NUTRITIONAL, FUNCTIONAL AND IN-VIVO STUDIES OF COOKIES PRODUCED FROM FLOUR BLEND OF PLANTAIN, SESAME AND RICE BRAN

BY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, COLLEGE OF BASIC AND APPLIED SCIENCE

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF BARCHELOR OF TECHNOLOGY IN FOOD SCIENCE AND TECHNOLOGY

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DECLARATION

I hereby declare that this project has been written by me and is a record of my own research work. It has not been presented in any previous application for a 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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Moses, Mercy

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Date

CERTIFICATION

This is to certify that the content of this project entitled; **Nutritional, Functional and In-Vivo Study of Cookies produced from Flour Blends of Plantain, Sesame Seed and Rice Bran** was prepared and carried out by **Moses, Mercy** in partial fulfillment of the requirement 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

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DEDICATION

I will like to dedicate this research work to God Almighty for His inspiration and guidance throughout my years of study. Also, to my parents for being every step of the way to support and encourage me throughout my academic years.

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ABSTRACT

Cookies are widely consumed as snacks, but deficient in protein, resulting in protein-energy malnourishment. Its enrichment with protein-rich and fibre-rich food sources could minimize malnutrition and help in managing diabetes and cardiovascular diseases which are prevalent, with side effects associated with use of orthodox medications for its treatment. The objective of this study therefore was to develop cookies from plantain flour enriched with defatted sesame seed and rice bran and evaluate its nutritional, sensory properties and ability to lower blood glucose and blood cholesterol using animal experiment. The cookies was prepared using the 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). Minerals (Ca, Mg, Na, P, K, Cr) (85.67 to122.27, 23.58 to 43.31, 45.50 to 68.54, 18.37 to 39.47, 85.61 to 120.42 and 45.50 to 68.54 mg/100g), protein (4.93% to 16.36%), fibre (0.50 to 3.50%) and ash contents (1.59% to 3.59%) increased significantly (p<0.05) with the enrichment. The samples showed no significant difference from the sensory attributes of unenriched cookies. The developed cookies could be preferred as it provides better nutritional quality, substitute for wheat-intolerant individuals, potential for lowering blood glucose and blood cholesterol level and more utilization of local food materials.

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CHAPTER ONE INTRODUCTION

1.1 Background of study

Cookies are sweet biscuits that are flat and dry. The term biscuit derives from the French word "biscuit," which means "twice-cooked," which is a literal explanation of how biscuits were made in the beginning. Biscuits and other pastries such as meat pies, cookies, and cake can be made from flours of locally available crops such as sweet potato, cassava, corn, rice, millet, sorghum. (Hasmadi *et al*., 2014). Cookies are a popular confectionary food item in Nigeria, especially among children. It is a ready-to-eat, easy, and affordable food product that contains important digestive and dietary properties (Oyeyinka *et al.* 2014). In Nigeria, the pastry and bakery industries' reliance on wheat flour has limited the use of other cereals and tuber crops available for domestic consumption over time. In recent years, the government has supported the use of composite flours in the development of bread and related foods such as biscuits by working closely with research institutes. This initiative has increased the use of flours made from cassava, sweet potato, breadfruit, plantains, and other underutilized flour-producing crops. The use of these locally manufactured flours in the bakery industry would increase the use of indigenous Nigerian crops while also lowering bakery product costs (Oyeyinka *et al.* 2014)

Rice processing or milling generates a variety of materials which includes milled rice, parboiled rice and rice bran. During the milling, rice bran is obtained as a by-product of the rice milling industry, it is an indispensable, less costly, abundantly available soft and fluffy off-white powdery content (Mohammed., *et al.* 2014). It accounts for 10% of the weight of the whole grain, which comprises the majority of the nutrients. Most of the time rice bran is used as fuel for cooking purposes or for feeding animal and also, a good quality edible oil could be produced from it. Rice bran contains important amino acids, micronutrients, dietary fibers, and bioactive substances that may help to lower total blood cholesterol, triglyceride, and low-density lipoprotein concentrations while raising high density lipoprotein concentrations (Liang *et al*: Ryan., *et al.* 2011).

Sesame (*Sesamum indicum* Linn) is a high-quality edible oil seed and are high in protein (Idowu *et al* 2021). Sesame seeds are utilized in a variety of food goods, both raw and roasted, as well as industrial applications such as soaps, lubricants, lamp oil, as a cosmetics

ingredient, pharmaceutical applications, and animal feed. It's high in oil, proteins, carbs, vital minerals, methionine and tryptophan, fibers, and secondary metabolites like lignans, saponins, and flavonoids, moreover, the seeds are a good source of calcium, phosphorus, and iron and are rich in vitamin B, E, and a small amount of trace elements (Idowu *et al* 2021).

Plantain which belongs to the family of banana and is popularly called cooking banana since it is not often eaten raw (Rodriguez- Ambriz *et al*, 2008). Unripe plantain which is known to be a highly perishable food in Nigeria are processed into flour and are traditionally prepared as gruel or paste (Badejo, *et al* 2017). Plantain is an excellent source of nutrients such as vitamin A, C, B_1, B_2, B_3, potassium and fiber (Oboh and Erema 2010, Adetuyi *et al* 2012) furthermore, plantain has high carbohydrate content but low in fat and it is also a good source of iron, and calcium. The flour contains resistant starch type 2, which are native uncooked granules whose crystallinity makes them scarcely sensitive to hydrolysis, and the unripe plantain is high in indigestible carbohydrates starch (sarawong, *et al* 2014). Resistance starch provides the benefit of improving the digestive system's function, blood cholesterol levels, and diabetic management (Fuentes Zaragoza *et al* 2010).

Rapid changes are occurring in every human activity domain today, causing customer preference problems to become more complex. Consumers are becoming more health-conscious, preferring locally produced foods that promote a healthier lifestyle over imported foods. Food products must be easy to prepare while reducing saturated fat, cholesterol, sodium, and calories to succeed in today's market. However, as people's lifestyles have changed, their eating habits have shifted in favor of convenience, speed, and nutritional benefits (Giarnetti *et al.*, 2015). As a result, modern customers expect the food industry to play a significant role in meal preparation (Kiharason *et al.* 2017). Taste, price, nutrition, health, technical innovation, and convenience have all taken precedence in consumer preferences. Due to time constraints, there is a growing demand for convenience. There are more convenience goods and snacks eaten at work now than there were before (Alozie *et al.*, 2009). Traditional food crops are suffering from poor consumption as a result of this shift, particularly in urban and cosmopolitan areas where residents prefer to buy processed and packaged foods (Onyango *et al*. 2008). Baking products made from wheat flour, such as bread, cakes, biscuits, and doughnuts, are very popular (Kiharason *et al.* 2017), The nutritional value of these foods is determined by the recipes used in their production. The low protein content of wheat flour, due to deficiency in one or two essential amino acids, and yet it is the most vital ingredient in these baked products, is the main concern in its utilization

(Kiharason *et al*.2017). When processed whole wheat grain is used to make white flour, the nutritional density and fiber content are drastically reduced (Maneju *et al*., 2011). Consumer awareness of the importance of eating high-quality, healthy foods, also known as functional foods, which contain ingredients that provide additional health benefits beyond basic nutritional needs, is increasing these days (Hasmadi *et al*., 2014).

1.2 Statement of the problem

Cookies made from wheat flour alone contain low fibre, vitamins and minerals (WHO/FAO,2003: Chinma and Gernah.,2007) It has also been discovered that certain individuals with celiac disease react to certain cereal protein particularly gluten in wheat. Processing of defatted sesame seed, unripe plantain flour and rice bran into different commodities will help increase their contents of vitamins, mineral, amino acids essential fatty acids dietary fiber and some antioxidant nutrient which help to fight against disease and also promote good health

1.3 Aim and Objective of the study

The aim of this study is to produced and assess the quality attributes of cookies from plantain flour, defatted sesame seed, and rice bran flour blends.

The specific objectives were to:

a) produce cookies from different proportions of unripe plantain flour, defatted sesame seed, and rice bran flour mixes

b) determine the functional properties of different flour blends of unripe plantain, defatted sesame seed, and rice bran.

c) to determine the proximate composition, nutritional and sensory properties of cookies made from flour blends.

d) check the effect of the developed products on blood glucose and blood cholesterol using animal experiment.

1.4 Significance of the study

This study evaluates the development of cookies made from plantain flour, defatted sesame seed, and rice bran there by combining the nutritional benefit of unripe plantain, defatted sesame seed and rice bran, which could be useful in protein energy malnutrition, celiac disease, diabetes and obesity.

1.5 Scope of study

This study center on the nutritional quality of cookies produces from unripe plantain flour, defatted sesame seed and rice bran, while checking the blood glucose and blood cholesterol levels through the in-vivo study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cookies

Biscuits and cookies are both made from wheat and other composite flours; however, the British refer to them as biscuits while the Americans refer to them as cookies (Ishinwu, 2011). Children and adults are increasingly shifting away from the typical three-meal-a-day eating pattern and opting for snacks instead. Composite flour has recently become popular in the pastry business for cakes and biscuits. Cookies, in combination with ice cream, make an excellent summer desert. They may be made in advance with no danger of spoilage and can be made in a great many varieties. Varieties depend upon the balance between four basic ingredients: flour, sugar, (shortening) fat, and liquids (milk and/or eggs). All cookies are more or less a variation of one basic formula. Because of its numerical balance of ingredients, the pound cake recipe could well serve as a basis for cookie recipes. Leavening agents, added to most varieties, have an effect on the size, color, and eating qualities. Additional ingredients are added for flavor and texture. There are two main types of cookies, hard and soft. Soft (soft batter) cookies contain a maximum amount of moisture. They may require a greater percentage of eggs to produce the necessary structure. Characteristics of good soft cookies are moistness and softness. Hard cookies contain a minimum amount of moisture. Desired characteristics of hard cookies are crispness and brittleness.

2.2 Functions of Ingredients used in Cookies Production

Each ingredient used in cookies baking is employed for the specific characteristics it has and/or the result it has on the finished product. If these effects are understood, the ingredients may be selected with the assurance that the products produced will be good (Ishinwu, 2011).

2.2.1 Sugar

Sugar in some form is used in all cookies recipes. It is an important tenderizing ingredient. Undissolved sugar crystals melt during baking which contributes to the flow or spread of the cookies.

2.2.2 Shortening (Fat)

Shortening promotes tenderness in the cookie and prevents excessive gluten development during mixing. Without shortening, cookie dough would be tough and rubbery, which would result in cookies being dry and lacking in eating qualities. Shortening contributes to the spread of the cookies. Regular, bland-tasting hydrogenated shortening is recommended and widely utilized. Cookies with butter and margarine have a more appealing taste and flavor.

2.2.3 Eggs

Eggs are both tenderizers and tougher in cookies baking. Egg yolks contain a very large percentage of fat which helps to tenderize the cookies. On the other hand, the egg white acts as structure builders because of the proteins which coagulate during baking. Eggs also contribute moisture. Some cookie recipes such as macaroon coconut cookies call for egg whites. Whole eggs contribute the combined characteristics of shortness, aeration, and tenderness.

2.2.4 Milk

Milk tends to exert a slight binding action on the dough. Milk is a valuable addition to cookie recipes because they provide added nutritional value. The milk sugar lactose, adds to the richness of the crust color.

2.3 Origin and Distribution of Sesame Seed

Sesame (*Sesamum indicum* L.) is an erect annual herb that is also known as sesamum, benniseed, or simsim. It is a member of the Pedaliaceae family. It is one of the oldest and most common oilseed crops, with high-quality seed oil as its main product. Sesame cultivation was derived from wild populations native to South Asia, according to recent archeological findings, and it was developed in South Asia. According to FAOSTAT (2020), seventy six percent (76%) of world production of sesame is produced in Asia while 26% of world production of sesame is produced in Africa. It is also known that sesame seed mostly grow in arid and semiarid land where its productivity is limited by drought and salinity

Nigeria is one of the top ten sesame-producing countries, and sesame is a valuable crop not only for oil production but also for internal and international markets. It's also an important

part of Nigerian cultural rituals and traditional cuisine, especially in the north. In some meals, it can also be used as a cooking oil, a garnish, a snack, or a flavoring enhancer. Nigeria produces two type of sesame seed namely; the black (NCRI-97-28), and white (NCRI-98-60), which are mostly grow in the northern part of the country such as the north east, north west and north center (Idowu *et al.,* 2021).). The white one are normally roasted and used as a topping in bakery products, snacks, and salads, while the black one is a high-value ingredient that are exported to Japan and other consuming countries, and the mixed seeds (red, brown, and yellow) are used for oil extraction and medicinal purposes, but are rarely found in Nigeria.

2.4.1 Uses of Sesame Seed

Sesame is planted for its nutritious seed, which is high in linoleic acid, protein, calcium, vitamin E, and trace amounts of vitamins A, B1, and B2. Nearly 70% of the world's sesame seed is used to make oil and meal, with the rest going to the food and confectionery industries (Morris, 2002). The oil is mostly used in cooking and salads dressing, as well as in the production of margarine. Sesame seed is used on bread, buns cookies, health snacks and as an additive to breakfast cereal mixes. The seeds may be eaten whole either raw or roasted and salted, or mixed with lemon and honey. In Africa, the paste, is used as a spread in preparing soups and sauces.

2.4.2 Dietary and Health Benefits of Defatted Sesame Seed

Sesame seeds are high in iron, magnesium, copper, and calcium, and contain 50% oil, 25% protein, 20–25% carbohydrates (Gebremichael, 2017). Phytosterols found in the seed have been linked to lower cholesterol levels in the blood (Zerihun, 2012). (Chinma *et al*.2012), defatted sesame flour includes 55.70% protein, 29.10% carbohydrate, 9.83% ash, and 1.64% crude fiber, which, when added to recipes, can offer a food product the correct nutritional balance. Their dietary protein is high in high-quality amino acids, which are important for children's growth (Tunde-Akintunde *et al*., 2012). Sesame seeds are very good source of B-complex vitamins and many essential minerals that have vital role in bone mineralization and red blood cell production (Tunde-Akintunde *et al*., 2012). Sesame boosts gamma tocopherol levels in the blood and enhance vitamin E activity, both of which are proven to help against cancer and heart disease (Chinma *et al*., 2012).

2.5 Origin and Distribution of Plantain

Plantain (*Musa paradisiaca*) is a plant of the Musaceae family that belongs to the Genus Musa. It's a massive perennial herb that's grown in various tropics and subtropical regions around the world. It is Nigeria's third most sustainable crop after yam and cassava (Akomolafe & Aborisade,2007). Millions of people in Nigeria rely on it as a source of starchy staple food. plantain pulp that has reached maturity is high in iron, potassium, and vitamin A, but low in protein and fat (Adeniji *et al.*, 2006). The water content of the green plant is at 61 percent, and it rises to around 68 percent as it ripens. The breakdown of carbohydrates during respiration is thought to be the cause of the increase in water. Due to the hydrolysis of the starch in the unripe plantain, amylase and amylopectin are replaced by sucrose, fructose, and glucose during the ripening stage (Zakpaa *et al.*, 2010). Plantain's chemical composition varies depending on the variety, maturity, degree of ripeness, and growing location (soil type)

2.5.1 Health benefit of plantain

Plantain soluble and insoluble fiber fractions have been shown to improve blood pressure, reduce salt sensitivity, and reduce kidney stone susceptibility (Mohamed *et al.*, 2010). Plantain also has a high concentration of vital minerals such potassium, phosphorus, chlorine, and magnesium, as well as vitamins A, B1, B2, and ascorbic acid. (Daniells, 2003; Krishnan and Prabhasankar, 2010). Potassium, one of the major minerals in plantain, is the third most abundant mineral in the human body and is important for regulating blood pressure, water retention, and muscle activity (Mohamed *et al*, 2010).

It has also been reported in literature that Green, unripe plantains have a protective capacity against acute aspirin-induced gastric mucosal injury. They are effective in healing of ulcers as well as having protective effect on the gastric mucosa against an acid insult in rats (Lewis, *et al* 2001). This is attributed to the presence of water-soluble polysaccharides and surface-active phospholipids in unripe plantains.

2.5.2 Uses of plantain

Plantains feed roughly 70 million people in West Africa on a daily basis (Eshetu and Tola, 2014). It is used in a variety of traditional cuisines and can be fried, boiled, roasted, or crushed and consumed with other foods or processed into beverages (Akubor, 2003;

Mohapatra *et al*., 2009). Once boiled, fried, or roasted, it can be eaten unripe (green), somewhat ripened (yellowish-green), or fully matured (yellow). Fruits of the plantain are often used to feed livestock. Diabetics commonly consume unripe plantain meal to lower postprandial glucose levels. This is because increased consumption of carbohydrate-rich foods with a high glycemic index increases the risk of diabetes and obesity (Oboh &Erema, 2010).

2.5.3 Plantain flour

A trend towards healthy eating has been witnessed (Singh *et al*, 2008). Therefore, food components that were once thought to be non-nutritive have since been found to be the key in disease prevention and overall maintenance of good health (Conforti and Davis, 2006). Considerable effort has been put into baking that has both health benefits and good sensory properties (Ivanovski *et al*, 2012). One strategy to achieve this is by enriching cookies with plantain flour. It is a good source of carbohydrates and nutritionally interesting bioactive compounds, fibre, resistant starch, vitamin A, B, C as well as calcium and iron (Kolawole and Ayojesuomi, 2010; Daniells, 2003). There is great interest in unripe plantain because of their functional components i.e., resistant starch and dietary fiber. The name plantain refers to the species that requires cooking (Adegunwa, 2011). Plantain is usually harvested when it is mature but unripe. It is highly perishable since it ripens within 2- 7 days when stored under normal conditions (Kolawole and Ayojesuomi, 2010; Muranga *et al*, 2010). Plantains are produced in excess in plantain producing regions leading to large quantities being lost during commercial handling (Ovando- Martinez *et al*, 2009). In tropical regions, postharvest losses are estimated to be about 300 g/ kg of produce (Yomeni *et al*, 2004).

This situation is exacerbated by the fact that, the industrial utilization of plantain is underdeveloped. Plantain flour contains a high amount of indigestible compounds such as resistant starch and dietary fiber which have been reported to possess beneficial effects on human health (Bello-Pérez *et al*, 2011; Rabbani *et al.*, 2010).

2.6 Origin and distribution of Rice Bran

Rice bran is obtained from the outer layer of the rice grain and contains a number of nutrients and physiologically active substances. It is a byproduct of the rice milling process. Stabilization, fractionation, enzymatic treatment, and fermentation are all common methods

for processing rice bran. Functional bran refers to rice bran that has been processed. Rice bran's standing as a functional food has been bolstered by the discovery of its bioactive components. It's high in B vitamins as well as minerals including phosphorus, potassium, iron, copper, and zinc. Rice bran has about 12-15% protein, according to reports (Faiyaz *et al*. 2007). The protein of rice bran has relatively high nutritional value. Rice bran protein has an unusual feature in that it contains a high amount of lysine, an important amino acid (Sudarat *et al*. 2005). Because of its nutritional superiority, abundance of micronutrients, extended shelf life, and stability at higher temperatures, rice bran oil is an ideal cooking medium (Sharma, 2002). Rice bran possesses anti-nutritional properties in addition to its nutritional benefits. Lipases are naturally occurring enzymes in rice that become active and rapidly hydrolyze unsaturated fat into free fatty acids and glycerol. The oxygen in the air oxidizes these fatty acids, causing them to turn rancid (Faiyaz *et al*. 2007).

Rice bran content varies depending on rice variety, geographical conditions, and processing methods. Rice bran, the outer layer of the rice grain, only accounts for 8–10% of the overall weight of the grain, but it includes the majority of the nutrients: carbohydrates (34–62%), lipids (15–20%), protein (11–15%), crude fiber (7–11%), and ash (7–10%) (Oliveira *et al*. 2011; Gul *et al*. 2015). Rice bran contains a high concentration of rice lipids and bioactive components. Rice bran is high in fatty acids such palmitate (21–26 percent), linoleate (31–33 percent), and oleate (37–42 percent). Rice bran is also regarded a nutritious food due to its high level of polyunsaturated fatty acids. Rice bran contains considerable amounts of bioactive substances such oryzanol, tocotrienol, tocopherol, and sitosterol, as well as dietary fibers including glucan, pectin, and gum (Oliveira *et al*. 2011). Oryzanol, the primary antioxidant found in rice bran, has ten times the antioxidant activity of tocopherol, whereas tocotrienol has 40–60 times the antioxidant activity of tocopherol. The quantities of these phytochemicals, however, differ depending on the rice variety. Rice bran also includes 4hydroxy3methoxycinnamic acid (FA), a photoprotective and antioxidative compound (Alauddina *et al*. 2017).

2.6.1 Health Benefit of Rice Bran

Rice bran provides health benefits oil and isolated active components stimulate the immune system Rice bran, which is high in phytosterols, oryzanol, and antioxidant chemicals, may help to regulate the immune system. Furthermore, rice bran possesses a number of health-promoting properties in general. Rice bran supplementation, for example, improves gut health

by stimulating Lactobacillus rhamnoses growth and colonization, and also protects pigs from human rotavirus diarrhea by modifying gut permeability. Long-term supplementation improves survival, cognition, and brain mitochondrial activity, potentially delaying Alzheimer's disease (Alauddina *et al*. 2017). Rice bran supplements can be used as ergogenic supplements by bodybuilders and athletes, and they may help to alleviate menopausal symptoms including hot flashes and osteoporosis bone loss in older women (Alauddina *et al*. 2017). Rice bran can be used as a source of plant-derived active compounds and as a cheaper alternative to animal-derived vitamins. Micronutrients can be found in varied colored rice bran, including a large reserve of carotene, which can be converted to vitamin A.

2.6.2 Uses of Rice Bran

Rice bran is being used extensively in the food industry to improve the nutritional quality of processed meals. Because rice bran is high in dietary fiber and has medicinal potential, it can help with the development of value-added or functional foods, which are now in high demand. Rice bran has been successfully supplemented in a variety of meals, including bread, cakes, noodles, spaghetti, and ice creams, without compromising the functional or textural features (Lavanya *et al*.,2017). Rice bran is mostly used as a food additive due to its high fiber content, which aids intestinal regularity. The most widely available rice bran-derived product from a marketing standpoint is the oil (Prasad *et al*. 2012). Rice bran oil has a high nutritional value, making it ideal for nutraceutical applications. Different product has been developed using rice bran by various researchers has shown in table2.1.

Table2.1: products from rice bran

Product enriched	Purpose of addition	Inference	Reference
Pizza with stabilized rice bran flour	Effect on chemical and functional properties of storage frozen pizzas	5% rice bran incorporated pizza dough stable for 60 days at −18°C	DeDelahaye *et al*. (2005)
Pasta	Effect on textural and antioxidant properties	pasta supplemented with rice bran was highly acceptable up to 4 months of storage	Kong *et al*. (2012)
Bread	Effect of replacing wheat flour by infrared stabilized rice bran on minerals and B vitamins	increase in the amount of B vitamins and minerals, especially niacin and phytic acid	Tuncel *et al*. (2014)
Pork meatballs enriched with bran	Effect on sensory and physicochemical properties	Protein, fat, and white index decreased as bran level increased	Huang *et al*. 2005
Cookies	Fiber and mineral enrichment	Supplementation improved dietary fiber content and mineral profile Defatted rice bran can be substituted up to 20% in wheat flour	Sharif *et al*. (2009)

2.6.3 Stability of Rice Bran

To minimize rancidity, off-flavor, refinement loss, and nutrition deterioration, the rice bran must be stabilized using appropriate ways for controlling unwanted responses. Lipase, the enzyme that causes the formation of free fatty acid, is destroyed or inhibited by stabilization (Lavanya *et al*.,2017). This is done to cut down on refining losses, which are directly proportional to the amount of free fatty acid in the oil. All components that cause degradation must be eliminated or their activity must be stopped in order to turn bran into a food-grade product with good keeping quality and high industrial value. In this regard, it's critical to note that enzyme inactivation must be full and irreversible (Lavanya *et al*,2017). Simultaneously, essential nutrients must be preserved. Bran can be a good source of protein, vital unsaturated fatty acids, calories, and nutrients such as tocopherols and ferulic acid derivatives following adequate stabilization. Rice bran is stabilized using a variety of thermal processes (to inhibit lipase activity). The most frequent approach for stabilizing rice bran is heat treatment. High temperatures above 120°C denature the lipid-degrading enzyme in rice bran without compromising the rice bran's nutritional value (Thanonkaew *et al*. 2012). The majority of the methods entail heat treatment, either dry or wet. Although it has been proposed that moist heat treatment is more effective than dry heat, few steam-based techniques have yielded adequate results. Depending on the time and temperature of the treatment, each distinct bran particle must have the right moisture content to accomplish effective stabilization.

2.7 Diabetes

Diabetes is a non-communicable lifestyle illness that affects both young and old people in all parts of the world, regardless of gender. The disease is a metabolic disorder caused by the body's inability to create or utilize insulin, and it has a significant impact on people's quality of life. With 3,921,500 cases reported and a prevalence rate of 4.99%, Nigeria has the highest number of persons with diabetes in Africa. Type 2 diabetes (T2D) accounts for 95% of all diabetes cases (Okoduwa *et al*.,2017). The causes of T2D are multi-factorial which includes both genetic and environmental elements that affect the β-cell function and insulin sensitivity. Africa is blessed with enormous biodiversity of resources yet plagued with several diseases. To comprehend diabetes, one must first comprehend the physiological processes that occur during and after a meal. Food is digested and absorbed into the bloodstream, where nutrients such as proteins, fats, and carbohydrate are absorbed (WHO., 2019). Functional foods, in

general, increase the concentration or contribute to, or improve the bioavailability of specific components. When it can be proven that a food improves body function or lowers the risk of disease, it is deemed functional.

2.8 Cholesterol

Cholesterol is an unsaturated alcohol from the steroid family that is necessary for the regular function of all animal cells and is a component of their cell membranes. 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 them (Niva et al., 2019).

CHAPTER THREE

MATERIAL AND METHOD

3.1 Material

3.1.1 Source of raw materials

Sesame seed was purchased from Jimeta modern market in Jimeta Yola, Adamawa State. The unripe plantain flour was purchase from Mowe market along Lagos, Ibadan express way, in Ogun state and while the rice bran was got from Royal sibling's ventures limited in Ketu, Lagos. The equipment's were obtained from food science and technology department laboratory (Mountain Top University).

3.1.2 Equipment

Oven, milling machine, table, rolling pin, blender, weighing balance, biscuit cutter, spoons, trays, conical flasks, beakers, pipette, burette, retort stand, measuring cylinders, apparatus, crucibles, tins, Soxhlet apparatus, distilled water, kjehdal machine and centrifuge

3.1.3 Reagent

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

3.2 SAMPLE PREPARATION

3.2.1 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 (figure 3.1).

3.2.2 Sample preparation of unripe plantain flour

The unripe plantain sticks were separated from the bunch and wash to remove sand and dirt thereafter the stick of plantain was peeled and soaked into water to minimize enzymatic browning, thereafter the size of the plantain was reduced with the dicing machine to enhance uniform and rapid drying. The diced plantain was dried using a forced air oven at 70^0C for hours. It was then milled and sieved to pass 200um mesh size and packaged into an air tight container (figure 3.2).

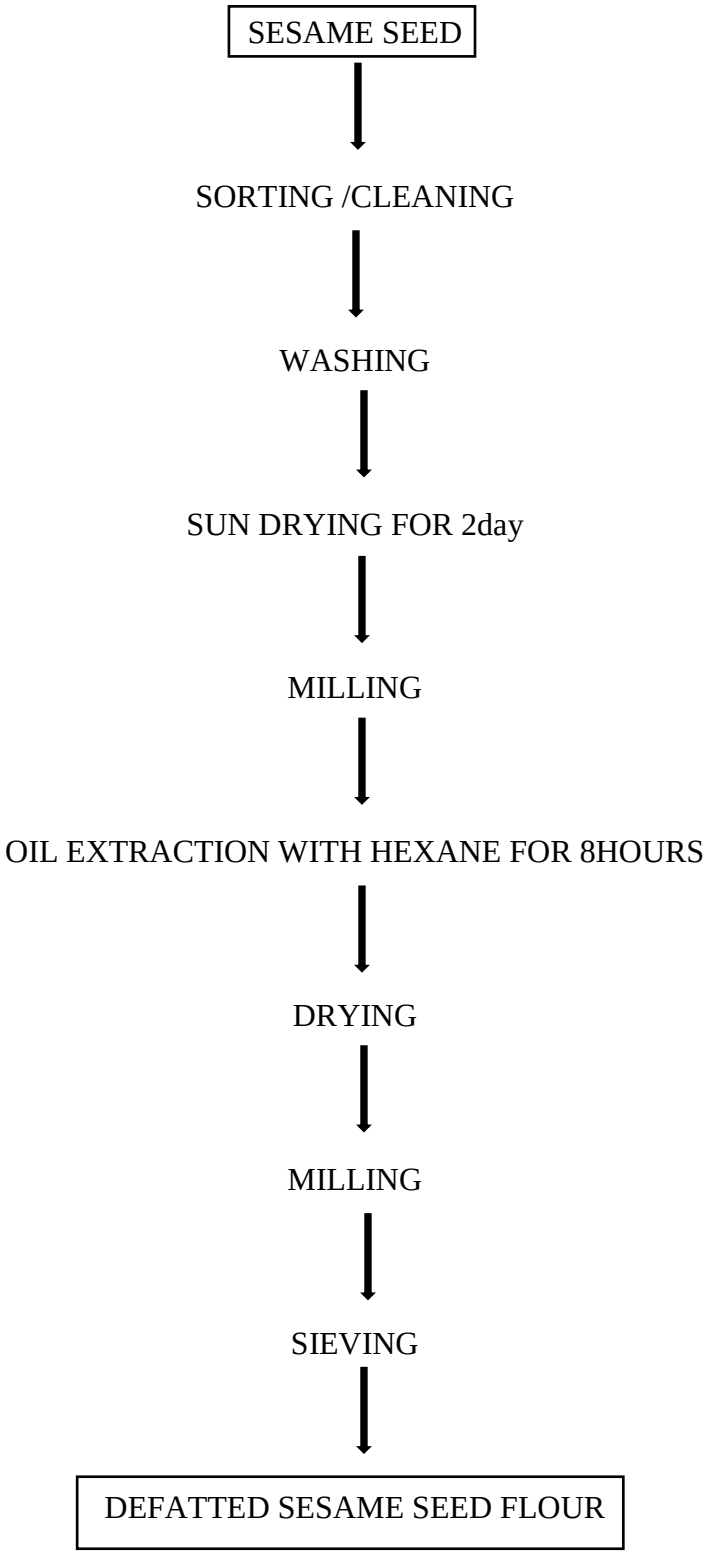

Figure 3.1: Flow chart of defatted sesame seed flour production

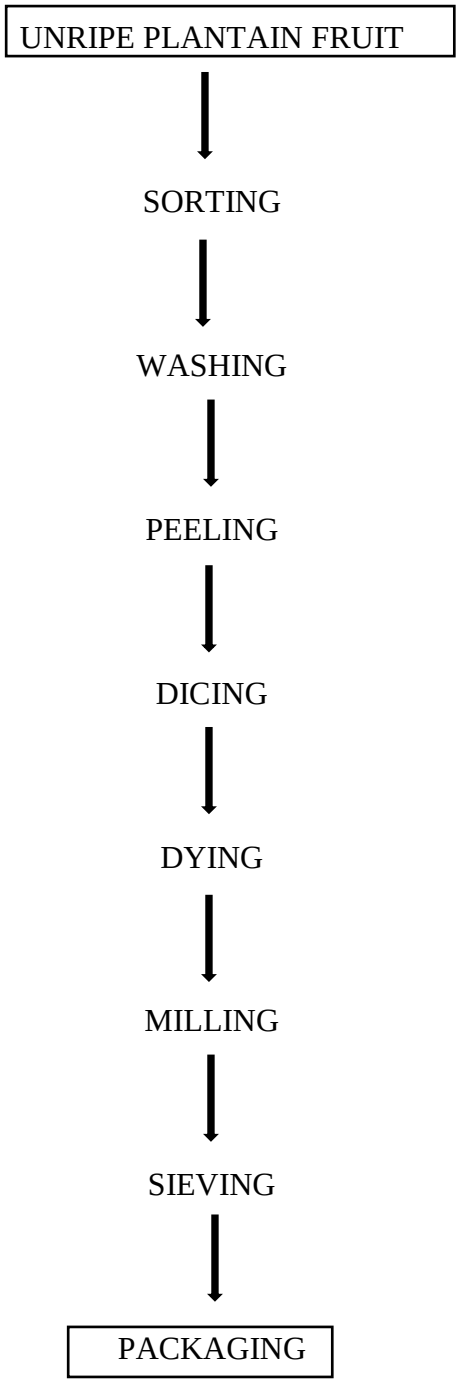

Figure3.2: Flow chart of plantain flour production

3.2.3 Sample preparation of rice bran

The rice bran was dried using the air oven dryer to dry the moist bran for few hours, afterwards the rice bran was then stabilized at 120^0c for 5mins in other to inactivate the enzyme work on the bran and also to stop rancidity in the bran because of the oil of the bran (Fig.3.3).

3.2.4 Flour formulation

Table1 shows how the flours were mixed in the following ratios: i.e, unripe plantain flour defatted sesame seed and rice bran respectively (ratios 100:0:0 75:15:10, 70:30:0, 70:22:8 and 65:30:5)

Table 3.2 shows the recipe formulation use in the production of cookies from the blends of defatted sesame seed unripe plantain flour and rice bran

3.2.5 Production of Cookies from Mixture of Flour Blends

Butter and sugar were poured into a mixer bowl and mixed until a fluffy mixture was obtained. Eggs were properly whisked in a separate bowl and milk also added and mixed continuously for few minutes, vanilla flavor was added and also formulated flour was slowly added into the mixture. After proper mixing the dough was extruded using a die, placed on oiled baking trays and baked in the oven at 200 ℃ for 35minutes.

3.3 Determination of 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 Determination of moisture content

Two (2.0) g of each sample was weighed using analytical balance (A&D co. Ltd, International Division HR-200 (1596-5A-1E-99.03.26) Cert No; T2733 made in Japan**)** into previously weighed dish. The weighed samples were put into the pre-set oven (Uniscope (SM9053) air oven SURGIFRIEND medical, England) at 105℃ for 5hours. The samples were removed and cooled in a desiccator to room temperature and the weight was noted, they were then returned to the

oven at 105℃ for 30min, 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).

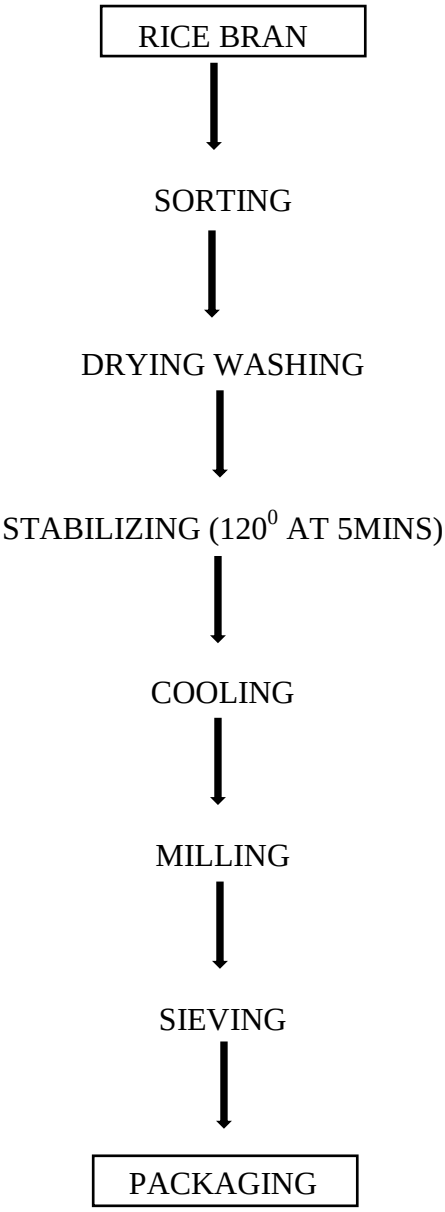

Figure 3.3: Flow chart of rice bran

Table3.1; formation of flour mixture

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

Table3.2; Recipe of flour blend of cookies

Ingredient	Quantity
Butter	40g
Sugar	25g
Milk	10g
Flavor	1g
Egg	1

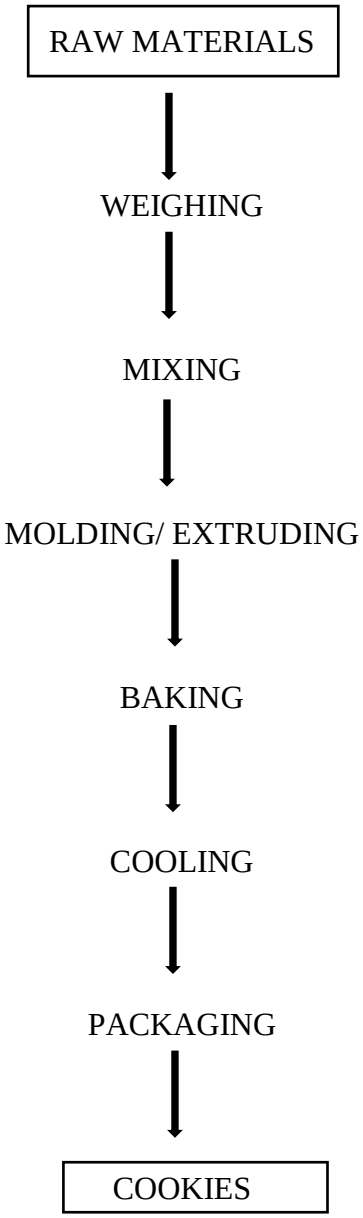

Figure3.4; flow chart on the production of cookies

Where

M_0 = weight in g of dish

M_1 = weight in g of dish and sample before drying

M_2 = weight in g of dish and sample after drying

$M_1 - M_0$ = weight of sample prepared for drying

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

3.3.2 Determination of Ash content

Ash content was determined using the method AOAC (2012). Five (5) 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 were cooled to room temperature in a desiccator. The crucible with the sample was weighed and the percentage of ash was calculated as;

Where W_3 = weight of crucible + ash

W_2 = weight of sample only

W_1 = weight of crucible

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

3.3.3 Determination of protein content

The protein content of the cookies produced was determined according to AOAC, (2012). One (1) g of the grinded samples was weighed into a digestion flask and one (1) kjehdal catalyst tablet was added, 12ml of conc.H_2SO_4 was added and digested in tecator digestion block at 420^0c for 1hour 30minutes until a clear solution was obtained. The digest was cooled and transferred into 100ml volumetric flask and made up to mark with distilled water. Thirty (30)ml of 4% boric acid was dispensed into a conical flask and 5 drops of methyl red indicator and 70ml of distilled water was added to it.

Ten (10) ml of the digest was dispensed into Kjehdal distillation flask, the conical and the distillation flask was fixed in place and fifty (50) ml of 2% NaOH was added through the glass funnel into the digest. The steam exit was closed and timing started when the solution

of the boric acid and indicator turned green. The distillation was done for 15 minutes and the distillate was titrated with 0.05NHCl.

% Total Nitrogen = Titre Value × Atomic mass of nitrogen × Normality of HCl used × 4

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

% Crude protein = % N × 6.25.

3.3.4 Determination of fat content

This was determined by using the method described by AOAC, (2012). One (1) g 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;

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

3.3.5 Determination of Crude Fibre

The crude fibre was determined according to the method described by AOAC, (2012). Two (2) g of the sample was accurately weighed into flask and 200ml of 2.50% 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 2.50% NaOH added and heated for another 30 minutes. The residue was removed and finally transferred into the crucible. The crucible and the residue were 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 W1. The crucible with W1 was transferred to the muffle furnace for ashing at 550℃ for 2 hours. The content of the crucible turned white or grey ash (Free of carbonaceous materials) which was cooled in the desiccator and weighed to obtain W2.

The difference in W1 and W2 gave the weight of fibre.

$$\%\, fibre = \frac{W1 - W2}{original\ weight\ of\ sample} \times 100$$

W1 = Dried crucible + residue before ashing

W2 = Dried crucible + residue after ashing

3.3.6 Determination of carbohydrate content.

The determination of carbohydrate in the samples was determined by a difference method. That is the values or percentages of moisture, ash, protein, fat and fibre was summed up and then the results were subtracted from hundred which gives the carbohydrate content (AOAC, 2012)

3.4 Functional properties of flour blend produced from unripe plantain flour, defatted sesame seed and rice bran

3.4.1 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 the volume. The volume of the compacted sample was recorded and the bulk density was calculated as follows:

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

3.4.2 Water absorption capacity/oil absorption capacity

This was determined using the method described by (Wang and Kinsella, 2006). Fifteen (15) ml of distilled water was added to 1g of the sample in a pre-weighed centrifuge tube, the tube with its content was agitated on a flask Gallen Kamp shaker for 2minutes and centrifuged at 4000 rpm for 20 minutes in a centrifuge. The clear supernatant was discarded and the centrifuge tube was weighed with the sediment. The amount of water bound by the sample was determined by difference and expressed as the weight of water bound by 100g dry flour.

3.4.3 Determination of swelling capacity

The swelling capacity was determine using the method of (Leach *et al.,* 1959) with modification for small samples. One (1) g of the sample was mixed with 15ml 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 formular as shown below;

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

3.5 Determination of mineral content

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)

3.6 Sensory evaluation of produced cookies

Sensory evaluation was performed on the produced cookie samples with 15 untrained panelists that cut across Mountain Top University community and gender groups. The descriptive 9-point hedonic scale was used with the rating 9 as like extremely and 1 as dislike extremely. The produced cookies were evaluated on quality characteristics of appearance, texture, taste, crispness, color, aroma, and overall acceptability.

3.7 Blood glucose level and blood cholesterol levels determination

3.7.1 Experimental animals

Wistar Albino rats weighing 150-235g were used for the research. They were obtained from the animal house of the Mountain Top University, Ogun state-Nigeria. The rats were kept in properly ventilated cages where bedding was replaced daily, at a room temperature of about 27^0C and 12 hours light/dark cycle. They were allowed to acclimatize for 14-daysprior to

experimentation. During this period, they were all provided with the same commercially available diet and tap water. Their weights were also recorded. The experimental protocol was reviewed and approved by Institutional community of and Science Technology, The rules and regulations and directives were strictly adhered to. Efforts were made to minimize suffering. The rats were divided into four groups fed with commercially available normal-diet-feed with water and formulated diet feed with water.

3.7.2 Animal grouping

Thirteen wistar rats were randomly allocated into four groups and designated as 1, 2, 3 and 4.

Group 1: Female (control)

Group 2: Male (control)

Group 3: Female (formulated feed)

Group 4: Male (formulated feed)

3.7.3 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 blood lancet, blood from the tail region was allowed to drop on the glucose test strip which was inserted into a glucometer. The fasting blood glucose concentration (mg/dL) of the rats were obtained in all the rats (Saidu *et al*., 2014).

3.7.4 Preparation of Serum

The method as described by Yakubu *et* al (2008) was used to prepare the serum and tissue supernatant. The rats were weighed individually and thereafter anaesthetized in a jar containing cotton wool soaked in diethyl ether. The neck area was cleared of fur and skin to expose the jugular veins. The jugular veins were displaced slightly from the neck region and thereafter 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).

3.7.5 Assay for Cholesterol

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

Tubes were labeled according to identity and 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 mins and the absorbances were 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).

3.7.6 Assay for Triglyceride

The serum was used for the triglyceride assay using Meril kit. Tubes were labeled according to identity and 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 mins and the absorbances were 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).

3.7.7 Assay for HDL-cholesterol

The serum was used for the High-Density Lipoprotein-cholesterol using Randox kit.

Tubes were labelled according to the identity and group given to the experimental animal then 200 µL of samples was pipetted into sample bottles, five hundred (500) µL of the

reagent was added and were allowed to incubate for 10 mins at room temperature. The mixture were centrifuged for 10 mins at 4000 rpm and the clear supernatant was pipetted from the sample bottles into clean test tubes, alongside one tube for blank and another for standard. Ten (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 mins and the absorbances were 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 (203 mg/dL).

3.8 Statistical analysis

All analysis were performed in triplicate and the data generated were analyzed using one way of variance (ANOVA) using SPSS version 26. The means were separated using the Duncan New Multiple Range Test and significance was accepted at $P < 0.05$

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Proximate composition of cookies produced from unripe plantain flour, defatted sesame seed and rice bran.

4.1.1 Moisture content

One of the most essential and extensively used indicators for measuring the quality of dry processed foods is the moisture level of the food. The moisture content values of the blends varied significantly ($p < .05$) from each other. The moisture content of biscuits samples ranged from 8.93% to 11.50% (Table 4.1). Biscuit produced from sample A, B and E are low in moisture and that of C, D are high and a similar result was reported by (Chinma *et al.,* (2012). This could be due to the difference in the ratio composition of each sample.

4.1.2 Ash content

The ash content provides insights into the mineral quality of the biscuit. The ash content of the biscuit's samples ranged from 2.27% to 4.40%. Biscuit produced from sample A, B, C had the lowest ash content, and that of sample D, E had the highest ash contents. The biscuit sample increased significantly across the blends of sample D, E.

4.1.3 Protein content

The protein content of the cookies showed the significance difference at ($p<0.05$) ranging from 8.05% to 16.28%, (chinma *et al.* 2012) reported values which range from 6.06% to 17.90%. This could be due to difference in the composition ratio of the flour blend used for the production of cookies. Cookies from 100% plantain flour had the lowest protein value and this is due to the fact that the analysis shows plantain flour to contain lower protein content. From literature, the protein content of plantain flour is 3% while that of defatted sesame seed and rice bran are 55.5% and 12-15% respectively. Sample E had the highest protein content (16.90%) followed by Sample B 12.43% while sample A had the lowest (8.05%). Samples C and D showed no significant difference in their protein content.

Table 4.1: Proximate compositions of cookies produced from unripe plantain, defatted sesame seed and rice bran.

Sample	Crude Fibre	Ash	Moisture content	Fat content	Protein	carbohydrate
A	0.18±0.07^{c}	2.27±0.27^{b}	9.16±0.84^{b}	16.06±0.15^{bc}	8.05±1.31^{c}	64.27±1.96^{a}
B	2.43±0.08^{b}	2.92±0.08^{b}	9.21±0.30^{b}	17.01±0.46^{b}	12.43±1.31^{b}	56.00±1.14^{b}
C	2.51±0.45^{b}	2.94±0.06^{b}	10.59±1.09^{ab}	15.32±1.09^{c}	15.54±1.71^{ab}	53.10±0.87^{c}
D	2.89±0.90^{ab}	3.08±0.10^{ab}	11.50±0.26^{a}	19.17±0.99^{a}	15.19±1.88^{ab}	48.17±1.43^{d}
E	3.56±0.42^{a}	4.40±1.60^{a}	8.93±1.93^{b}	15.28±0.33^{c}	16.28±2.71^{a}	51.55±1.63^{c}

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

Samples are flour blends of Plantain flour: defatted sesame seed flour and rice bran. Where Sample A,B,C,D,E are in ratio 100:0:0, 75:15:10, 70:30:0, 70:22:8, 65:30:5 respectively.

4.1.4 Fat content

The fat content of biscuits samples ranged from 15.28% to 19.17%. The cookie produced from sample E had the lowest fat content and that of sample D had the highest. There were significant ($p < .05$) differences in crude fat contents of the biscuit blends.

4.1.5 Crude fibre

The crude fiber content of the biscuits ranged from 0.18% to 3.56%. Sample A showed the lowest crude fiber, while sample E showed the highest. The crude fiber contents of the samples were significantly ($p < .05$) different from each other. The sample B, C and D were found not be significantly different from each other. As a result of the consumption of dietary fiber which is essential for preventing constipation, hemorrhoids, and diverticular disease by softening and increasing the size of the stool.

4.1.6 Carbohydrate content

There was a significance difference between the carbohydrate content of the samples, values range from 48.17% to 64.27%. The carbohydrate content was generally high because the main constitute of all the flours used was carbohydrate. Sample A had the highest carbohydrate content of 64.27% while sample D had the lowest due to the high content of other nutrients (ash, fibre, fat and protein).

4.2 Functional properties of flour blends from unripe plantain, defatted sesame seed and rice bran (Table 4.2).

4.2.1 Bulk density

At (p<0.05), there was significant difference in the bulk densities of the different ratios of flour blends. Bulk densities ranged from (2. 00 to 3.17) g/ml (Table 4.2). Sample E had the highest bulk density of 3.17g/ml, while sample A had the lowest bulk density of 1.80g/ml. This could be due to the particle size of the flour. Samples B and D also had the same bulk density. Samples E and C are not significantly different from each other. The particle size and density of flour affect bulk density, which is critical in determining packaging requirements, materials handling, and application in wet processing in the food industry (Wang et al., 2006).

4.2.2 Water absorption capacity

There is significance difference at (P<0.05) in the water absorption of the flour blends which ranged (0.8 to 4.2) g/g (Table 4.2). Sample E had the lowest WAC of 2.13g/g while sample C had the highest WAC of 3.21g/g. There was no significant difference between samples B, D and E as it was at the same group range of WAC while sample A range was significantly different from the other sample. The water absorption capacity determines the amount of water the flour will absorb during mixing.

4.2.3 Oil absorption capacity

There was significant difference in the oil absorption of the flour blends which ranged between (2.81 to 3.08) g/g (Table 4.2). Sample D had the highest OAC of 3.08 while the sample A had the lowest OAC.

4.2.4 Swelling capacity

There are significance differences at (P<0.05) in the swelling capacity of the flour blends which range (4.59 to 5.58) g/g (Table 4.2). Sample C had the highest (5.58) g/g while sample D had the lowest (4.59) g/g. sample B, D and E were not significantly different from each other and Sample A and C were not significantly different from each other. Swelling power is an indication of the absorption index of the granules during heating (Coffman, 2007).

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Table 4.2: Functional composition of cookies produced from unripe plantain, defatted sesame seed and rice bran.

Sample	Bulk Density	Water Absorption	Oil Absorption	Swelling Capacity
A	1.80±0.00^{c}	2.69±0.01^{c}	2.81±0.08^{b}	5.28±0.04^{a}
B	2.03±0.06^{b}	2.90±0.06^{b}	3.00±0.01^{a}	4.70±0.29^{b}
C	2.50±0.17^{a}	3.21±0.10^{a}	2.96±0.14^{ab}	5.58±0.15^{a}
D	2.00±0.00^{b}	2.98±0.00^{b}	3.08±0.05^{a}	4.59±0.20^{b}
E	3.17±0.17a	2.13±0.03^{b}	2.94±0.11^{ab}	4.76±0.04^{b}

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

Samples are flour blends of Plantain flour: defatted sesame seed flour and rice bran. Where Sample A, B, C, D, E are in ratio 100:0:0, 75:15:10, 70:30:0, 70:22:8, 65:30:5 respectively.

4.3 Mineral composition of cookies produced from unripe plantain, defatted sesame seed and rice bran.

4.3.1 Calcium

Calcium is a component of bones and teeth, which gives them strength and hardness when combined with phosphorus. Normal neuron and muscle activity, blood coagulation, heart function, and cell metabolism all require calcium. The calcium content of biscuits samples ranged from 85.67 to 122.27 mg/g. Sample A had the lowest 85.67 mg/100g while sample had the highest 122.27mg/100 g There were significant ($p < .05$) differences in the calcium content of the biscuit samples. However, some of the biscuit's samples were not significantly ($p > .05$) different from each other.

4.3.2 Magnesium

Magnesium is vital to both hard and soft body tissues. It is essential for metabolism and regulates nerve and muscle function, including the heart, and plays a role in the blood-clotting process (Roth, 2011). Though rare, the deficiency symptoms included nausea and mental, emotional, and muscular disorders. The magnesium content of the biscuit's samples ranged from 23.58 to 43.31 mg/100 g There was significant ($p < .05$) difference in the level of magnesium of the biscuit samples. The recommended daily intake (RDI) of magnesium for children aged 1 to 8 years is 80 to 130 mg, and for adults aged 9 to 70 years is 240 to 420 mg (Roth, 2011). As a result, 100 g of the biscuits with the greatest magnesium content will provide 43.31 percent of the RDI for children.

4.3.3 Potassium

Potassium is the most abundant electrolyte in intracellular fluid. It is necessary for fluid equilibrium and osmosis, just as sodium. It is also required for nerve impulse transmission and muscle contractions. Some of its deficiency symptoms included diarrhea, vomiting, diabetic acidosis, and severe malnutrition. Additional symptoms are nausea, anorexia, fatigue, muscle weakness, and heart abnormalities. The potassium content of the biscuit's samples ranged from 85.61 to 120.42 mg/100 g .sample A had the lowest value 85.61 while sample E had the highest value 120.42. The potassium content of the biscuit sample was significantly ($p<0.5$) different from each other.

Table 4.3 Mineral composition of cookies produced from unripe plantain, defatted sesame seed and rice bran.

Sample	Calcium	Magnesium	Phosphorus	Potassium	Chromium	Sodium
A	85.67±0.24^{d}	23.58±0.33^{e}	18.37±0.12^{e}	85.61±0.06^{e}	3.05±0.04^{e}	45.50±0.08^{e}
B	93.36±0.11^{c}	25.79±0.30^{d}	20.44±0.11^{d}	89.54±0.01^{d}	3.15±0.04^{d}	49.56±0.03^{d}
C	96.63±0.31^{b}	33.08±0.03^{c}	29.45±0.03^{c}	96.73±0.23^{c}	3.96±0.02^{c}	54.80±0.07^{c}
D	121.89±0.05^{a}	37.41±0.16^{b}	33.82±0.07^{b}	103.44±0.02^{b}	4.27±0.02^{b}	59.76±0.12^{b}
E	122.27±0.62^{a}	43.31±0.11^{a}	39.47±0.06^{a}	120.42±0.12^{a}	4.32±0.03^{a}	68.54±0.01^{a}

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

Samples are flour blends of Plantain flour: defatted sesame seed flour and rice bran. Where Sample A, B, C, D, E are in ratio 100:0:0, 75:15:10, 70:30:0, 70:22:8, 65:30:5 respectively.

4.3.4 Phosphorus

Phosphorus is necessary for carbohydrate, lipid, and protein metabolism. It is vital for a normal acid–base balance in the blood and for the effective action of numerous B vitamins because it is a constituent of all bodily cells. The phosphorus content of the cookie's samples ranged from 18.37 to 39.47 mg/100 g (table 4.3). sample A had the least phosphorus content (18.37 mg/100 g) while sample E had the highest phosphorus content 39.47 mg/100 g. There were significant ($p < .05$) differences in the phosphorus content of the biscuit sample. Phosphorus is found in many foods, and its deficiency is therefore rare.

4.3.5 Sodium

The sodium content of cookies samples ranged from 45.50 to 68.54 mg/100 g (Table 4.3). Sample A had the lowest sodium quantity, 45.50mg/100g while the highest amount 68.54mg/100 g was found in sample E. The sodium contents of the samples were significantly ($p < .05$) different from each other.

4.3.6 The chromium

Chromium helps to move blood sugar (glucose) from the bloodstream into the cells to be used as energy and to turn fats, carbohydrates, and proteins into energy. The chromium content of the cookies sample ranges from 3.05 to 4.32 mg/100g (table 4.3). Sample A showed the lowest amount of chromium while sample E showed the highest amount of chromium. The result of the samples shows they were significantly different from each other

4.4 Sensory properties of produced cookie

The result of the sensory evaluation of the cookies is shown in (Table 4.4). There was no significant difference ($p<0.5$) in the appearance, taste, crispness, and aroma while the crispness and colour showed significant different. In the crispness of the cookies sample E was different from the others and had a low score of 4.60. Generally, there were no significant difference in the overall acceptability. All the sample were within the like region, with sample A having the highest overall acceptability.

Table 4.4 Sensory properties of cookies produced from unripe plantain, defatted sesame seed and rice bran.

Sample	Appearance	Taste	Crispness	Colour	Aroma	Overall acceptability
A	6.80±0.63[a]	6.40±1.71[a]	6.50±1.18[a]	6.80±0.79[a]	6.30±1.25[a]	7.10±0.74[a]
B	6.60±1.58[a]	6.30±1.34[a]	6.50±1.90[a]	6.10±1.60[ab]	6.90±1.45[a]	6.70±0.82[a]
C	6.50±1.43[a]	6.40±0.84[a]	6.40±1.71[a]	6.60±1.17[a]	6.30±0.95[a]	6.70±0.95[a]
D	5.30±1.42[a]	6.50±2.12[a]	6.20±1.62[a]	5.30±1.16b[c]	6.80±1.23[a]	6.40±1.35[a]
E	5.30±2.31[a]	5.10±1.60[a]	4.60±1.51[b]	4.80±1.32[c]	5.80±1.14[a]	6.50±1.18[a]

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

Samples are flour blends of Plantain flour: defatted sesame seed flour and rice bran. Where Sample A, B, C, D, E are in ratio 100:0:0, 75:15:10, 70:30:0, 70:22:8, 65:30:5 respectively.

4.5 Blood glucose level and cholesterol of wistar rats on nutritional evaluation of produced cookies from unripe plantain, defatted sesame seed and rice bran.

4.5.1 Blood glucose level

Due to the result obtained for the nutritional composition, Sample D was chosen to be fed to experimental animals to check its effect on blood glucose level. There was a decrease in the mean blood glucose concentration after feeding with experimental diet. The control diet still recorded blood sugar concentration that was higher while the rats fed the treatment diets showed a lower blood sugar concentration (Figure 4.1). The experimental diet the sample D about significant reduction in the blood glucose level when compared with the control ($p<0.05$). The blood glucose concentration was significantly reduced after the 21days of treatment in all animals except control group.

4.5.2 Serum total cholesterol level of experimental animal

There was a significant decrease ($p < 0.05$) in the serum cholesterol concentration upon consumption of the experimental diet compared to the normal control feed.

4.5.3 Serum triglyceride level of experimental animal

There was a significant decrease ($p < 0.05$) in the serum triglyceride concentration upon the experimental diet compared to normal control.

4.5.4 Serum of High density lipo-protein

There was a significant increase ($p < 0.05$) in the serum HDL-cholesterol concentration upon consumption of the experimental diet compared to control diet.

The effects of feeding control diet and functional cookies samples to the experimental diet for 21days on the total cholesterol (TC) and triglycerides (TG) values are presented in the Figure 4.5.1 and Figure 4.5.2. The results indicated a significant elevation ($P < 0.05$) in both TC and TG in normal diet group (control) as compared to treatment group (formulated diet). Through the studied groups, graph revealed that the reduction in TC and TG levels was obvious by the feeding of diets contained in sample D (70%unripe plantain flour, 22% sesame seed flour, 8%rice bran) compared to normal diet (grand cereal). The range of reduction in TC and TG levels was significantly different ($P < 0.05$).

The effect of feeding normal diet and formulated feed to the experimental rats for 21 days on high density lipoproteins cholesterol (HDL-c) are given in the graph. The obtained graph revealed significant increase ($P< 0.05$) in HDL-c and significant decrease ($P < 0.05$) in normal diet group (control), as compared with experimental group.

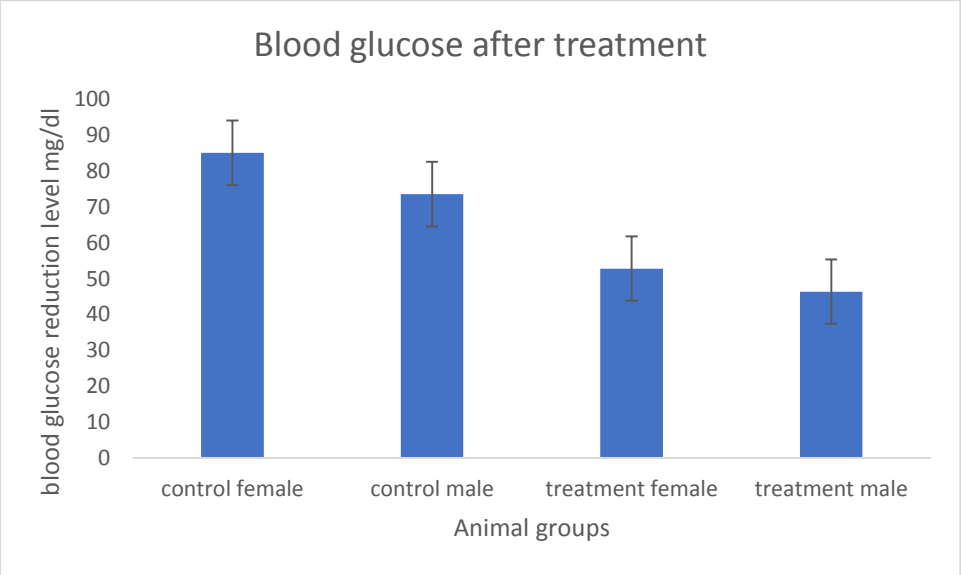


Figure 4.1 blood glucose level of experimental rats

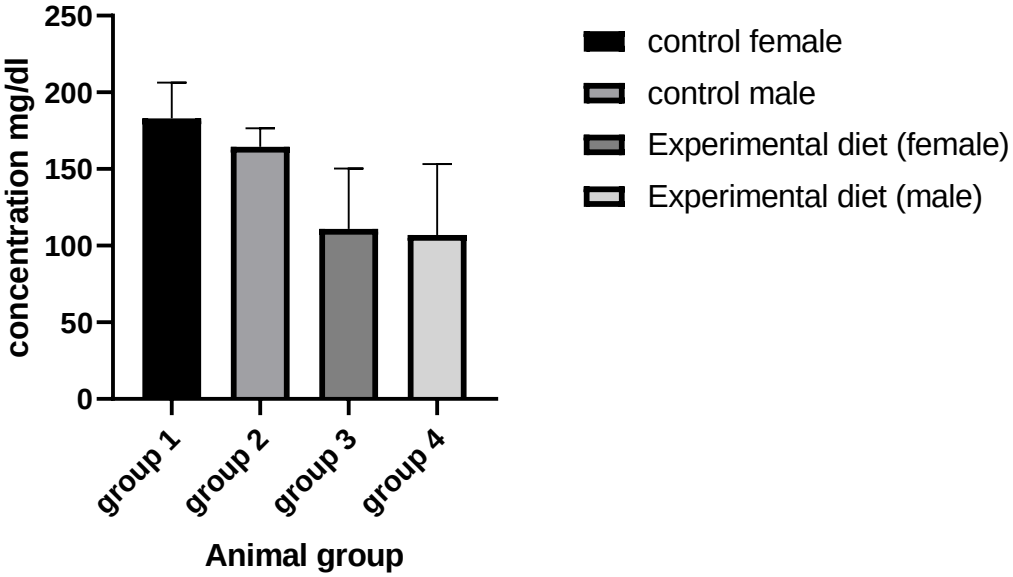


Figure 4.2 Serum triglyceride concentrations in experimental rats

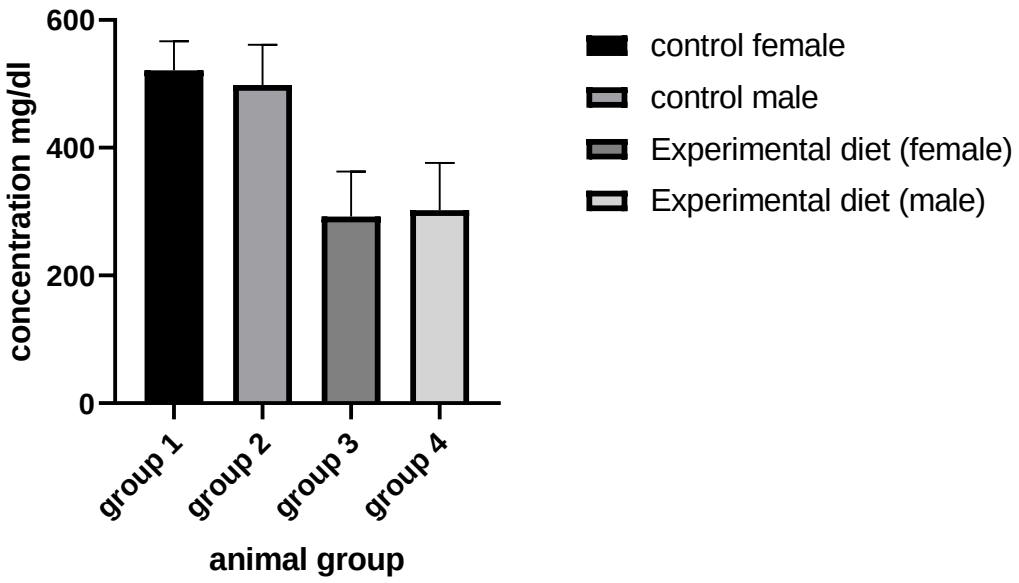


Figure 4.3 Serum total cholesterol of experimental rats

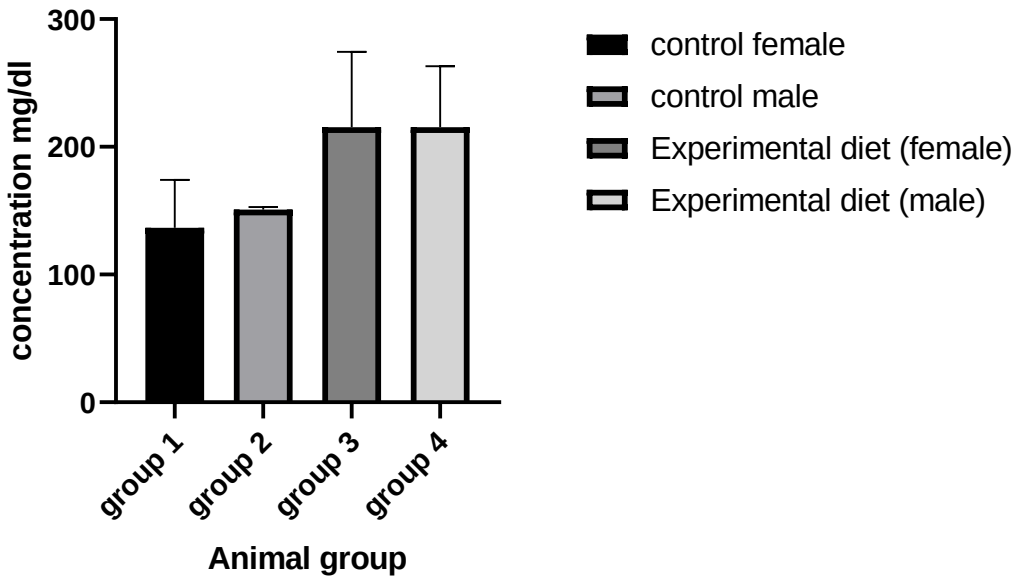
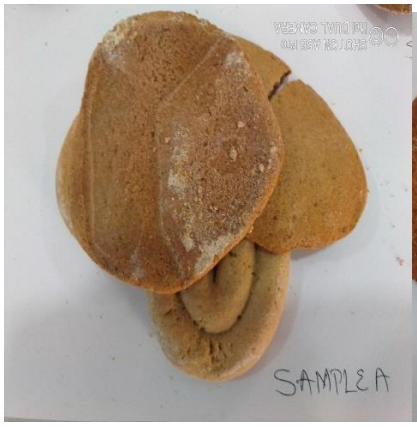


Figure 4.4 Serum High density lipo-protein cholesterol concentrations in experimental rats

4.1 plate



CHAPTER FIVE

5.1 Conclusion

One of the strategies of controlling this growing burden of diabetes is to eat a healthy, easily accessible and affordable diet. The combination of unripe plantain, defatted sesame seed, and rice bran composite flour in cookie production improves, nutritional and sensory quality without compromising baking properties. Because of their poor starch and high protein digestibility, high crude fiber, high minerals, and low carbohydrate, cookies made from composite flour have the potential to be a functional diet for celiac, diabetes, obese, and hypertension patients.

5.2 Recommendation

Further work should be carried out to improve the cookies and also composite flour may be used instead of wheat flour, which contain more nutritional component to provide healthy benefit and I recommend that sample D and E should be consume when the need to reduce blood glucose arises.

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QUESTIONNAIRE OF THE SENSORY PROPERTIES OF NUTRITIONAL, FUNCTIONAL and IN-VIVO STUDY of COOKIES PRODUCED from FLOUR BLEND of PLANTAIN, SESAME AND RICE BRAN

Dear sir/ma,

This study is for research purposes only. Please feel free to express your opinion on each of the samples.

Please evaluate each of the composite cookies and indicate your preference for appearance, taste, crispness colour, aroma and overall acceptability. Assign the samples with the following ranks for each parameter:

9- Like extremely

8- Like very much

7- Like Moderately

6- Like slightly

5- Neither like nor dislike

4- Dislike slightly

3- Dislike moderately

2- Dislike very much

1- Dislike extremely

Sample	Appearance	Taste	Crispness	Color	Aroma	Overall Acceptability
A						
B						
C						

D						
E						

Comment Freely

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