached 150ml total volume. The distillate was titrated with 0.1 NHCl until an end point was reached (violet color).

$$\% \text{ Total Nitrogen} = \frac{(Titre\ Value - blank) \times\ Normality\ of\ HCl\ used \times 1.4007}{weight\ of\ sample}$$

Therefore, the crude protein content was determined by multiplying percentage Nitrogen by a constant factor of 6.25 i.e

% crude protein = % N $\times$ 6.25.

3.3.1.2 Determination of Ash content

Ash content was determined using the AOAC (2012) method. Two (2) g of the finely grinded sample was weighed into a pre weighed empty crucible. This was transferred into the muffle furnace set at 550°C and left for about 5 hours. About this time it will have turned to white ash. The crucible and its content was cooled to room temperature in a desiccator. The crucible with the sample was weighed and the percentage of ash was calculated as;

$$\% \, Ash \; content = \frac{weight \; of \; ash}{original \; weight \; of \; sample} \times 100$$

3.3.1.3 Determination of moisture content

Three (3) g of each sample was weighed using analytical balance (Denver instrument company, TR-2102) into previously weighed crucible The weighed samples were put into the pre-set oven (memmert air oven model UN 55, (SCHWBACH, GERMANY) at 105 ℃ for 3 hours. The samples were removed and cooled in a desiccator to room temperature and the weight was noted, and returned to the oven at 105 ℃ for 1 hour, this was repeated until a constant weight was obtained for each sample. The differences in weight between sample before drying and sample after drying is the moisture loss (AOAC, 2012). Moisture content is done to determine the dry solids in the flour and the stability in a room temperature (shelf life).

$$\% \, moisture \; content = \frac{wt \; of \; sample \; before \; drying \; - wt \; of \; sample \; after \; drying}{original \; weight \; of \; sample} \times 100$$

3.3.1.4 Determination of fat content

This was determined by using the method described by AOAC, (2012). 4g of dried sample was weighed into a fat free thimble plugged lightly with cotton wool and extracted with n-hexane in soxhlet apparatus set up for 5 hours. The residue extract was evaporated in an air oven at 100℃ for 30 minutes, cooled and weighed. The fat content was calculated as;

+

$$\% \, fat = \frac{(weight \; of \; flask + fat \;) - weight \; of \; empty \; flask}{original \; weight \; of \; sample} \times 100$$

3.3.1.5 Determination of Crude Fibre

The crude fibre was determined according to the method described by AOAC, (2012). 2g of the sample was accurately weighed into flask and 200ml of 1.25% H_2SO_4 was added. The mixture was heated under reflux for 30 minutes. The hot mixture was filtered through a fibre muslin cloth. The obtained filtrate was thrown off and the residue was returned to the fibre flask with 200ml of 1.25% NaOH will be added and heated for another 30 minutes. The residue was removed and finally transferred into the crucible. The crucible and the residue was oven dried at 105 ℃ overnight to drive off the moisture. The oven dried crucibles containing the residue was cooled in a desiccator and later weighed to obtain the W_1. The crucible with W_1 was transferred to the muffle furnace for ashing at 550 ℃ for 4 hours. The crucible containing white or grey ash (Free of carbonaceous materials) was cooled in the desiccator and weighed to obtain W_2.
The difference in W_1 and W_2 give the weight of fibre.

$$\% \, fibre = \frac{W_1 - W_2}{original \; weight \; of \; sample} \times 100$$

$W_1 =$ Dried crucible + residue before ashing

W2 = Dried crucible + residue after ashing

3.3.1.6 Determination of carbohydrate content.

The determination of carbohydrate in the samples was determined by differenced. That is the values or percentages of moisture, ash, protein, fat and fibre was summed up and the value obtained was subtracted from hundred which gives the carbohydrate content (AOAC, 2012).

3.3.2 Determination of Mineral Composition

Five hundred milligram (500 mg) of sample was weighed in a digesting flask and 10 ml of each of HCl and HNO3 was added. The mixture was digested for 10 minutes on a Bunsen burner and allowed to cool. The mixture was then filtered using filter paper and the filtrate was made up-to

mL with distilled water and injected into the atomic absorption spectroscopy (Perkin Elmer, model 402) for quantification of the mineral elements except potassium and sodium which were determined using flame photometer as described by Famuwagun and Gbadamosi (2021)

3.3.3 Functional Properties of the flour blends

3.3.3.1 Bulk density

This was determined using the method described by Wang and Kinsella, 2006. Ten (10) g of sample was weighed into a 50ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top 60 times until there was no more decrease in volume. The volume of the compacted sample was recorded and the bulk density was calculated as follows.

Calculation:

Bulk density (g/ml or g/cm^3) = $\frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}$

3.3.3.2 Determination of swelling capacity

The swelling capacity method of Leach et al, (1959) with modification for small sample was used. One (1) g of the sample was mixed with 10ml of distilled water in a centrifuge tube and heated at 80°C for 30 minutes in a water bath continuously shaking during the heating period. After the heating, the suspension was centrifuged at 1000rmp for 15minutes. The supernatant was decanted and the weight of the paste was taken. The swelling capacity was calculated using the formula as shown below;

Swelling capacity = $\frac{weight\ of\ paste}{weight\ of\ dry\ flour}$

3.3.3.3 Wettability

This was determined according to the method described by Wang and Kinsella, 2006. One (1) g of sample each was placed in a 25ml graduated cylinder with a diameter of 1cm. A finger was placed over the open end and the cylinder was inverted and clamped at a height of 10cm from the surface of a 600ml beaker containing 500ml distilled water. The finger was

removed to allow the material to be dumped and the time required for the sample to become completely wet was recorded. Duplicate determination was made and the result averaged.

3.3.3.4 Water/Oil Absorption (WAC/OAC)

One (1) g of sample was weighed into a conical graduated centrifuge tube. Using a waring whirl mixer, the sample was thoroughly mixed, 10 ml distilled water or oil was added and mixed again for 30 seconds. The sample was allowed to stand for 30 minutes at room temperature and then centrifuged at 5,000 rpm for 30 minutes. The volume of free water or oil (the supernatant) was read directly from the graduated centrifuge tube.

Note: Absorption capacity was expressed as grams of oil or water absorbed (or retained) per gram of sample.

Calculation: The amount of oil or water absorbed (total minus free) was multiplied by its density for conversion to grams. Density of water is 1g/ml that of oil varies depending on the type of oil (which can be determined). Canola oil for example has a density of 0.914 to 0.920g/1ml (AOAC, 2012).

3.3.4 Pasting properties

The pasting properties was determined using Perten RVA (4500).

3.3.5 Sensory evaluation of dough meal prepared from flour blends

Panelists who are familiar with dough meal were used for the organoleptic evaluation of the dough meal made from the blends of plantain, defatted sesame and rice bran flour using a 9 point hedonic scale, 9 indicating like very much and 1 indicating dislike very much. The dough meal was assessed for colour, aroma, appearance, texture, mouthfeel, taste and overall acceptability.

3.4 Experimental Design

3.4.1Animal grouping and treatment

Thirteen Wistar rats of weight >180g were acclimatised for two weeks under standard room condition (temperature of 22±3^{o}C; photoperiod of 12h/12h light/dark cycle) and fed with rat feed. After 2 weeks of acclimatization to the new environment, the initial baseline blood glucose levels of the animals were taken; after fasting the rats overnight, and it was repeated twice over the 3 weeks of treatment.

The rats were randomly grouped into four groups as follows:

Group 1 –control female

Group 2–control male

Group 3–experimental diet female

Group 4– experimental diet male

At the end of the treatment regimen which lasted for 3 weeks, rats were fasted overnight, the blood glucose level was taken. The rats were anaesthetized with diethyl ether and sacrificed by jugular puncture. Blood samples were collected in a non heparinsed tube and serum was separated by centrifugation of the clotted blood for 25 minutes at 3000rpm . The serum collected wasused for biochemical analysis (shittu *et al.,* 2013)

3.4.2 Determination of Fasting Blood Glucose Level

The level of fasting blood glucose was determined using the glucometer kit by Accu-Chek after an overnight fast for 12 hours. In the morning, the tip of the tail of the rats were punctured using a lancet, blood from the tail region was allowed to drop on the glucose test strip which was inserted into a glucometer to determine the fasting blood glucose level.

3.4.3 Sample collection Preparation of serum and samples

The serum and supernatant were prepared using the method reported by Yakubu et al (2008). The rats were weighed individually and then placed in a jar with cotton wool soaked in diethyl

ether to anaesthetize them. The jugular veins were exposed after the fur and skin on the neck were removed. The jugular veins were slightly moved from the neck area before being cut with a sharp sterile blade. The animals were held head downwards, allowed to bleed into clean, dry sample tubes and left at room temperature for 10 minutes to clot. The blood samples were centrifuged at 4000rpm for 10 minutes to obtain the supernatant from the stock using Thermo Scientific Centrifuge (Heraeus Megafuge 8).

The sera were thereafter aspirated using Microflux pipette into clean, dry, sample bottles and were then stored frozen (-4^{0}C) till it was needed.

3.5 Biological Assays

3.5.1 Assay for Cholesterol

The serum were used for the cholesterol assay using Randox kit.

Tubes were labeled and grouped accordingly: one tube for blank and another for standard. Ten (10) µl of the samples was pipetted into clean test tubes, 1000µl of the working reagent was added to each test tubes, 10 µl of the standard reagent was pipetted into a clean test tube, 1000 µL of the working reagent was added to the test tube, 10 µl of distilled water was pipetted into a clean test tube, 1000 µl of the working reagent was added to the test tube. All the tubes were incubated at 37 ℃ for 5 minutes and the absorbance was read at 500 nm against blank using a spectrophotometer (Cole-Palmer Ltd, UK). Concentration of cholesterol was obtained using the formula:

(Absorbance of sample/Absorbance of standard) x concentration of standard (203 mg/dl).

3.5.2 Assay for Triglyceride

The serum were used for the triglyceride assay using Meril kit.

Tubes were labeled according to the identity and the group given to the experimental animal, alongside one tube for blank and another for standard. 10 µl of the samples was pipetted into clean test tubes, 1000 µl of the working reagent was added to each test tubes, 10 µl of the standard reagent was pipetted into a clean test tube, 1000 µl of the working reagent was added to the test tube, 10 µl of distilled water was pipetted into a clean test tube, 1000 µl of the working reagent was added to the test tube. All the tubes were incubated at 37 ℃ for 5 min and the absorbance was read at 500 nm against blank. The concentration of cholesterol was obtained using the formula:

(Absorbance of sample/Absorbance of standard) x concentration of standard (192 mg/dl).

3.5.3 Assay for HDL-cholesterol

The serum was used for the HDL-cholesterol using Randox kit.

Tubes were labelled according to identity and group given to the experimental animal then 200 µl of samples was pipetted into sample bottles, 500 µl of the reagent was added to the sample bottles. The sample bottles were allowed to incubate for 10 min at room temperature then they were centrifuged for 10 min at 4000 rpm. After centrifugation the clear supernatant was pipetted from the sample bottles and put into clean test tubes, alongside one tube for blank and another for standard. 10µl of the samples was pipetted into clean test tubes, 1000 µl of the working reagent was added to each test tubes, 10µl of the standard reagent was pipetted into a clean test tube, 1000 µl of the working reagent was added to the test tube, 10 µl of distilled water was pipetted into a clean test tube, 1000 µl of the working reagent was added to the test tube. All the tubes were incubated at 37 ℃ for 5 min and the absorbance were read at 546 nm against blank. The concentration of cholesterol was obtained using the formula:

(Absorbance of sample/Absorbance of standard) x concentration of standard (203 mg/dl).

3.6 Statistical Analysis

The statistical analysis was carried out using Graph Pad Prism Software (GPPS 9.0) and Statistical Product and Service Solution (SPSS) version 26. The results were reported as mean ± SEM (standard error of mean). The data collected were subjected to one way analysis of variance (ANOVA). Test of significance was at 0.05% probability ($p < 0.05$).

3.7 Waste disposal

Experimental wastes were incinerated, and the mice carcasses were buried in designated location.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Proximate composition of flour blend

The result obtained from the proximate analyses of different samples as illustrated in table 4.1. The table shows that there was significant difference ($p \leq 0.05$) in the moisture content of the different ratios of flour blend. The moisture content ranged from 10.89-12.30%, the variation in the values obtained for the moisture content might be due to the ratio of defatted sesame flour and rice bran flour present in it. Oluwajuyitan *et al* (2021) reported the moisture content of plantain flour to range from 4.20–5.43%. There was a significant decrease in moisture content of the flour with the increase of rice bran flour inclusion. Sample E (65% plantain flour, 30% defatted sesame flour and 5% rice bran flour) was observed to have the lowest moisture content while sample D (70% PLT flour, 22% DFS flour and 8% RB flour) had the highest moisture content. There was no significant difference between sample A and B and also sample C and E. These samples are at minimum limit of moisture content for flour. According to research it is stated that finished flour can reach a maximum of 14.0% in moisture. The moisture content goes a long way in suggesting the shelf life of the product. The low moisture contents will also improve the storage stability of the flour blends as mold growth and moisture-dependent biochemical reactions will be retarded.

There was a significant difference ($p \leq 0.05$) in the protein content of the flour blend with values ranging from 4.93% to 16.36%. Odebode *et al.* (2017) reported that the values of the protein contents of flour blends of unripe plantain, soy bean cake and rice bran ranged from 16.86 to 18.15 g/100 g. The difference in the value could be due to the use of soybean in place of sesame in the flour blend and the quantity of the defatted sesame flour used Sample C (70 PLT,

30% DFS) had the highest protein content (16.36%) while sample A (100% PLT flour) had the lowest (4.93%). There was a significant difference ($p \leq 0.05$) in the protein content of the samples with the increase of DFS in the flour blend.

A significant difference ($p < 0.05$) exists between the ash values of the flour blends. The values of ash content of the flour blend ranged from 1.59% to 3.59%. The values reported by Oluwajuyitan et al, (2021) 1.9 to 4.9% is similar to the values obtained for this flour blends in this work. The ash values were relatively high.

The value obtained for the crude fibre ranges from 2.0 % to 3.50 % for the flour blend. Sample A (100% PLT) had the lowest ash and crude fibre content, having 1.59% ash and 0.50 % fibre respectively. There was a significant difference ($p < 0.05$) between crude fibre values for the flour blends compare to the 100% PLT. Sample B (70% PLT, 20% DFS, and 10% RB) has the highest percentage of crude fibre because it contains the highest percentage of RB flour compared to the other flour blends. There was no significance difference between samples C, D and E. Odebode *et al.* (2017) reported the fibre content of the blends of plantain flour-soybean-rice bran ranged from 5.26 to 6.99g/100, this could be due to the higher content of rice bran used for the flour blends, Oluwajuyitan et al. (2021) also reported high value 1.23 to 5.43% for the flour blends which is due to the combination of rice bran (RB) and oat bran. Onsaard *et al.* (2013) reported values for DFS as 5.27% and Bhosale *et al*. (2015) reported value of 4.64 to 4.92 % for RB. Regular dietary fiber intakes have been shown to delay carbohydrate breakdown and absorption in the gastrointestinal tract, lowering postprandial blood glucose and diabetes risks (Latimer et al., 2010).

There was a significant difference ($p < 0.05$) between the carbohydrate content of the samples, which values ranges from 64.09% to 74.92%, The starch content was generally high because the main constitute of all the flours used was plantain flour. Sample A had the highest carbohydrate content of 74.92% while sample E had the lowest due to the decrease in percentage of PLT flour used. Sample B and D are not significantly different ($p > 0.05$) from each other, also sample C and E are not significantly ($p > 0.05$) different each other.

The values obtained for the crude fat content of the flour blends ranged from 2.33% to 5.80%.It was observed that the fat content decreased with increase in DSF and RB. Sample A

had the highest fat content of 5.80% while sample B had the lowest value of 2.33%.There was no significant difference between sample B, D and E having the similar fat content of 2.33, 2.63% and 2.61% respectively.

Table 4.1 Nutritional composition of plantain, defatted sesame, and rice bran flour

Sample	Protein (%)	Ash (%)	Fibre (%)	Moisture (%)	Fat (%)	Carbohydrates (%)
A	4.93±0.67^{e}	1.59±0.20^{c}	0.50±0.00^{c}	11.57±0.04^{b}	5.80±0.30^{a}	74.92±1.33^{a}
B	10.52±0.62^{d}	3.09±0.10^{b}	3.50±0.00^{a}	11.63±0.10^{b}	2.33±0.13^{c}	68.94±0.94^{b}
C	16.36±0.34^{a}	3.09±0.11^{b}	2.00±0.00^{b}	10.95±0.35^{c}	3.46±0.21^{b}	64.15±0.12^{c}
D	11.72±0.09^{c}	3.59±0.00^{a}	2.50±0.50^{b}	12.30±0.05^{a}	2.63±0.14^{c}	67.27±0.51^{b}
E	14.75±1.09^{b}	3.50±0.10^{a}	2.50±1.00^{b}	10.89±0.11^{c}	2.61±0.15^{c}	64.09±1.45^{c}

Mean values with different superscript in the same column are significantly different at ($P<0.05$).

Key:

A- 100:0:0

B- 75:15:10

C- 70:30:0

D- 70:22:8

E- 65:30:5

Where: ratio represents

Plantain: defatted sesame: rice bran flour

PLT=plantain, DFS= defatted sesame, RB= rice bran

e

4.2 Functional properties of flour blends

Table 4.2 shows the results for functional properties of the blends of plantain, defatted sesame and rice bran flour. There was significant difference ($p \leq 0.05$) in the bulk densities of the different ratios of flour blends. Bulk densities ranged from 1.80 to 3.17 g/ml. Sample E had the highest bulk density of 3.17g/ml, while the lowest bulk density of 1.80g/ml (100% PLT). This could be due to the particle size of the flour. Sample B, C and D had similar bulk density. Sample E which has the highest bulk density may be as a result of its rice bran quantity, it has highest percentage of rice bran. Bulk density is generally affected by the particle size and density of the flour and it is very important in determining the packaging requirement, materials handling and uses in food preparation (Wang et al., 2009).

The water absorption capacity determines the amount of water the flour will absorb during mixing. During mixing, sample C will absorb the available water within the dough compared to other samples. There was a significant difference ($p<0.05$) in the water absorption of the flour blends which ranged 2.13 to 3.21 g/g. Sample E had the lowest WAC of 2.13 g/g while sample C had the highest WAC of 3.21g/g. There was no significant difference between samples B, and D as they had similar values of WAC.

Oil absorption capacity (OAC) is a measure of the amount of oil that will be absorbed by the flour when mixing. It is an important functional attribute that enhances mouth feel while conserving food taste (Adebowale & Lawal, 2004). There was a significant difference ($p<0.05$) in the oil absorption of the flour blends which ranged from (2.81 to 3.08). Sample D had the highest OAC of 3.08. Sample B and D had similar values also sample C and E had similar values they were not significantly different ($p>0.05$) from each other.

Swelling power is an indication of the absorption index of the granules during heating (Coffman, 2007). There was a significant difference ($p<0.05$) in the swelling capacity of the flour blends which ranged 4.59 to5.58 g/g. Values obtained for Samples, B, D and E were not significantly different ($p>0.05$). Sample A and C were not significantly different ($p>0.05$) from each other. Sample C had the highest swelling capacity.

The wettability increased as the water absorption decreased. For wettability it ranged from 64.67 to 152.33 g/ml sample E had the lowest value of wettability, this may because of it contains least amount of plantain.

Table 4.2 functional properties of plantain, defatted sesame, and rice bran flour

SAMPLES	Bulk Density g/g	Swelling Capacity g/g	WAC (g/g)	OAC (g/g)	Wettability (g/ml)
A	1.80±0.00[c]	5.28±0.04[a]	2.69±0.01[c]	2.81±0.08 [b]	152.33±4.04 [a]
B	2.03±0.06 [b]	4.70±0.29[b]	2.90±0.06[b]	3.00±0.01 [a]	109.30±10.78 [b]
C	2.50±0.17[a]	5.58±0.15[a]	3.21±0.10[a]	2.96±0.14 [ab]	102.00±12.28 [b]
D	2.00±0.00 [b]	4.59±0.20[b]	2.98±0.00[b]	3.08±0.05 [a]	74.00±1.00 [c]
E	3.17±0.17a	4.76±0.04[b]	2.13±0.03[b]	2.94±0.11 [ab]	64.67±8.39 [c]

Mean values with different superscript in the same column are significantly different at (P<0.05).

Key:

A- 100:0:0

B- 75:15:10

C- 70:30:0

D- 70:22:8

E- 65:30:5

Plantain: defatted sesame: rice bran flour

PLT= plantain, DFS= defatted sesame, RB= rice bran

4.3 Mineral composition

There was significant difference (p<0.05) in the mineral content of the flour blends, the mineral content increased as the PLT content decreases. Sample A (100% PLT flour) had the lowest mineral content and sample E had the highest mineral content. The calcium content of the flour ranged from (44.34% to 67.66%), the magnesium content ranged from (18.50 to 31.47%), the phosphorous content ranged from (10.53 to 21.65%), the potassium content ranged from (55.61 to 75.90%), the chromium content ranged from (3.87 to 5.74%), and the sodium content ranged from (33.14 to 49.58%).

The above mineral elements in the flour was significantly different (p <0.05) from each other except that of the magnesium content of Sample C and D which were not significantly different (p >0.05) from each other.

Table 4.3 Mineral composition of plantain, defatted sesame, and rice bran flour

Sample	Calcium	Magnesium	phosphorous	Potassium	Chromium	Sodium
A	44.34±1.38^{e}	18.50±0.07^{d}	10.53±0.03^{e}	55.61±0.29^{e}	3.87±0.04^{e}	33.14±0.17^{e}
B	45.91±0.07^{d}	21.19±0.21^{c}	10.88±0.05^{d}	59.55±0.10^{d}	4.13±0.03^{d}	33.87±0.11^{d}
C	52.41±0.07^{c}	28.51±0.06^{b}	11.36±0.04^{c}	62.36±0.04^{c}	4.58±0.01^{c}	38.59±0.08^{c}
D	62.57±0.23^{b}	28.60±0.13^{b}	14.65±0.30^{b}	75.52±0.09^{b}	5.17±0.05^{b}	43.66±0.16^{b}
E	67.66±0.16^{a}	31.47±0.45^{a}	21.65±0.23^{a}	75.90±0.11^{a}	5.74±0.03^{a}	49.58±0.07^{a}

Mean values with different superscript in the same column are significantly different at ($P<0.05$).

Key:

A- 100:0:0

B- 75:15:10

C- 70:30:0

D- 70:22:8

E- 65:30:5

Plantain: defatted sesame: rice bran flour

PLT= plantain, DFS= defatted sesame, RB= rice bran

4. 4 Sensory Evaluation of flour blend

Table 4.5 shows the results of the sensory analysis of dough meal prepared from the flour blends. The values ranged from 4.00 to 7.25 for appearance, 4.00 to 7.00 for taste, 5.50 to 7.50 for color, 3.00 to 7.25 for texture, 5.25 to 7.00 for smell, 3.75 to 7.25 for mouth feel, and 4.00 to 7.50 for overall acceptability. Samples B, C, D and E had no significant difference in their appearance at (p<0.05). Only sample A was significantly different, with the value 7.25. There was a significance difference between values obtained for the taste samples, sample A was the highest in taste but it showed no significant difference compared with sample C and D. Also sample C and D was not significantly different at (p<0.05) from sample B and E. There was a significant difference in the texture between sample A and the rest of the samples (B, C, D, and E) this may be due to coarse and gritty nature of rice bran flour.

There was no significant difference at (p>0.05) in the taste and aroma of the samples. For the mouth feel, sample A was the highest, and it showed no significant difference to sample D.

For the overall acceptability sample A was the highest, for the other samples sample B, C, D and E, there was no significant difference (p<0.05). The overall acceptability was affected likely by the texture. The result shows that the more work needs to be done for the acceptability of the flour blends sample D and E had the value which means it is neither like nor dislike.

The results of the evaluation also showed that dough made from the flour blend of PLT, DFS and RB is acceptable as the control. The highest score was sample A (7.50), followed by sample D and E with the score 5.50 and the last place was sample B and C with the value as 4.00.

Table 4.4 Sensory analysis of plantain, defatted sesame, and rice bran flour

SAMPLE	Appearance	Taste	Texture	Color	Aroma	Mouth feel	Overall acceptability
A	7.25±1.26^{a}	7.00±0.82^{a}	7.25±0.50^{a}	7.50±1.00^{a}	7.00±1.41^{a}	7.25±0.96^{a}	7.50±0.58^{a}
B	4.25±0.96^{b}	4.00±0.82^{b}	4.00±0.82^{b}	5.50±1.29^{a}	5.25±0.96^{a}	3.75±0.50^{c}	4.00±0.82^{b}
C	4.00±2.16^{b}	5.00±0.82^{ab}	3.00±1.41^{b}	5.25±1.71^{a}	6.25±0.96^{a}	4.75±0.96^{bc}	4.25±1.50^{b}
D	4.00±1.63^{b}	5.00±1.15^{ab}	4.00±2.45^{b}	7.25±0.96^{a}	6.50±1.91^{a}	6.00±0.82^{ab}	5.00±1.41^{b}
E	4.50±1.29^{b}	4.75±2.22^{b}	4.75±1.50^{b}	5.50±1.73^{a}	5.75±1.71^{a}	5.25±2.06^{bc}	5.50±1.00^{b}

Mean values with different superscript in the same column are significantly different at (p<0.05).
Key:

A- 100:0:0

B- 75:15:10

C- 70:30:0

D- 70:22:8

E- 65:30:5

Plantain: defatted sesame: rice bran flour

PLT= plantain, DFS= defatted sesame, RB= rice bran

4.5 Pasting properties of the flour blend

In the food sector, the pasting property is critical in assessing quality and aesthetic features. It has an impact on the texture and digestibility of starch-based foods, as well as their final use.(Adebowale, Sanni, & Awonarin, 2005; Ajanaku, Ajanaku, Edobor-Osoh, & Nwinyi, 2012; Onweluzo & Nnamuchi, 2009). It is an index for predicting the ability of a food to form a gel when exposed to heat applications. There was no significant difference ($p \leq 0.05$) in the pasting properties of the flour blend. The peak viscosity is known as the maximal viscosity created during or shortly after the heating stage. It's a measure of a starch-based food's ability to swell freely before physical breakdown. The value obtained for the peak viscosity (1533.67 cP to 4098.33 cP) is similar to the values of the peak viscosity of the flour blends reported by (Odebode *et al*, 2017). Trough viscosity is the point in which the viscosity reaches its lowest point during either heating or cooling processes. It assesses the paste's ability to withstand breakdown during cooling. The values obtained for the trough viscosity ranged from 1392.67 cP to 3545 cP).

Breakdown ranged from (141cP to 553.33 cP), breakdown measures the stability of the flour to withstand heating and shear stress during cooking. Final viscosity shows the ability of a flour to form a viscous paste after cooking and during cooling. It ranges from 1695.67 cP to 5195.33 cP. Setback value ranged from 303 to 1650.33, it is the tendency of starch granules to revert as they cool. Peak time is a measure of the cooking time and it ranged between 3.62 to 4.44min for the flour blends. Pasting temperature indicates the minimum temperature it requires for the flour to form paste or cook. It ranges from 56.42 ^{o}C to 56.87 ^{o}C. According to the statistical analysis there was no significant difference ($p<0.05$) in the pasting properties of the flour blends.

Table 4.5 Pasting properties of plantain, defatted sesame, and rice bran flour

Samples	Peak (cp)	Trough (cp)	Breakdown (cp)	Final viscosity (cp)	Setback (cp)	Peak time (min)	Pasting temperature(^{o}c)
A	4098.33[a]	3545.00[a]	553.33[a]	5195.33[a]	1650.33[a]	3.62[a]	56.42[a]
B	1997.00[a]	1745.67[a]	251.33[a]	2358.33[a]	612.67[a]	3.91[a]	56.43[a]
C	1855.67[a]	1642.00[a]	213.67[a]	2124.00[a]	482.00[a]	4.27[a]	56.88
D	1800.33[a]	1600.67[a]	199.67[a]	2081.33[a]	480.67[a]	4.09[a]	56.95[a]
E	1533.67[a]	1392.67[a]	141.00[a]	1695.67[a]	303.00[a]	4.44[a]	56.87[a]

Mean values with different superscript in the same column are significantly different at ($P<0.05$).

Key:

A- 100:0:0

B- 75:15:10

C- 70:30:0

D- 70:22:8

E- 65:30:5

Where: ratio represents Plantain: defatted sesame: rice bran flour

PLT= plantain, DFS= defatted sesame, RB= rice bran

Cp: centipoise

4.6. Animal study result

4.6.1 Blood glucose reduction level

Blood glucose reduction level in Wistar rats fed with the experimental and control diets was observed (Figure 4.1). It was found that blood glucose before the experimental diet was introduced was higher compared to the final blood glucose level taken. The experimental animal blood glucose was lower compared to the control diet animal. There was a significant decrease ($p < 0.05$) in the blood glucose level of the rats fed with experimental diet compared to that of the control. The blood glucose reduction level of the rats ranged from 67 to 73.50 mg/dl for the rats fed with control diet, and 49 to 50 mg/dl for the rats fed with experimental diet.

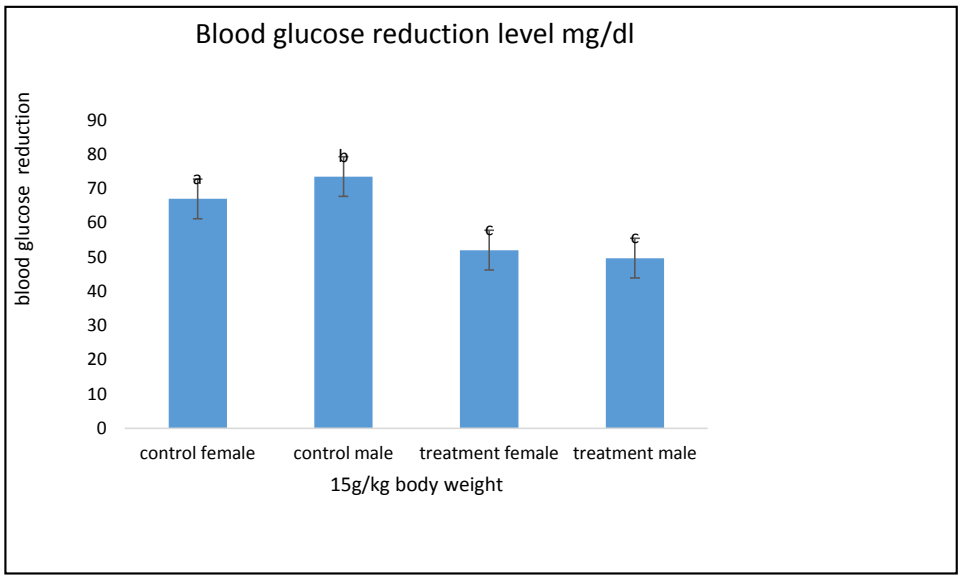


FIGURE 4.1: Blood glucose reduction level graph inExperimental rats

4.6.2 Total cholesterol level

There was a significant difference ($p < 0.05$) in the serum total cholesterol concentration of the experimental rats (Figyre 4.2). The group of rats fed with experimental diet had a lower total cholesterol compared to the group that was fed with normal rat feed (control animal). The total cholesterol level ranged from 121.49 to 173. 78 mg/dl, the control male having highest and the experimental male having the lowest level of total cholesterol

This is comparable to the values, 147.4 to 156.2 mg/dl obtained by Odebode et al. (2017) for the flour blends effect on total cholesterol.

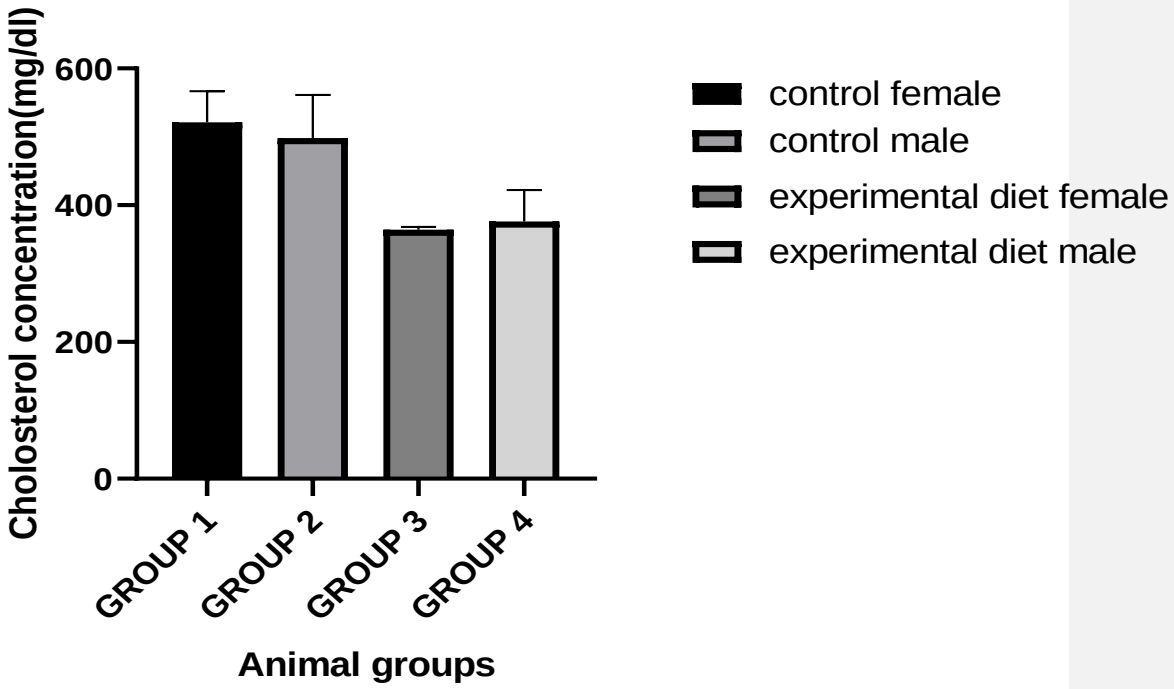


Figure 4.2 Serum Total cholesterol level in Experimental Rats

4.6.3 Triglycerides

There was a significant difference ($p < 0.05$) in the serum triglycerides concentration of the rats fed with the experimental diet (Figure 4.3). The group fed with experimental diet had a lower triglycerides compared to the group that was fed with normal rat feed (control animal).

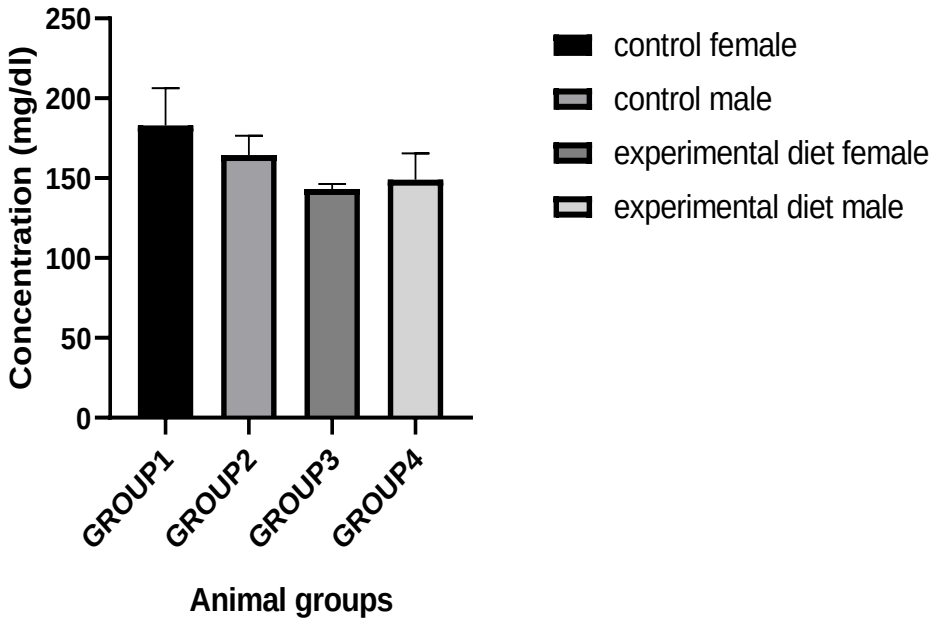
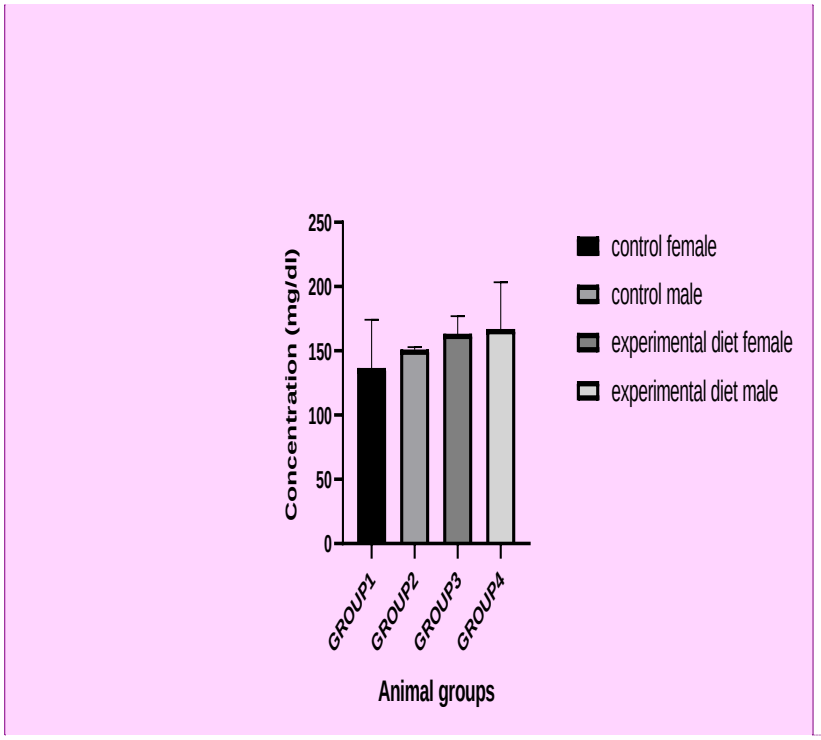


Figure 4.3 Serum Triglycerides level in Experimental Rats

4.6.4 High density lipoprotein (HDL)

There was a significant difference ($p < 0.05$) in the HDL concentration of the experimental rats (Figure 4.4). The group fed with experimental diet had a higher HDL concentration compared to the group that was fed with normal rat feed (control animal). The increase of high-density lipoprotein may help to reduce the risk of cardiovascular diseases. The value for HDL ranged from 45.50 to 55.62mg/dl the female experimental rats showed the highest value. Compared to the FAO standard reference which is >40 HDL range the experimental diet had a positive effect.



Comment [OA1]: ditto

Figure 4.4 Serum High density lipoprotein levels in Experimental rats

Where: HDL-High density lipoprotein

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Flour blends was produced, dough meal was further produced from the blends of plantain, defatted sesame and rice bran flour. The flour blends was analyzed.

In this study, the addition of defatted sesame and rice bran to improve the protein content and crude fibre respectively.

The nutritional analysis of the PLT, DFS and RB revealed that the fiber, ash and protein of the samples were significantly increased.

This can help in the reduction in malnutrition, and in side effect associated with taking medication to reduce blood sugar level.

In conclusion, the obtained outcome of this study stated that addition of defatted sesame and rice bran flour by different ratios to plantain flour as used in the developed dough meal did not only improve its nutritional value but could also help in the management of diabetes and cardiovascular diseases associated with blood glucose and blood cholesterol.

5.2 Recommendation

Clinical studies of the flour blend is recommended to further validate its potential in managing diabetes. For maximum acceptability, inclusion of rice bran flour should not excess 10%, but consumer preference can also be noted. The flour blend can also be produced for commercialization after the clinical studies is carried out.

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