UTILIZATION OF CEREAL, LEGUMES AND SEAFOOD IN THE FORMULATION OF DIET FOR A DIABETIC PATIENT

By

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CERTIFICATION

This is to certify that this project was carried out by **ABDULRAHEEM HALIMOH AYOKA**, with Matriculation Number **ND/23/NAD/FT/0067** of the Department of Nutrition and Dietetics, institute of Applied Sciences, in partial fulfillment of the requirements for the award of National Diploma in Nutrition and Dietetics of the Kwara State Polytechnic, Ilorin.

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DEDICATION

This project is dedicated to Almighty God the Alpha and Omega of all wisdom and understanding that made it possible and given me the opportunity to complete my National Diploma (ND) and also to my lovely parents **MR. AND MRS ABDULRAHEEM**, sisters and brothers whose unwavering support and encouragement mean the world to me.

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia, which arises due to defects in insulin secretion, insulin action, or both. It is one of the leading causes of morbidity and mortality globally, with nutrition recognized as a cornerstone in its management. The formulation of therapeutic diets that incorporate functional food groups such as cereals, legumes, and seafood has been shown to improve glycemic control, enhance nutrient adequacy, and reduce the risk of diabetes-related complications. This study examined the nutritional composition and health benefits of selected cereals (sorghum), legumes (soybeans), and seafood (crayfish) in relation to their suitability for diabetic meal planning. Nutritional analysis revealed that cereals provide complex carbohydrates and soluble fiber that lower postprandial glucose levels; legumes contribute plant proteins, resistant starch, and bioactive compounds that enhance satiety and insulin sensitivity; while seafood supplies high-quality protein and omega-3 fatty acids that support cardiovascular health. A sample diabetic diet plan was formulated to demonstrate practical application of these food groups in daily meals. The findings confirm that the integration of cereals, legumes, and seafood into diabetic diets offers a holistic, affordable, and culturally adaptable nutritional strategy for effective diabetes management. The study concludes that dietary patterns rich in these food groups can improve quality of life and recommends their promotion by healthcare practitioners, nutritionists, and public health stakeholders.

CHAPTER ONE

1.0 INTRODUCTION

1.1 General Background of the Study

Diabetes is a chronic metabolic disorder characterized by high blood glucose levels affecting millions of people world-wide, Diabetes is a global health concern characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. According to the international Diabetes federation (2021), approximately 537 million adults aged 20-79 were living with diabetes, with the majority of the cases being type 2 diabetes, a figure projected to rise to 643 million by 2030. Managing diabetes effectively is crucial, as it is associated with significant complications affecting various organ system. Dietary interventions plays a fundamental role in diabetes controlling of blood glucose levels and reducing the risk of complications (American Diabetes Association, 2020).

Diabetes management involves a multifaceted approach, including lifestyle modifications, medication, and dietary intervention. Dietary management plays a crucial role in controlling blood sugar levels and preventing complications. The American Diabetes Association (ADA)-(2020), recommends a personalized meal plan that takes into account. The individual's nutritional needs lifestyle, and cultural preferences (ADA 2020).

Cereals, legumes and seafood present a promising avenue for dietary formulation due to their nutritional profiles. Whole grains, such as wheat and sorghum are rich in soluble fiber, which has been shown to improve glycemic control and reduce cardiovascular risk (slavin, *et al*., 2013).

Legumes including Bambara groundnuts and soybeans are high in protein and fiber while having a low glycemic index, making them beneficial for blood sugar regulation (Bojanowski *et al*., 2018). Seafood a source of Omega-3 fatty acids, has been linked to anti- inflammatory properties and improved heart health, which is critical for patients with diabetes, who are at increased risk of cardiovascular disease (Mozaffarian and Wu, 2018).

1.2 **Statement of the Problem**

In (Africa), the traditional diet is rich in cereals, legumes and seafood's, which are rich in nutrients and fiber. However, the increasing adoption of western-style diets has led to a decline in the consumption of these traditional foods group. This shift in dietary patterns has contributed to the rising prevalence of diabetes and other non-communicable diseases.

Despite the importance of diet in diabetes management, many diabetic patient in (Africa/South Africa) Lack access to personalized and culturally appropriate dietary guidance. The existing diet often focuses on restriction rather than optimizing of nutrients intake, leading to inadequate nutrition and poor health outcomes

Diabetes has enlarged as a major public health and challenge globally, characterized by elevated blood glucose levels that can lead to serious complications kidney, failure, and the role of cereals, legumes and seafood in in the formulation of diabetic diet is under-researched particularly concerning their specific impacts on blood glucose regulation, overall nutritional balance, and patient compliance. This gap necessitate a comprehensive investigation into how these food group can be effectively integrated into dietary recommendations for diabetic patient to improve glycemic control, enhance quality of life, and reduce the risk of associated health complications: Cereals, legumes and seafood could provide valuable insights for healthcare providers on developing tailored nutrition interventions for individuals living with diabetes.

1.3 **Justification of the Study**

This project work will fill gaps in existing literature by providing insight into the optimal combinations of cereals, legumes and seafood for managing diabetes, contributing to evidence based dietary guidelines. Neuropathy despite the availability of various treatments options, inadequate dietary management remains a critical barrier to effective diabetes control the utilization of cereals, legumes and seafood in the formulating diets for diabetic patients is grounded in the increasing prevalence of diabetes worldwide and the critical need for effective dietary management strategies. Blending of cereals sea food and legumes which are rich in essential nutrients can help regulate blood sugar levels and improve glycemic control.

Seafood provides high quality protein and Omega-3-fatty acids that promote cardiovascular health, an important consideration for diabetes. American Diabetes Association (ADA) and World Health Organization (WHO).

Cultural Relevance Including locally available cereals, legumes and seafood can enhance dietary compliance among diabetic patients by incorporating familiar and culturally appropriate foods. Making it easier for recommendations.

A well formulated diet from cereal, legumes and seafood can reduce the risk of diabetes related complications, such as cardiovascular disease, obesity and hypertension. Formulating a balance diet using locally available cereals, legumes and seafood for a diabetic patient will help individuals with diabetes in managing their condition effectively through diet, improve their blood sugar control, and reduce the risk of complication associated with diabetes.

1.3.1 Contribution to existing knowledge

The research will fill gaps in existing literature by providing insight into the optimal combinations of cereals, legumes and seafood for managing diabetes, contributing to evidence based dietary guidelines.

1.4 **Aim and Objectives**

1.4.1 Aim

To utilize cereal, legumes, and seafood in the formulation of diet for a diabetic patient.

1.4.2 Specific Objectives

1. To determine the proximate composition and glycemic index of the composite flour
2. To evaluate the sensory attribute of the composite flour product
3. To assess the nutritional profile of cereals, legumes and seafood and their potential benefit to diabetic patient.
4. To evaluate current dietary practices of diabetic patients regarding the consumption of cereals, legumes and seafood. .

1.5 Research Question

1. What are proximate composition and glycemic index of the formulated composite flour?
2. Does the sensory attribute determine the acceptability of the product compared to single ingredient flour product
3. How do the nutritional profile of cereal, legumes and sea food impact blood sugar level insulin sensitivity
4. How does cereal legumes and sea food contribute to overall nutrient intake in diabetic patient?

1.6. Significant of the Study

1. To create awareness in promoting healthier eating patterns by utilization of locally available food commodity in reduction and eradication of diabetes in the society
2. To provide public health initiative and educational programs that aim to reduce the burden of diabetes and improve the quality of life for those affected.
3. To enhance the nutritional management of diabetes
4. To contributing to better health outcomes and quality of life for diabetic patient. And also
5. To educate diabetic patients and healthcare providers on the benefits of a diet rich in cereals, legumes and seafood.

1.7. Scope and Limitations

The scope and limitations of a study define its boundaries and acknowledge factors that could affect the interpretation and generalization of the results.

1.7.1 Scope of the Study

The scope of outlines of the study will cover the utilization of sorghum, wheat, fonio Bambara, groundnut, soyabeans and crayfish in formulating a diet for a diabetic patient, the scope

1.7.2 Limitation of the Study

The limitation identify potential weakness or challenges that may impact the results or generalizability of the study. These are important for transparency and setting realistic expectations for the study on cereals, legumes and seafood for a diabetics, potential.

Limitation could include:

1. Sample size: limited number of diabetic patients, affecting the statistical power and generalizability of the findings.

2. Dietary adherence: variability in participant's adherence to the dietary intervention may influence results.

3. Financial constraints and limited time

1.8. Definition of Terms

1. Diabetes: A chronic concentration of glucose levels due to insulin production deficiency, insulin action impairment, or birth.

2. Dietary management: The implementation of specific dietary strategies and food choices aimed at regulating blood glucose levels and promoting overall health in diabetic patients.

3. Cereal: Grains that are cultivated for food, such as rice, wheat, oats, corn and barley, recognize for their carbohydrate content and nutritional value.

4. Legumes: A group of plants, including beans, lentils, pears, and chickpeas, known for their high protein, fiber and micronutrients content, beneficial in a diabetic diet.

5. Seafood: Any form of sea life consumed as food, including fish and shell fish, which are generally low in carbohydrates and high in healthy fats and protein

CHAPTER TWO

2.0 LITERATURE REVIEW

Diabetes mellitus, commonly referred to as diabetes, is a chronic metabolic disorder characterized by elevated blood glucose levels (hyperglycemia). This condition arises when the body cannot effectively utilize the insulin it produces over time, uncontrolled diabetes can lead serious health complications, including cardiovascular diseases, kidney failure, nerve damage and vision problems (American Diabetes Association, 2020)

Types of Diabetes

Diabetes is primarily classified into three main types: Type 1, Type 2, and gestational diabetes. Each type has distinct causes, characteristics, and management strategies.

Type 1 Diabetes (T1D)

Type 1 diabetes is an autoimmune condition where the immune system attacks and destroys insulin producing beta cells in the pancreas. This results in little to no insulin production, leading to high blood glucose levels

Etiology: This exact cause of type 1 diabetes is not fully understood, but genetic predisposition and environmental factors, such as viral infections, may play a role (Dabelea et al., 2014).

Symptoms: Common symptoms include excessive thirst (polydipsia), frequent urination (polyuria), extreme hunger (polyphagia), fatigue, and blurred vision (American Diabetes Association).

Management: Individuals with type 1 diabetes require lifelong insulin therapy, along with regular blood sugar monitoring and a balanced diet.

Type 2 Diabetes (T2D)

Type 2 diabetes is the most common form accounting for approximately 90-95% of diabetes cases worldwide. It is characterized by insulin resistance, where the body's cells do not respond effectively to insulin

Risk Factors: Key risk factors include obesity, physical inactivity, older age, family history of diabetes, and certain ethnic backgrounds (Americans Diabetes Association, 2020).

Symptoms: symptoms may be similar to those of Type 1 diabetes but can develop more gradually, many individuals may remain symptomatic for years.

Management: Treatment options include lifestyle modifications (diet and exercise), oral hypoglycemic medications, and in some cases, insulin therapy (zheng *et al*., 2018).

Type 3 Diabetes (T3D)/ Gestational Diabetes Gestational diabetes occurs during pregnancy and typically resolves after childbirth. It is characterized by high blood lucose levels that develop in some women during pregnancy (Mcintyre *et al.*, 2019).

Risk factors: Obesity, previous history of gestational diabetes, and advanced maternal age increase. The risk of developing gestational diabetes.

Management: management involves lifestyle interventions, blood glucose monitoring, and in some cases, insulin therapy to ensure the health of both the mother and the baby

Complications of Diabetes

Uncontrolled diabetes can lead to various acute and chronic complications.

1 Diabetes Ketoacidosis (DKA) primarily associated with Type 1 diabetes, this condition occurs when insulin levels are insufficient, leading to the breakdown of fat for energy and ketones production, resulting in acid buildup in the blood . Symptoms include nausea, abdominal pain, and altered consciousness (kitabchi *et al*., 2009).

Hyperglycemic Hyperosmolar state (H.H.S): More common in type 2 diabetes, HHS occurs due to extremely high blood sugar levels, leading to severe dehydration and electrolytes imbalances symptoms include confusion, excessive thirst, and blurred vision (American Diabetes Association 2020).

2. Chronic Complications

Cardiovascular disease: Diabetes significantly increases the risk of heart disease and stroke due to endothelial dysfunction and arterial plague buildup (Buse *et al*., 2007)

Neuropathy: Diabetic neuropathy results from nerve damage due to prolonged high blood glucose levels, leading to symptoms such as pain, ting lings and loos of sensation (calleghan *et al.,* 2012).

Retinopathy: Diabetic retinopathy is a common eye complication that can lead to blindness.it is caused by damage of blood vessels of the retina (Klein *et al.,* 2015).

Nephropathy: Diabetic: Diabetic nephropathy can lead to kidney failure, requiring dialysis or transplantation, resulting from damage to the kidney's filtering unit (Baker *et al*., 2016).

1 Management and prevention

Lifestyle modifications preventing type 2 diabetes often involves lifestyle changes, including:

1 Diet: A balanced diet rich in whole grains, fruits, vegetables, and lean proteins combined with reduced intake of refined sugars and saturated fats, is essential (ma *et al* .,2016)

2 Physical Activity: Regular exercise enhance insulin sensitivity and help maintain a healthy weight .The American Diabetes Association recommends at least 150 minutes of moderate-intensity exercise weekly (American Diabetes Association,2020)

2. Pharmacological Treatments

Insulin therapy: Required for individual with Type 1 diabetes and may be necessary for some with Type 2 diabetes if other medications fail to control blood glucose levels (Garber *et al* .,2014) oral medications : various classes of oral hypoglycemic agents (e.g. , met formin , sulfonylureas ,and GLP—1 receptor agonists) are used in managing Type 2

Diabetes (zheng *et al.*, 2018).

Regular monitoring and screening

Regular monitoring of blood glucose levels, HBA1C, and screening for complications are crucial for effective diabetes management (American Diabetes Association 2020).

2.1. The causes of diabetes

The causes of diabetes can be complex and multi factorial, involving a combination of genetic, environmental and lifestyle factors. Below is a detailed examination of the causes of the two primary types of diabetes: Type 1 and Type 2 along with gestational diabetes.

1• Type 1 Diabetes (T1D)

Type 1 diabetes is primarily an autoimmune condition where the immune system attacks and destroys insulin producing beta cell in the pancreas. The exact cause is not entirely understood, but several factors contribute to it development:

Autoimmune factors: The destruction of beta cells is due to an autoimmune response, which may be triggered by viral infections (e.g., enteroviruses) or other environmental factors. The autoimmune attack lead to little to no insulin production (Mohiuddin *et al* 2020).

Environmental Triggers: Factors such as childhood diet, exposure to certain viruses and possibly other environmental toxins have been proposed as triggering agents for the onset of Type 1 diabetes, especially in genetically susceptible individuals (Patterson et al., 2019).

2. Type 2 Diabetes (T2D)

Type 2 diabetes is predominantly characterized by insulin resistance and relative insulin deficiency. The cause are multi factorial and include:

1. Genetic factors: - A strong genetic component is evidently with a higher risk in individual with a family history of diabetes. Specific genetic variants have been linked to type 2 diabetes susceptibility (the diagram consortium 2014)
2. Obesity:- Excess body weight, particularly visceral fat, is a significant risk factor for developing insulin resistance obesity leads to inflammatory cytokine production and altered adipokine secretion which negatively affect insulin signaling (kalin *et al*; 2014)

   3. Physical inactivity: - sedentary lifestyles contribute to weight gain and insulin resistance regular physical activity is crucial for weight management and enhancing insulin sensitivity (colberg *et al*, 2016)
3. Dietary factors:- Direst high in refined carbohydrates sugars and saturated fat are associated with increased risk conversely diets rich in whole grains, fruits vegetables, and healthy fats can reduce risk (Moraes *et al*; 2018)
4. Age: the risk of types 2 diabetes increases with age, party duae to a progressive decline in insulin sensitivity coupled with age related weight gain and decreased physical activity (Cameron et al; 2016)

3. Gestational diabetes

Gestational Diabetes occurs during pregnancy and is characterized by glucose intolerance. The cause are often similar to those of type 2 diabetes and include

Hormonal changes: - pregnancy hormones can lead to insulin resistance especially during the second and third trimesters (Buchanan et al., 2012)

Obesity and overweight: - women who are overweight or obsess prior to pregnancy have a higher risk of developing gestational diabetes (Hirst *et al*; 2015)

Family history: - a family history of diabetes increases the like hood of gestational diabetes (Langer *et al;* 2025)

2. 2 Effect of Diabetes on human health

1e: Cardiovascular disease increase risk of heart attacks, strokes, and peripheral artery disease (ADA 2020)

2. kidney damage: Diabetic neuropathy can lead to kidney failure (NIDDK, 2020)

3. nerve damage due: Diabetes neuropathy can cause numbness, pain, and tingling (NIDDK, 2020)

4. Vision loss: retinopathy can lead to blindness (CDC, 2020)

5. food damage: increased risk of foot ulcers and amputations (IDF, 2020)

Economic Effects of Diabetes

1. Health care cost: Diabetes is a significant economic burden on health care systems (WHO, 2016).

2. Lost productivity: Diabetes can lead to reduced productivity, absenteeism and presenters (IDF, 2020).

3. Premature mortality: Diabetes can lead to premature death, resulting in economic losses (WHO, 2016).

2.1 Cereals

Cereals are fruits of cultivated grasses belonging to the monocotyledonous family Graminae. The principal cereal crops of the world are wheat, barley, oats, rice, rye, maize, sorghum and millets but the chief cereals in the developing countries in West Africa are maize, rice, sorghum and millets. Wheat is the principal protein source of the world, followed by maize, rice, oats, soybeans, etc. The most commonly grown ones in Nigeria are sorghum, millet, maize, rice and wheat. These five crops occupy an estimated measure of over 16 million hectares of farmland.

The anatomical structure of all cereals grains is basically similar differing from one another in details only. The important grain cereals, maize, sorghum, naked grain millets and rice (tropical cereals) and wheat (temperate cereal), have a fruit coat (pericarp) and seed. The seed comprise the seed coat, germ and endoplasm (Okaka, 2005).

Cereals and cereal products are staple foods in most human diets in both developed and developing countries, providing a major proportion of dietary energy and nutrients. They are composed of approximately 75% carbohydrates, mainly starches and about 6–15% protein, contributing in global terms more than 50% of energy supply. The importance of cereals and cereal products is also supported by the fact that global food security depends to the greatest degree on cereal production, which yearly amounts to approximately 2600 million tons [FAO 2025].

Currently, the importance of cereals in the diet, particularly wholegrain ones, is being explored due to the presence of dietary fiber and bioactive compounds. Dietary fiber components are unevenly distributed in a grain and their highest concentration occurs in the outer tissues (Wacław 2019). Whole kernel or coarsely milled grains contain more dietary fiber and phytochemicals with potential anti-inflammatory and antioxidant properties than refined grains (Wacław 2019). On the basis of a series of systematic reviews and meta-analyses, it can be stated that there is substantial epidemiologic evidence that dietary fiber and wholegrain foods are associated with decreased risk of diet-related non-communicable diseases (DRNCD) (Wacław 2019). Diet with high levels of dietary fiber and whole grains result in reduced risk of all-cause and cardiovascular related mortality, atherosclerotic cardiovascular diseases (Wacław 2019).ischemic stroke type 2 diabetes (Wacław 2019).

Cereals are one of the main sources of energy and nutrients for animal and human food and have been used historically for centuries. Among the cereals, wheat is one of the most important worldwide, from which the main product called flour and by-products called bran and germ are obtained. Wheat flour is mainly used in human food in bakery processes. On the other hand, wheat bran is a product intended for animal feed due to its high content of amino acids and a high percentage of protein superior to other existing cereals. This wheat bran (technically called pericarp) consists mainly of the external parts of the wheat grain after processing.

Table 2.1: Proximate Composition of the main Cereals grown in Nigeria (% dry matter basis)

Cereal	Protein	Fat	Carbohydrate	Crude Fiber	Mineral Salt
Maize	10.50	5.40	68.00	2.40	1.60
Sorghum	9.28	2.27	85.20	2.01	1.24
Millet	13.69	5.39	77.26	1.80	1.96
Rice	7.07	2.25	89.89	0.23	0.56
Wheat	11.63	2.33	81.91	2.97	1.16
Acha	6.96	2.10	87.48	1.02	2.44

Source: Mbaeyi, 2005

2.1.1 Sorghum

Sorghum bicolor (L). Moench is the crop for grain for human and animal consumption. Sorghum is produced in areas that are too hot, a minimum average temperature of 25°C is necessary to ensure maximum grain production. The morphological characteristics of the culture make it one of the currently cultivated cereals that have the best drought tolerance. During the drought, it rolls its leaves to reduce water loss due to perspiration. If the drought continues, it becomes dormant instead of dying. The leaves are protected by a waxy cuticle to reduce vapor transpiration. Sorghum is the fifth most important cereal crop in the world after rice, wheat, corn and barley. (Ramatoulaye et *al.*, 2019)

Sorghum is an important food crop in Africa and is the fifth most important cereal crop grown in the world as well as the most important cereal food in the Northern states of Nigeria that cover the Sahelien, Sudanian and Guinea Savannah ecological zones. Sorghum is locally called guinea-corn or dawa, the most widely cultivated cereal crop and the most important food crop in the Savanna areas of Nigeria.

Nigeria is the second largest producer of sorghum, grown on about 5.9 million ha with current annual production estimated to be about 6.7 million tons. Sorghum is grown by over 59% and 55% of farmers in Adamawa and Borno States, respectively. It is mostly grown for domestic consumption and the excess sold to generate income.

2.1.2 Sorghum As a food material,

Sorghum has a high nutritional content because it is rich in macronutrients and micronutrients, including minerals and vitamins. Sorghum grain contains protein, B vitamins, and iron higher than rice and corn. Sorghum is gluten-free, so it is safe for people with gluten allergy and celiac disease Nevertheless, the use of sorghum to substitute wheat produces products that are not much different from those made from wheat flour. Since it is in the same family, sorghum has similar characteristics to wheat. Sorghum has a low glycemic index, which is suitable for people with diabetes. (Ariningsih et al., 2023)

In addition, sorghum has antioxidant substances, so it is recommended for cancer patients Therefore, sorghum is ideal as an alternative food for rice and wheat while also serving as a functional food. Sorghum has long been traditionally cultivated and has become a local staple food in several parts of West Africa addition to rice, cassava, and corn. However, its cultivation and development are still very limited. Along with the Green Revolution several decades ago, the role of sorghum and other local staple foods has been increasingly displaced by rice, and most people have been increasingly dependent on rice. This is exacerbated by the early diversification policy, which unintendedly has encouraged people to make wheat the second staple food after rice. (Ariningsih *et al.* 2023)

2.1.3 Uses of Sorghum

A majority of the domestic produce is used for household consumption by many rural communities. It finds uses in the production of beverage, malt, sorghum meal, and livestock feed, among others. Whole grain is ground into flour used to make traditional foods. Sorghum is mainly used as flour or paste processed into tuwo (thick porridge), kamu (thin diet porridge), and pate (soup like and light porridge mixed with vegetables, sometime containing beans).

A gradual increase in demand for pre-processed sorghum convenience foods as well as for industrial sorghum products has been observed. Sorghum is also processed into malt for malted drinks and foods, high quality flours, and as a raw material for the poultry and fish feed industries. Sorghum is also processed into cake, biscuits, sweets and other confectionaries (Ajaigbe *et al.*, 2020).

2.1.4 Economic Importance of Sorghum

Sorghum is one of the important cereal crops and major staple food in most part of the world with more than 40.5 million hectares and production figures of 55.7 million tonnes, in which Nigeria cultivates 4.7 million hectares. However, area cultivated in Africa was 24.8 million hectares with the production quantity of 20.9 million tonnes and average yield of 0.8 M tonnes per hectare (FAO. 2010).

There is growing interest in sorghum in the region due to mutually reinforcing circumstances including: the realisation that sorghum can play a significant role in fighting hunger and food insecurity because this crop is more drought-tolerant; frequent droughts often lead to widespread crop failure particularly of non-traditional food crops; recognition of the nutritive importance of this crop; and increasing appreciation of the cultural roles of foods made out of sorghum. Sorghum is ranked the fifth most important cereal after wheat, rice, maize and barley in the world. Besides Africa, sorghum is also produced in Australia, the United States, and other developed countries, mainly as an ingredient for animal feed.

2.1.5 Wheat

Wheat is the dominant crop in temperate countries being used for human food and livestock feed. Its success depends partly on its adaptability and high yield potential but also on the gluten protein fraction which confers the viscoelastic properties that allow dough to be processed into bread, pasta, noodles, and other food products. Wheat also contributes essential amino acids, minerals, and vitamins, and beneficial phytochemicals and dietary fiber components to the human diet, and these are particularly enriched in whole-grain products.

However, wheat products are also known or suggested to be responsible for a number of adverse reactions in humans, including intolerances (notably coeliac disease) and allergies (respiratory and food). Current and future concerns include sustaining wheat production and quality with reduced inputs of agrochemicals and developing lines with enhanced quality for specific end-uses, notably for biofuels and human nutrition. (Shewry, 2009) .Wheat is counted among the ‘big three’ cereal crops, with over 600 million tons being harvested annually. For example, in 2007, the total world harvest was about 607 m tons compared with 652 m tons of rice and 785 m tons of maize (http://faostat.fao.org/). However, wheat is unrivalled in its range of cultivation, from 67 N in Scandinavia and Russia to 45 S in Argentina, including elevated regions in the tropics and sub-tropics (Feldman, 1995). It is also unrivalled in its range of diversity and the extent to which it has become embedded in the culture and even the religion of diverse societies.

2.1.6. Wheat in nutrition and health

Wheat is widely consumed by humans, in the countries of primary production (which number over 100 in the FAO production statistics for 2004) and in other countries where wheat cannot be grown. For example, imported wheat is used to meet consumer demands for bread and other food products in the humid tropics, particularly those with a culinary tradition dating back to colonial occupation. Statistics are not available for the total volume of wheat which is consumed directly by humans as opposed to feeding livestock, although figures for the UK indicate about one-third of the total production (approximately 5.7m tons per annum are milled with home production being 15–16 m tons).

Globally there is no doubt that the number of people who rely on wheat for a substantial part of their diet amounts to several billions. The high content of starch, about 60–70% of the whole grain and 65–75% of white flour, means that wheat is often considered to be little more than a source of calories, and this is certainly true for animal feed production, with high-yielding, low-protein feed varieties being supplemented by other protein-rich crops (notably soybeans and oilseed residues). However, despite its relatively low protein content (usually 8–15%) wheat still provides as much protein for human and livestock nutrition as the total soybean crop, estimated at about 60 m tons per annum (calculated by Shewry, 2000). Therefore, the nutritional importance of wheat proteins should not be underestimated, particularly in less developed countries where bread, noodles and other products (e.g. Bulgar, couscous) may provide a substantial proportion of the diet

2.1.7 Wheat Nutrition Facts

The nutritional composition of wheat is shown in table 2.1. Wheat is mainly composed of carbs but also has moderate amounts of protein. Here are the nutrition facts for 3.5 ounces of whole-grain wheat flour

Table 2.2 Proximate Composition of Wheat

Nutritional	**Composition** (100 grams)
Calories:	340 kcl
Water:	11
Protein:	13.2
Carbs:	72
Sugar:	0.4
Fiber:	10.7
Fat	2.5

Source (Nwanekezi, 2016).

Like all cereal grains, wheat is mainly composed of carbs. Starch is the predominant carb in the plant kingdom, accounting for over 90% of the total carb content in wheat (Nwanekezi, 2016).The health effects of starch mainly depend on its digestibility, which determines its effect on blood sugar levels. High digestibility may cause an unhealthy spike in blood sugar after a meal and have harmful effects on health, especially for people with diabetes. Similar to white rice and potatoes, both white and whole wheat rank high on the glycemic index (GI), making them unsuitable for people with diabetes (Nwanekezi, 2016). On the other hand, some processed wheat products such as pasta are digested less efficiently and thus don't raise blood sugar levels to the same extent (Nwanekezi, 2016).

2.1.8 Uses of Wheat

1. Wheat is milled to produce flour which is used to make a variety of products around the world including bread across the world. Wheat contains a protein called gluten which is necessary

for the basic structure in forming the dough system for bread, rolls and other baked goods. Many of the foods we consume on a daily basis such as bread, cookies, cakes, pies, pastries, cereals, crackers, pasta, flour tortillas and noodles are all made from wheat flour.

2. Wheat is used for cattle, poultry, and other livestock feed. Wheat is a raw materials used for feed and animal production worldwide for its nutritional and economic value
3. Wheat also forms the base for three extremely popular alcoholic drinks, whiskey, vodka, and beer.
4. Young wheatgrass is becoming increasingly popular as a nutritional supplement offering vitamin A, B-complex, C, E, and K It is also extremely rich in protein, and contains 17 amino acids, which are the building blocks of protein.
5. Since 2010, wheat has been substituted for corn and used to produce bioethanol in the UK and U.S.
6. Some strains of wheat are grown to produce starch in South Asia used in textile manufacturing.

2.1.9. Acha (*Digitaria exilis and Digitaria iburua*)

Acha (*D. exilis*) is an annual, erect herbaceous plant of the family Graminae which reaches stature heights from 30 to 80 centimetres. The ears consist of two to five narrow part ears, which are up to 15 centimetres long. The spikelets comprise a sterile flower and a fertile flower, the latter of which gives rise to the fonio grain. The grain is a caryopsis, which remains surrounded by glumes and husks. Its size is very small, only 1.5 mm (around 2000 seeds to 1 gram).The colour ranges from white, yellow and purple. Fonio mature faster than all other cereals. Some varieties can already be harvested 42–56 days after sowing. Other ripens more slowly, usually in 165–180 days (Jideani, 2012).

Acha (*D. exilis*) also known as funio is of considerable importance in Nigeria where it is commonly eaten, often in preference to other cereals, as many as three times a day as a porridge, couscous or non-alcoholic beverage, valued as a weaning food because of its low bulk and high caloric density with minimal processing requirement, it grows even where rainfall and soil fertility are poor and can be stored in closed containers for many years without need of preservatives (Chukwu and Abdulkadir, 2008).Despite its valuable characteristics and widespread cultivation, fonio has generally received limited attention research and development, which is also why the species is sometimes referred to as an underutilized crop, (Jideani, 2012). Acha showed a high water absorption capacity of 40, 60, 80 and 100% due to appreciable amounts of pentosans, (Shelton, 1985). Acha contains 33 g/kg pentosan, (Lasekan, 1994), which gives the ability to form gel.

In West Africa, the common species cultivated are *Digitaria exilis* (white *acha*), and *Digitaria iburua* (black *acha*). *Acha* is now being gradually "rediscovered" and considered for improvement as cultivated species. (Okeme *et al.*, 2017) *Acha* or *Fonio* is a great crop of antiquity and the most ancient indigenous cereal of West Africa with a cultivation history dating back to 7000 years Cruz, (2004) but has a low yield of 931 $kgha^{-1}$. *Acha* is a low input demanding crop which tolerates a wide range of soils, including loamy, sandy, stony, and shallow but not waterlogged clayed soils indexes Philip and Itodo (2006). According to (Belton and John (2002) which are intermediaries in glycemic. *Acha* has the potential to improve human nutrition, boost food security, foster development, and support land use is one of the world's fastest growing cereals that can mature in three to four months.

Digitaria iburua or black *acha* is one of the species of *Digitaria* that has few tillers, internodes, thicker stems, wide and longer leaves, bigger seeds with black seed coats, and white seeds when processed. It is grown mainly in the Republic of Benin, Burkina Faso, Gambia, Mali, Niger, Nigeria, and Togo. The underutilized grain, which *acha* is considered as a member are often indigenous ancient crops that are still used at some level within the local community, national or even international levels but they have the potential to further contribute to the mix of food sources than they currently do (Okeme, *et al.*, 2017). Among the different varieties of *acha* grown the white *acha* (*Digitaria exilis*) is more popular in Nigeria and is more widely grown while the black *acha* (*Digitaria iburua)* is rarely cultivated. According to (Chukwu and Abdulkadir 2008), *acha* is probably one of the oldest African cereals which have been cultivated for thousands of years across the dry Savannas of West Africa.

Acha is a very handy crop and can grow well on poor soils, it can even produce seed on soils with Aluminum levels that are toxic to other crops and can be relied on in dry savannah lands, where rains are brief and unreliable. The tiny grains are gluten-free and are rich in protein; consumers outside Africa are beginning to recognize its flavor and nutritional quality. Folio is sometimes regarded as the “grain of life” as it provides food early in the farming season when other crops are yet to mature for harvest (Ibrahim, 2001). Among the native crop of Africa, it is selected as a target for biotechnology because of its exceptional culinary and nutritional properties. In Nigeria, *fonio* products are currently recommended as a choice of carbohydrate for diabetic patients today.

Table 2.3: Essential amino acid of *Acha* composition g/16g/N

Amino acid profile *Acha* grains	*(Digitaria exilis)*	*Digitaria iburua*
Lysine	1.29	1.91
Isoleucine	1.96	1.41
Leucine	4.26	4.43

Phenylalanine	2.34	2.35
Histidine	1.35	1.34
Valine	4.11	2.38
Methionine	5.19	3.12
Threonine	1.91	1.92

Source: (Ukim *et al*.2012): (Chukwu and Abdulkadirs 2008)

2.1.10 Food Uses of *Acha*

Some varieties of traditional food prepared from *acha* include thick porridge (*tuwo*), thin porridge (*kunu),* steamed product (brabusco or couscous), *gwote,* and alcoholic beverages. The grains of *acha* can also be boiled like rice and eaten with stew. Flour can be prepared from *acha* which may be fortified with other cereals flour for the production of porridge or pudding cooked in various forms with fish, meat, legumes, or vegetables. In some parts of Nigerian states such as plateau, Bauchi, and Kaduna, *acha* grain is not only consumed as food but the straws are burnt to produce ash of which its filtrate is used for cooking indigenous delicacies. The grains could be used for cookies, crackers, and popcorn. Whole meal *acha* (*Digitaria iburua)* flours can be used in the preparation of some biscuits and snacks that could be useful for individuals with gluten intolerance (Adekunle and Nkama, 2003).

As a Weaning Food: Whole *Acha* grains are used for quick-cooking non-conventional food products. It can be used as a weaning staple food in various parts of West Africa. It is traditionally a prestige food (Chief's Food) and a gourmet item in some communities. It is made into tick unfermented porridge '*tuwo acha*' or fermented beverage '*kunu*'. A boiled whole grain of *acha* is eaten with vegetables, fish, or meat. *Acha* is also popped and can be mixed with other flours to make bread Saidou *et al*, (2018). In the Dominican Republic, *acha* flour is made into porridge and cream mixed with other cereals flour to make cookies and it is used in the preparation of candy fermented beverages aside from everyday meals. *Acha* can also be used in the production of *dambu* (Agu *et al*. (2007) a popular mid-day meal of Fulani sprinkled into fermented skimmed milk or whole milk with sugar.

2.2 Legumes

Legumes or pulses are edible fruits or seeds of pod bearing plants (Sivasanka, 2005). Their seeds are put to a myriad of uses, both nutritional and industrial, and in some parts of the developing world they are the principal source of protein for humans (Trevor *et al*., 2005). Legumes have long been a staple food of low-cost meals around the globe. Thus, it is important that their low levels of intake be elevated. Legumes have high protein content, in the range of 20-40%; about twice that of cereals and several times that in root tubers (Sivasanka, 2005). The common legumes in Nigeria include, Cowpea (Vigna unguiculata), Soybeans (Glycine max), Pigeon pea (Cajanus Cajan), Groundnuts (Arachis hypogea), African yam bean (Sphenostylis stenocarpa), etc. (Okaka, 2005).

2.2.1 Groundnut

Groundnut is the only nut that grows beneath the earth. They become mature in about two months, when the leaves of the plant turn yellow. The groundnut is particularly valued for its protein contents, which is of high biological value. Groundnut contains more protein then meat, two and half more than eggs and more than any other vegetable food. The proteins in groundnut are well balanced.

Groundnuts (Arachis hypogaea), famous by its Indian name mongphaliis a species in the legume or "bean" family (Fabaceae). The peanut was probably first domesticated and cultivated in the valleys of Paraguay.] It is an annual herbaceous plant growing 30 to 50 cm (1.0 to 1.6 Ft.) tall. The leaves are opposite, pinnate with four leaflets (two opposite pairs; no terminal leaflet); each leaflet is 1 to 7 cm (⅜ to 2¾ in) long and 1 to 3 cm (⅜ to 1 inch) across. The flowers are a typical pea flower in shape, 2 to 4cm **(**0.8 to 1.6 in) (¾ to 1½ in) across, yellow with reddish veining. The specific name, hypogaea means "under the earth"; after pollination, the flower stalk elongates, causing it to bend until the ovary touches the ground. Continued stalk growth then pushes the ovary underground where the mature fruit develops into a legume pod, the peanut – a classical example of geocarpy. Pods are 3 to 7 cm (1.2 to 2.8 in) long, containing 1 to 4 seeds. . Samantha and Sevya 2020

Shelled groundnuts with skin Groundnuts have all the benefits of a perfect fruit, in fact they can be considered in the same league as fruits when it comes to contributing to our diet and health.

2.2.2 Health Benefit of Groundnut

1. Groundnuts contain five important nutrients namely food energy, protein, phosphorous, thiamin and niacin. It maintains and repairs body tissues.
2. Eating fresh roasted groundnuts with jiggery and goat's milk is very nutritious for growing children, pregnant women and nursing mothers. It builds a resistance against all infections, such as Hepatitis and tuberculosis.
3. Groundnuts contain 13 different vitamins (including Vitamin A, B, C and E) along with 26 essential trace minerals, including calcium and iron.

4. Groundnuts also contain zinc, good for protecting brain function, and boron, which helps to maintain strong bones. Ground nuts or groundnut products are useful in the treatment of hemophilia, and inherited blood diseases, which cause hemorrhage. It is also useful in nose bleeding and in cases of excessive bleeding during menstruation in women.
5. Groundnuts have good dietary fiber content so they are very good for digestion.
6. Groundnuts are valuable in diabetes. It is also useful in diarrhea, especially chronic diarrhea, which is more frequent immediately after a meal. The patient can use it by drinking goat's milk in which lemon is squeezed with a handful of fresh roasted groundnuts.

Table 2.3 Proximate and Mineral Composition of Groundnut

Nutritional Value of Groundnuts	(per 100 grams)
Water	6.50gm
Energy	567kcal
Energy	2374Kj
Protein	25.80g
Fat	49.24g
Carbohydrate	16.13
Fiber	8.5 g
Sugar, total	3.97gm
Calcium	93 mg
Iron	4.58mg
Magnesium	168mg
Phosphorus	376mg
Potassium	705mg
Sodium	18mg
Zinc	3.27mg
Copper	11.44mg

Manganese	1.934mg

Source Samantha and Sevya 2020

2.2.3 Bambara Groundnut

Bambara nut is considered the third common major legume after groundnuts. Bambara groundnut or nuts is regards as a false nut, rather it is a legume and contains lots of protein as well. It is mainly used in cooking especially in the making of Okpa which can be taken along with pap (Akamu or Ogi), drinks, soaked garri flakes and others. It can also be eaten fresh or boiled after drinks, and can neb ground either fresh or dry to make puddings. (Akpapunam and Darbe 1994), Bambara nut is a sustainable low cost source of complex carbohydrate, plant based proteins, unsaturated fatly acids, and essential minerals (magnesium, iron, zinc, and potassium) especially for those living in a rid and semi-arid regions. Scientific name: Vigna subterranean Family: Fabaceae Subfamily: Faboideae Order: Fabales Kingdom: Plantae (Ramatsetse et *al.*, 2022)

Bambara groundnut is indigenous to sub-Saharan Africa where it is widely cultivated. The center of origin is most likely North-Eastern Nigeria and Northern Cameroon, in West Africa. The species is also grown to a lesser extent in some Asian countries such as India, Malaysia, Philippines and Thailand. Bambara groundnut grain is a proper healthy food due to its high iron (4.9–48 mg/100 g) and protein contents (18.0–24.0%) when compared to other legume products, with great amount of amino acids content, fiber (5.0–12%), fat (5.0–7.0%), carbohydrate (57.43–63.09%)calcium (95.8–99 mg/100 g), potassium (1144–1935 mg/100 g), and sodium (2.9–12.0 mg/100 g). (Ramatsetse et *al.*, 2022)

Bambara groundnuts diverse nutritional composition suggests that it can meet dietary needs of people globally. Its high protein content which maintains a greater focus on improving procedures for processing its grains and expanding food applications. Bambara groundnut also contains several polyphenols such as flavonoids (medioresinol, catechin, catechin dimer anthocyanin, and epicatechin) and phenolic acids (quinic acid, chlorogenic acid, caffeic acid, and ellagic acid) that have positive health benefits and strengthen the immune system against infectious diseases. Furthermore, antioxidants properties from plant extracts including Bambara groundnuts have also been reported to inhibit lipid oxidation in food products, thereby preventing transition metals and oxygen from reacting with food. (Ramatsetse et *al.,* 2022

Bambara groundnut after being picked and dried, is processed and consumed in a variety of ways. After being grilled or boiled for almost an hour, picked fresh grains are eaten as snacks boiling dry grains makes them a functional food. Furthermore, after scorching or roasting, Bambara groundnut can be eaten matured and consumed as a snack or as porridge Dry grains are hard to ground because of their stiff and closely fitting grain coats. The grains are ground into powder which is utilized to bake little flat cakes, make biscuits, bread and as additives to yogurt and vegetable milk. Bambara groundnut is roasted and ground in Eastern Africa, and the powder is utilized to produce relish, soup, and coffee. The powder is also utilized to make a thin or hard porridge. (Ramatsetse *et al.*, 2022)

This type of food crop, also known as Bambara nuts is predominately cultivated in West Africa, it is a type of groundnut and also is one of the common food sources in Nigeria as it used in the production of various food delicacies.

It might be surprising to say that most people in Nigeria may not be conversant with this name as the local name is commonly used but it forms most parts of some families' daily meal. Locally, it is called Okpa (Igbo), Epa- Roro (Yoruba), Kwaruru or Gurjiya (Hausa).Just like groundnuts, Bambara groundnut or nuts is regarded as a false nut, rather it is a legume and contains lots of protein as well. It is mainly used in cooking especially in the making of Okpa which can be taken along with Pap (Akamu or ogi), drinks, soaked garri flakes, and others.

The method of cooking the nut (Okpa) is by steaming which after grounded into flour is used in the preparation, and this makes all the ingredients to remain intact, thus making it highly nutritive. It can as well be roasted, properly salted and then eaten as a snack or used in the making of probiotic beverages Most times, the Bambara groundnut is consumed because it gives energy and tastes great when prepared well but it has other great health benefits which make it a must-eat for everyone. Its nutrients consist of carbohydrates, protein, fat, fiber content, vitamins, minerals such as manganese, potassium, fluoride, magnesium, calcium, phosphorus, zinc, selenium, sodium, iron, copper, etc., and just like milk, it too is regarded as a complete food.

2.2.4 The Numerous Health and Nutritional Benefits of Bambara Nut Includes;

1. It has all the essential nutrients that food needs and because of this, it helps in the prevention of malnutrition and other health problems such as kwashiorkor, rickets, etc., which are triggered or caused by poor and inadequate dieting.
2. It helps in reducing the effects of various health conditions such as anemia as it contains iron and other essential nutrients which boost the body's blood level.
3. It also helps in reducing the chances of getting cancer and other health issues because of the presence of antioxidants that protects the body from harmful food chemicals.
4. The minerals contained in the Bambara nuts such as calcium protects the body from arthritis, osteoporosis and other related bone diseases .In as much as Bambara nuts or groundnuts is well known for its food source, it is also good to know that its health benefits are almost second to

none, as it is used for various medicinal and therapeutic purposes, and contains all the nutrients that our body needs to function well.

2.2.5 Origin of Soya beans

Soya beans was introduced to Nigeria in 1908 *(Ezedinma 1999)*. Most of the early research was carried out at the moor plantation in Ibadan. Germination of imported soya beans seeds was a great obstacle. According to Ezedinma the sudden change in the storage temperature might have been responsible for the rapid determination of the subsequent failures of the seeds germinate.

In 1997, soybeans was successfully grown at the Samaru experimental station. This success encouraged the development of the program which eventually resulted in the distribution of seeds to subsequent farmers in order to establish soya beans as a cash crop. A world shortage of oil seeds immediately after the World War II accelerated the drive for increased soya beans production in Nigeria.

The main soya beans growing area in Nigeria as outline big is the southern guinea zone where raining season of five months or more discourager the cultivation of groundnuts and cowpeas. (Ashaye and Co-worker 1975) Benue state is the main soya beans growing area, followed by Abuja federal capital city and the southern area of Kaduna state. The most common variety is the Malayan variety. The total soya beans production in Nigeria has been erratic, since there are only few incentives for the farmers, especially the rural farmer.

Soybean (Glycine max (L.) Merr.) is a non-native and non-staple crop in sub-Saharan Africa (SSA) with potential to be a commercial crop owing to its wide range of uses as food, feed, and industrial raw material. Soybean was first introduced to SSA by Chinese traders in the 19th century and was cultivated as an economic crop as early as 1903 in South Africa. In the past four decades, soybean cultivation area and production in SSA has increased exponentially, from about 20,000 ha and 13,000 t in the early 1970s to 1,500,000 ha and 2,300,000 t in 2016.

The soybean's pods grow on short stalk in group of three to fifteen. They are hairy. They come in various shades of pale, yellow grey tawny and black. They are slightly curved in shape, usually somehow compressed about 3.7cm by 1cm in size. These pods contain between one and five seeds. The seeds are round but may be flattened in some varieties, which are used as vegetables. The seeds coat is straw coloured, sometimes yellow, green brown or black. These seeds are sometimes blotched and mottled in various combinations of the above colours. The ileum in small and the cotyledon may be yellow or green and varies widely in size. The nutrients content of the soybeans differs with type. Black seeded ones are the richest in protein but low in oil. The yellow seeded types are high in oil, but low in protein. The mature beans contain a high percentage of protein than any other known grain or pulse, except the winged beans.

According to Igbozurike (2004) Soybeans are preferred by feed compounders and food manufacturers because soybeans have higher protein content than other legumes but soybeans cannot be grown successfully in temperate regions. Soybeans is not only used by food producers, but also by industrial operators. The oil from soybeans can be used for shortening margarine and industrial oil for resin and plastic. Onachie (2003) stated that "soybeans have a higher digestible nutrients percentage (91.99%) than cowpeas (79.52%) and therefore are better source of energy".

The federal institute of industrial research has developed a protein enriched pap called soyogi (Akinrele 2001*).* This is a combination of soybeans and maize in 1 to 3 ratios. And this is all about the idea of the researcher to increase and enrich Nigeria menu by combining soybeans with maize, and combining soya beans with wheat flour.

According to Learmonth *(*2005*)* Soybeans are superior to all other plant food as a source of proteins. Subsequently, they have been used extensively in many parts of the world to supplement other proteins especially those of cereals. Its value as a supplementary protein with cereals is as high as or higher than milk solids.

According to a study conducted by Onachie *(2000)* soya beans have a higher content of lysine than all other sources of plant protein. In addition to their high food value soya beans are also one of the least expensive sources of protein when compared to eggs, beef, milk and cowpeas.

2.2.6 The Need of Soya beans in Nigeria

According to Theodore Kay (2002) stated that we need soya beans in Nigeria giving the follow nutritional reasons:

1. It has a high protein and net protein utilization than cowpeas, groundnut and other legumes.
2. Soya beans milk has little taste and can be incorporated into traditional goods without changing the original taste and texture.
3. Can be processed into traditional food like soya moin moin, Amala soya, pap with acceptable paste.
4. Prevention of protein deficiency without resort to imported food as dried skin milk.
5. Soya bean protein can be used to eliminate protein energy malnutrition in a largely vegetarian community.

2.2.7 The Importance of Soya beans in Nigeria Diet

In Nigeria the total production of legumes, primarily cowpea is on the decrease with the growing population. If the rate of animal production and consumption of legumes is decreasing, it is possible that people who traditionally rely on legumes as a source of protein may suffer from protein deficiencies.

Soya beans play an important role in Nigeria diet because of its high protein content and cost of production than other legumes in Nigeria. If the use of soya beans products is widely promoted, nutrient deficient diseases will be reduced.

Glycemic Index

The glycemic index (GI) is a ranking system that classifies foods according to their effect on blood sugar levels. Grains, which are an important part of the human diet, have varying GIs and can be used to help manage diabetes or other health conditions. Whole grains tend to have lower GI values than processed grains because they contain more fiber and minerals that slow down digestion. Oats, for example, has a GI value of 55 whereas white bread has a much higher value of 95. Other whole grain options include barley, bulgur wheat, quinoa and brown rice. Processed grains such as couscous, farro, wild rice and buckwheat noodles or soba noodles can still offer low GI benefits when eaten in moderation.

These varieties may also provide additional nutrients including iron, zinc and B vitamins which would not be available from refined starches like white breads and pastas. For those seeking an even lower GI option there are some special products such as amaranth flour or millet that make great alternatives to traditional carbs like potatoes or pasta dishes.

CHAPTER THREE

3.0 MATERIAL AND METHOD

3.1 Source of Raw Materials

The raw materials used for production of formulated composite flour include; sorghum, soya bean, wheat groundnut crayfish and wheat were procured in Oja Tuntun Baboko Market Ilorin kwara state. While Bambara Groundnut and fonio were procured in sabo gari market Kano State.

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3.2 Methods

3.2.1 Production of cereal and legume flour

Sample Preparation

Production of sorghum Flour

Sorghum Flour was produced using the method descried by FAO

1.Cleaning Sorghum, groundnut, wheat, soya bean, *Acha* and Bambara groundnut seeds was properly cleaned and sorted to remove stones, dirt, chaff, weevil and other extraneous matters, before they were used for further processing.

2. Winnowing : the sorghum grain was winnowed to separates lighter chaff from heavier sorghum grains after threshing. This was done by tossing the grains into the air so wind or airflow to removes the lighter impurities.

4. Grading: the grains was graded to sorts the sorghum grains based on size, weight, or quality to ensures uniformity and improves final product quality, especially in milling.

5. Washing the sorghum was washed to removes surface dust, microbial contaminants, and pesticide residues to enhancing hygiene before further processing.

6. Soaking: the grains was soaked in water for 5 Hours to softens the grain, initiates enzymatic activity, and to reduce antinutritional factors like tannins and phytate and to also prepares the grains for easier drying and grinding.

7. Tempering: the soaked grains was tempered for (2 Hours) to allow moisture to evenly distributed through the grain after soaking. This helps toughen the bran and soften the endosperm, aiding efficient and clean milling.

8. Drying the grain dried at 50–60°C for 4–5 Hours to reduces moisture content to a safe level (below ~12%), which prevents microbial growth and prepares the grains for storage or milling.

9. Dry milling: the grain was dry mill using hammer mill machine to converts dried sorghum grains into flour.

Sorghum grain

↓

Winnowing

↓

Cleaning

↓

Grading

↓

Washing

↓

Soaked (in water for 5hrs)

↓

Tempering (for 2hrs

↓

Drying (50 -60 0c 4-5hours)

↓

Grinding

↓

Sieving

↓

Sorghum flour

Figure 3.1: Flow chart of sorghum flour
Source: (FAO) 2025

3.2.2 Production of fonio flour

Fonio flour was produced using the method descried by Nkiruka *et al.,* 2020

1. Cleaning (Manually) fonio cereal cleaning was done by hand-picking to remove stones, husks, broken grains, and other physical impurities. This ensures hygienic processing and improves the quality of the flour.

2. Washing the grain was washed to remove dust, surface dirt, and microbial contaminants from the grains which also contributes to better flour color and hygiene.
3. The grain was boiled in water for 5 minute and drained
4. It was then steeped in water for 24 hours
5. Oven drying (110°C for 1hrMinutes)
6. The dried fonio grain was dry mill using hammer Mill into fonio flour
7. Sieve (Using 212 µm Sieve Size)

Fonio
↓
Cleaning
↓
Washing
↓
Boiling for 5minutes
↓
Draining
↓
Steeping 24hrs
↓
Cabinet drying 110°C for 1hr
↓
Dry milling
↓
Sieving (0.6mm)
↓
Fonio flour

Figure 3.2: Flow chart of fonio flour
Source: Nkiruka *et al.,* 2020

3.2.3 Production of wheat grain into wheat flour

Wheat flour was produced using the method descried by Blessing *et al.,* 2015

1. Cleaning (Manually) wheat grain cleaning was done by hand-picking to remove stones, husks, broken grains, and other physical impurities. This ensures hygienic processing and improves the quality of the flour.
2. Washing the grain was washed to remove dust, surface dirt, and microbial contaminants from the grains which also contributes to better flour color and hygiene.
3. Oven drying at (60°C for 15Minutes)
4. The wheat grain was dry mill using hammer mill into wheat flour
5. Sieve (Using 212 µm Sieve Size)

Production of wheat flour.

Whole wheat grains

↓

Cleaning manually

Washing

↓

Oven drying (60°C for 15minutes)

↓

Milling (hammer mill)

↓

Sieving (using 212 um sieve size)

↓

Whole wheat flour

Figure 3.2: Flow chart of wheat flour
Source: Blessing *et al.*, 2015

3.2.4 Production of soya bean to soya bean flour

Fonio flour was produced using the method descried by Aminat *et al*., 2013

1. Cleaning (Manually) soya bean seed cleaning was done by hand-picking to remove stones, husks, broken grains, and other physical impurities. This ensures hygienic processing and improves the quality of the flour.
2. It was then soaked overnight to soften the seed coat, the water was decanted and boiled for 30 minute.

3. Soya bean seed coat was remove and washed to separate the coat from the seed, surface.
4. Oven drying at (50°C-60°C)
5. The soya bean was dry mill using hammer mill into soya bean flour
6. Sieve (Using 212 µm Sieve Size)

Production of soya flour

Soya beans grain
↓
Cleaning
↓
Soaking over-night
↓
Decanting water
↓
Boiling 30 minutes
↓
Removal of seed coat
↓
Washing
↓
Draining
↓
Dry oven at (60°C -65°C)
↓
Milling
↓
Soya flour

Figure 3.2: Flow chart of soya bean flour
Source Adeleke et *al.*, 2013

3.2.5 Production of Bambara groundnut flour

Bambara groundnut flour was produced using the method descried by

1. Cleaning (Manually) by hand sorting was done by hand-picking to remove stones, husks, broken grains, and other physical impurities. This ensures hygienic processing and improves the quality of the flour.
2. The Bambara groundnut was soaked for 24hours and dehulled manually oven dried at 60°C for 18hours
3. Milling into flour then sieve using 0.25 um sieve and package

Production of Bambara groundnut flour

Bambara groundnut grain

↓

Sorted

↓

Soaked (24 hours)

↓

Dehulled (manually)

↓

Oven dried (60 0c for 18 hours)

↓

Milled (Hammer mill)

↓

Sieved (0.25 um sieve)

↓

Bambara groundnut flour

Figure 3.2: Flow chart of Bambara flour
Source: Eke-ejiofor

3.2.6 Production of groundnut flour

Groundnut flour was produced using the method descried by lkese *et al*, 2016

4. Cleaning (Manually) by hand sorting was done by hand-picking to remove stones, husks, broken grains, and other physical impurities. This ensures hygienic processing and improves the quality of the flour.
5. The groundnut see was roasted at 120°C 30minute the dehulled to remove the seed coat
6. Milling into paste using blender

7. The paste was screw press to remove the oil then sun dry for 72 hours and pulverized into groundnut flour

Groundnut seed

↓

Cleaning by hand sorting

↓

Roasting at 120°C (30minute)

↓

Dehulling

↓

Milling

↓

Screw pressing

↓

Sun drying for 72hours

↓

Pulverizing

↓

Groundnut flour

Figure 3.2: Flow chart of Groundnut flour
Source: Uche *et al.*, 2016

3.2.7 Procedure for Preparation of Instant Breakfast (Ogi)

1. Four cups of water was measured into a pot
2. Slurry was made with cold water
3. The water was allow to boil at (100 0c)
4. The prepared slurry flour was pour into the water and stir continuously
5. The mixture was allow to boil for 5-7 minutes
6. Instant Breakfast is ready to serve

3.2.8 Procedure for preparation of Swallow

1. Measure 5 cups of water into a pot
2. Make the slurry with cold water
3. Allow the water to boil at 100 0c
4. Add the slurry to the boiling water and stir continuously for 5 minutes

5. Add composite flour and turn until smooth
6. Add little water and allow to steamer for 4 minutes
7. Stir again until a smooth paste is achieved
8. Portion in a plate

3.3 Analytical methods

3.3.1 Determination proximate composition:

The flours was analyzed for carbohydrate content and crude fiber.

3.3.2 Determination of Carbohydrate Content

The official method of AOAC (2005) was used to determine the carbohydrate content. This was obtained by the difference arrived at after subtracting the addition of the percentages Moisture, crude protein, fat, ash, and crude fiber from the total dry matter. Carbohydrate (%) = 100 – Moisture (%) + crude protein (%) + fat (%) +ash (%) + crude fiber (%)

3.3.3 Determination of crude fiber content

The sample from the crude fat determination was transferred into a digestion flask. A 200 ml of boiling sulphuric acid (H2SO4) solution and anti- foaming agent (asbestos) was added to the flask and immediately connected to a digestion flask with a condenser and heated. The sample was boiled for 30 min during which the entire sample was allowed to become thoroughly wetted while any of it was prevented from remaining on the sides of the flask and out of contact with the solvent. After 30 min, the flask was removed; its contents filtered through linen cloth in a funnel and washed with boiling water until the washings were no longer acidic. The sample with asbestos was washed back into the flask with 200 ml boiling sodium hydroxide (NaOH) solution. The flask was reconnected to the condenser and boiled for 30 min. The content were again filtered through linen cloth in a funnel and washed thoroughly with boiled water, then with 15 ml of 95% ethanol. The residue was transferred into previously dried and weighed porcelain, in an oven at 110oC to a constant weight. It was then cooled in a desiccator and weighed. The crucible and its contents were ignited in a muffle furnace at 550oC for 30 min until the carbonaceous matter has been consumed. Cooled in a desiccator and weighed (AOAC, 2012).

$$\%Crude\ fibre = \frac{Loss\ in\ Weight\ of\ alter\ incineration}{Weight\ of\ original\ food} x100$$

.

3.3.3 Determination of Glycemic Index

This experiment is done using an in-vitro protocol simulating human carbohydrate digestion to measure the rapidly digestible starch (RDS), slowly digestible starch (SDS), free glucose (FG), slowly available glucose (SAG) and rapidly available glucose (RAG) of foods according to Englyst *et al*. (1992, 1996, 1999)

3. 3. 4 Reagents/Solvents

Amyloglucosidase (140AGU/ml), Pancreatin, Invertase, Glucose, 0.5M Acetate Buffer pH 5.2, Glucose Oxidase Peroxidase reagent, Pepsin-guar gum solution (pepsin: 0.25g/50ml and guar gum; 0.25g/50ml in 0.05M HCl) (Internal Std), OR Arabinose-40g/L in 50% benzoic acid. 0.1M sodium acetate, 7M KOH, Absolute Ethanol

3.3.5 Preparation of Enzyme Solution

3.0g pancreatin is weighed into a centrifuge tube and suspended in 20ml water. Magnetic stirrer is added and stirred magnetically for 10mins, then centrifuged for 10mins at 3000rpm. The supernatant is taken out and mixed with 0.6ml diluted amyloglucosidase and 1.3ml invertase. This should be shaken well and prepared immediately before use.

3.3.6 Standard Glucose Solution

2500mg glucose is weighed and made up to 200ml with sodium acetate buffer to give a 25mg/ml solution.

3.3.7 Procedure Sample Treatment

For raw samples, boil for 11-30min depending on the nature. Filter and blend while hot. For already treated samples, blend to small size particles**.**

3.3.8 Measurements of Free Glucose

0.1g of the food samples were weighed into test tubes and 1.0 mL internal standard (arabinose), 2mL were added. The tubes were capped and the contents vortex mixed vigorously. The tubes were placed into a boiling water bath and left for 30 min. The tube contents were then vortex and mixed vigorously to completely disrupt the sample. The tubes were cooled to 37°C, 0.2 mL invertase was added, and the tubes placed into a shaking water bath at 37°C and left for 30 min. 2mL absolute ethanol was added to 0.2 mL of each sample and vortex mixed; this was the free sugar glucose (FSG) portion.

3.3.9 In vitro Measurements of Free Glucose/Fructose

Weigh 1.0g of sample into 100 ml conical flask. Add 5ml of arabinose or pepsin guar-gum (internal std) and 20ml of water to it. Vigorously shake the flask to ensure thorough mixing. Place the flask in a boiling water bath for 30mins. Thereafter, vortex the content to mix completely. Cool at 37°C and add 0.3ml invertase and place the tubes in a shaking water bath at 37°C for 30mins. Pick 0.2ml of the sample and add 2ml absolute ethanol to it and vortex to mix. The absorbance of this is recorded at 510 nm as the free glucose (FG) portion.

3.3.10 In vitro Measurement of RAG, SAG, Total Glucose and Starch Fractions

Weigh 0.50 g of the crushed food sample into a test tube. Add 5ml of freshly prepared pepsin-guar gum solution (pepsin: 0.25g/50ml and guar gum; 0.25g/50ml in 0.05M HCl). Cover the tube and vortex to mix. Place into a water bath at 37°C for 30mins. 5ml of 0.5M sodium acetate which was equilibrated at 37°C was added to each tube. The tubes were equilibrated at 37°C in a shaking water bath for 10mins.5ml of the prepared enzyme solution was added to each tube, capped and immersed horizontally in the shaking water bath at 37°C.

Each tube was removed from the water bath at exactly 20mins after the addition of the enzyme solution and 0.5ml of the content was added to 3ml absolute ethanol and mixed. This portion was labeled $G_{20\ \text{that}}$ is glucose content after 20mins of enzyme action. The tubes were returned into the water bath immediately after the sample was taken. After 100mins which makes 120mins after the addition of enzyme solution, 0.5ml was removed from the content of each tube and 3ml absolute ethanol was added and mixed. This portion was labeled $G_{120\ \text{that}}$ is glucose content after 120mins of enzyme action. After all the G_{120} had been collected, the remainder was mixed thoroughly. The tubes were place in a water bath at 100°C for 30mins. The content was mixed again and cooled at 0°C (in ice water) for 15mins.

2.5ml of 7M KOH was added and the tubes were capped and mixed again. The tubes were placed horizontally in a shaking water bath at 0°C for 30mins. The tubes were then removed from the ice water bath and 0.2ml of the content was added into 0.5ml of 1M acetic acid and 0.1ml amyloglucosidase (1:7 with distilled water) was added into each tube and placed into 70°C water bath for 30mins. The tubes were then placed in a boiling water bath for 10mins and cooled to room temperature before the addition of 3ml absolute ethanol; this was recorded as the total glucose (TG) portion.

3.3.11 Glucose Measurements

Prepare the glucose oxidase peroxidase reagent as directed in the kit. Pick 1ml of distilled water into a test tube as the blank and 1ml of the samples into separate test tubes in duplicates. Add 2ml of the glucose oxidase-peroxidase reagent to each of the test tubes and placed in a shaking water bath at 37°C for 10mins. Read the absorbance of the mixture at 510nm. The amount of glucose present in each sample is extrapolated from a standard glucose graph. (Englyst *et al.*, 1992)

Calculation:

Rapidly Available Glucose (RAG) = G_{20}

Slowly Available Glucose (SAG) = $G_{120} - G_{20}$

Rapidly Digestible Starch (RDS) = $(G_{20} - FSG) \times 0.9$

Free Sugar Glucose (FSG) = From Glucose Std Curve

Slowly Digestible Starch (SDS) = $(G_{120} - G_{20}) \times 0.9$

Total Starch = (Total Glucose - FSG) × 0.9

Resistant Starch (RS) = (Total Glucose - G_{120}) × 0.9

3.3.12 Statistical Analysis

All the analyses were conducted in duplicates in completely randomized design. The data were subjected to analysis of variance using Statistical Package for Social Science (SPSS) software version 23, 2017. Means where significantly different and separated by the least significant difference (LSD) test. Significance was accepted at p<0.05.

Sensory Evaluation

Ten panelists from the Department of nutrition and dietetics, Kwara State Polytechnic Ilorin assessed the instant breakfast ogi and swallow samples using the acceptance preference test. The colour, texture, taste, flavour and overall acceptability were evaluated. A nine-point rating scale ranging from ‘like extremely to ‘dislike extremely’ was used. Each panelist was asked to give a general comment on the sample

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Proximate composition carbohydrate fiber and glycemic index of the instant ogi and swallow produced from composite flour of wheat, fonio, soya beans, Bambara groundnut, groundnut and grayfish are presented in table 4.1 below

4.1.1 Glycemic Index Assay of swallow produced from composite flour of wheat, fonio, soya beans, Bambara groundnut, groundnut and grayfish

S/N	Parameter	Amount (mg/100g)
1	Rapidly Available Glucose (RAG)	1.074959
2	Slowly Available Glucose (SAG)	1.074959
3	Rapidly Digestible Starch (RDS)	1.058484
4	Free Sugar Glucose (FSG)	0.443328
5	Slowly Digestible Starch (SDS)	0.565898
6	Total Starch (TS)	0.014827
7	Resistant Starch (RS)	0.267381
8	Free Glucose (FG)	0.710708

4.1.2 Proximate composition of Instant ogi and from composite flour of wheat, soya beans, Bambara groundnut, groundnut and grayfish

Table 4.2

Proximate composition of instant breakfast *OGI*

Carbohydrate mg/100g	Fiber Content %
2.909777	2.295468
2.90419	2.124646

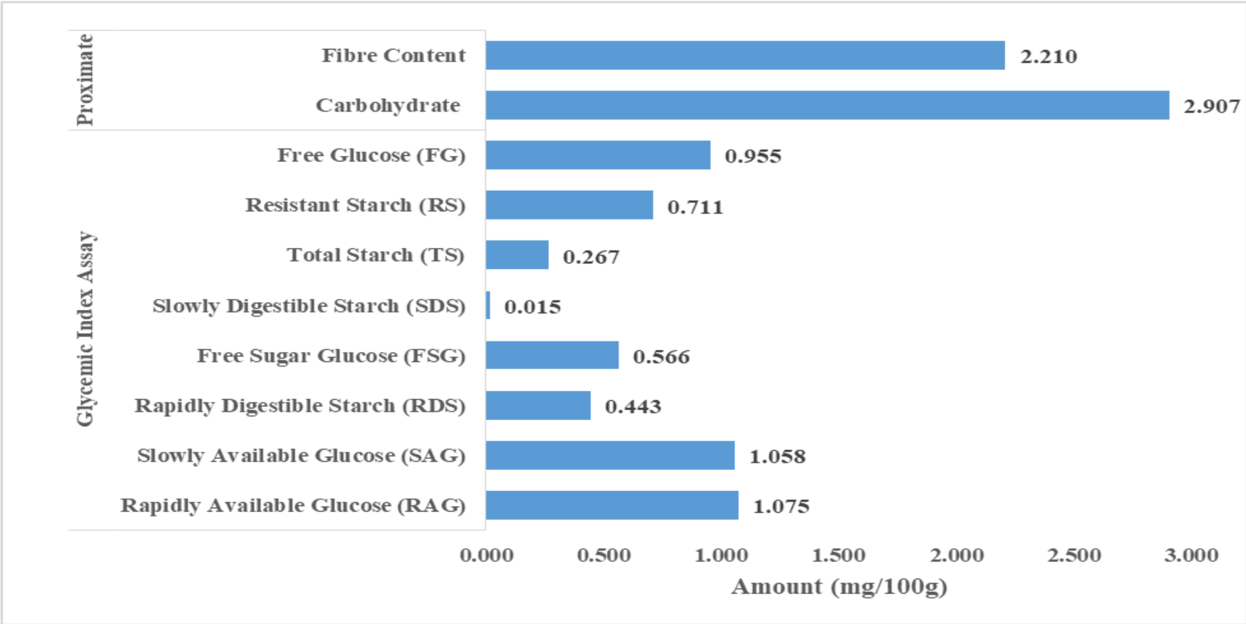

Figure 1. Bar diagram showing Glycemic index assay and Proximate

From Figure 1, the carbohydrate content of the swallow was (2.907 mg/100g) while fiber content was (2.21%).

Glycemic index Rapidly Available Glucose (RAG) was Slowly Available Glucose (SAG) 1.074959(mg/100g) , Rapidly Digestible Starch (RDS) 1.058484(mg/100g), Free Sugar Glucose (FSG) 0.443328(mg/100g), Slowly Digestible Starch (SDS) 0.565898(mg/100g), Total Starch (TS) 0.014827(mg/100g), Resistant Starch (RS) 0.267381(mg/100g) and Free Glucose (FG) 0.710708 (mg/100g)

The Sensory Evaluation result is presented in Fig 1-3 below

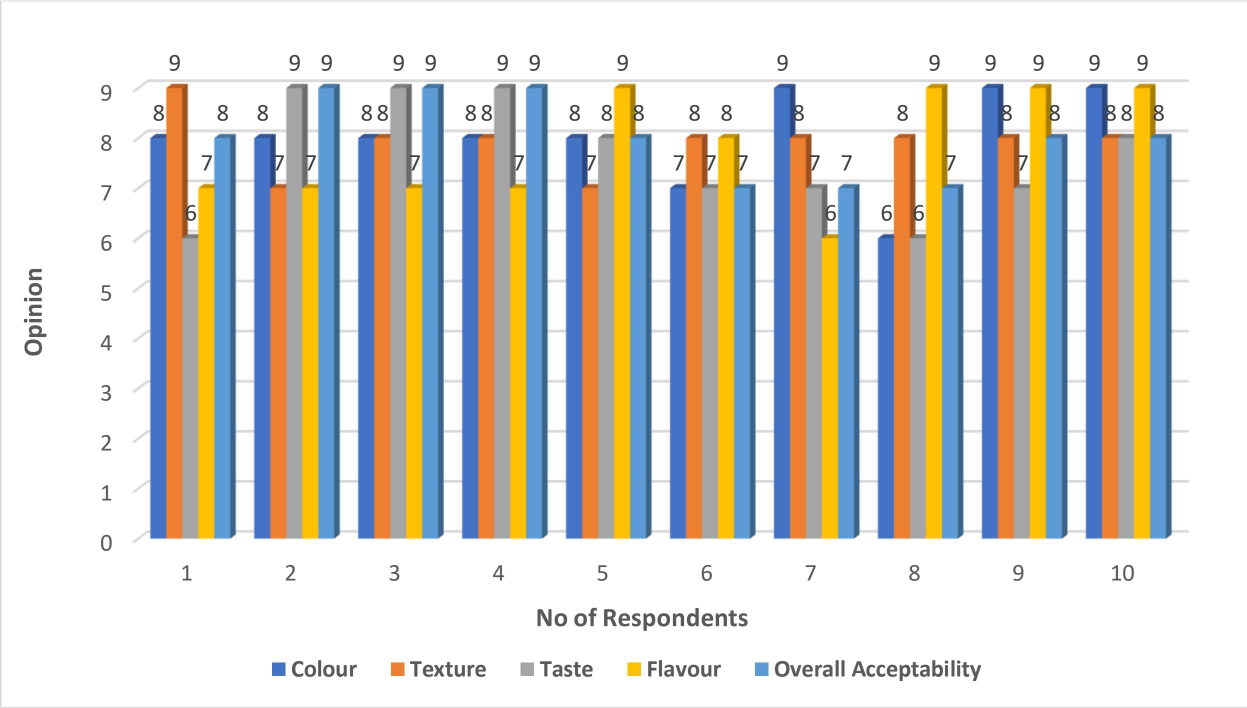

Figure 1: Assessment of Breakfast Ogi by the respondents

From figure 1, shows assessment of Breakfast Ogi by respondents. Ogi is traditionally white or creamy in colour, and its acceptable appeal contributes strongly to consumer interest. A well fermented ogi typically had a mildly sour pleasant flavour. Consumers often prefer a tangy-sour flavour, while smooth-lump free and moderately thick texture is ideal. Scores mostly fall between **7 and 9**, indicating that most respondents **liked ogi extremely or very much**. **Taste and flavour** received the highest marks — common in well-prepared ogi. **Overall acceptability** is high, suggesting that ogi is still a culturally favored breakfast. Minimal scores in the 4–6 range suggest few respondents were neutral or mildly dissatisfied. From the study, breakfast ogi was **well accepted**. The scores imply a strong cultural and sensory preference, especially in **taste and flavour**.

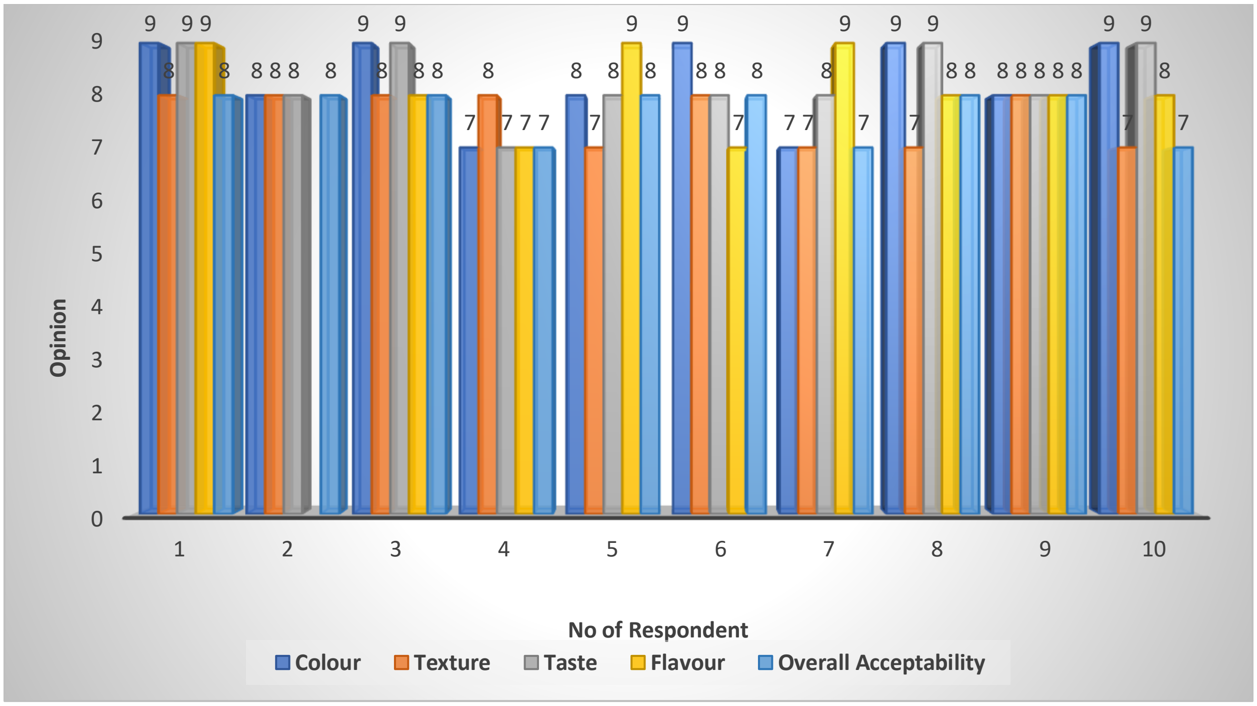

Figure 2: Assessment of Swallow from Wheat by the respondents

Figure 2: show the Assessment of Swallow from Wheat by the respondents. **Wheat Swallow** is a dough-like Nigerian meal eaten with soups, often considered healthier than cassava-based swallows. Smooth mold and light brown in colour, and slightly wheaty scent, neutral smell in flavour. The taste is slightly nutty, less than yam and cassava, while the elasticity and swallow ability are key texture attribute. The scores here are **more varied** than for ogi. **Taste and texture** scored are in the **6–8** range, suggesting moderate to high liking. A noticeable portion of responses fall into the **5–6 range**, showing some **neutral to slight dislike**, possibly due to; unfamiliarity with wheat swallow, issues with elasticity or clumping, and Preference for traditional cassava swallows. Wheat swallow had **moderate to good acceptance**. Some resistance may stem from textural differences or unfamiliar taste. However, its nutritional value might offset moderate sensory concerns.

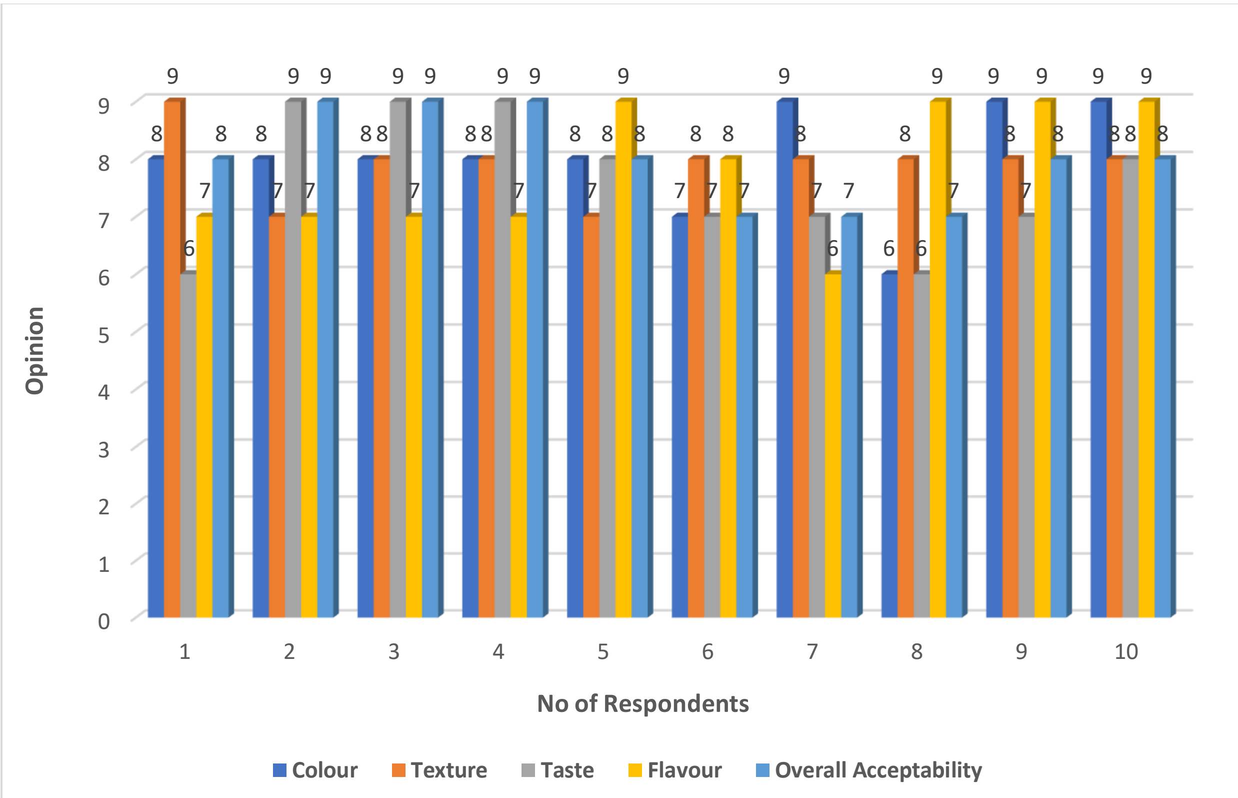

Figure 3: Assessment of Swallow from Acha by the respondents

Figure 3 show the assessment of Acha Swallow by respondents. **Acha Swallow** is made from fonio (Digitaria exilis), a small-grain cereal valued for high fiber and protein. The colour is usually off-white or light brown, and can be grainy. The Flavour is mild, and taste is sometimes nutty or unfamiliar. The texture is coarse when not properly process. Responses seem to show a **polarized pattern**: **Some high ratings (8–9)**, indicating that a segment of respondents **liked it very much**. But also **scores in the 4–6 range**, revealing **ambivalence or slight dislike** among others. **Texture and taste** are often challenges with acha swallow: It may feel grainier or softer than expected; also the nutty flavor may not suit everyone's preference. While it scores well among health-conscious or familiar consumers, general public acceptance might be limited by; lack of familiarity, and expectation mismatch (compared to eba or fufu).

CHAPTER FIVE

5.0 SUMMARY CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

Diabetes is a chronic metabolic disorder characterized by high blood glucose levels affecting millions of people world-wide, Diabetes is a global health concern characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Diabetes management involves a multifaceted approach, including lifestyle modifications and dietary intervention. Dietary management plays a crucial role in controlling blood sugar levels and preventing complications

Diabetes has enlarged as a major public health and challenge globally, characterized by elevated blood glucose levels that can lead to serious complications kidney failure. The role of cereals, legumes and seafood in the formulation of diabetic diet is under-researched particularly concerning their specific impacts on blood glucose regulation, overall nutritional balance, and patient compliance. This gap necessitate a comprehensive investigation into how these food group can be effectively integrated into dietary recommendations for diabetic patient to improve glycemic control, enhance quality of life, and reduce the risk of associated health complications: Cereals, legumes and seafood could provide valuable insights for healthcare providers on developing tailored nutrition interventions for individuals living with diabetes. The research will fill gaps in existing literature by providing insight into the optimal combinations of cereals, legumes and seafood for managing diabetes, contributing to evidence based dietary guidelines.

Composite flour was produced and formulated using different ratio from sorghum, soya bean, fonio, Bambara groundnut, crayfish, and wheat. Analysis was carried out on the glycemic index, carbohydrate and fiber on the composite flour to determine the quality of the diet for suitability for a diabetic patient. Also sensory evaluation was conducted to assess the acceptability of the sample

5.2 CONCLUSION

Diabetes is a very serious disease and enormous number of people are suffering from this disease in the country. The daily diet is a critical factor for maintaining diabetes in all ages, but due to the lack of proper distribution of micro and macro nutrients in food, people are not well balanced with diet. A diet complete in proper ratio of protein, fiber, carbohydrate is a pre-requisite for proper management of diabetes. Low glycemic index food, or diet can be used to slow down blood glucose hike in the body. The ogi produced from the composite flour was moderately accepted. The swallow produced from wheat was likely more accepted than that of fonia which may due to the familiarity of swallow been produced from wheat. The Glycemic index of composite flour produced from both wheat and fonia was low likewise the carbohydrate and the fiber.

5.2 RECOMMENDATION

1. Incorporate Whole Grains: Utilization of whole cereals like sorghum, Fonio and whole wheat in diabetic diets due to their high fiber content can help regulate blood sugar levels.

2. Legume Inclusion: Incorporate legumes such as soybeans, Bambara nut and groundnut into meals to provide protein, fiber and essential nutrient will maintain a low glycemic index.

3. Seafood Consumption: Encourage the consumption of seafood like crayfish, sardines, salmon, which are rich in omeg-3 fatty acids that can improve heart health and reduce inflammation.

4. Balance Meal Planning: Formulate balanced meals that combine cereals, legumes and seafood to provide a mix of carbohydrates, proteins and healthy fats, which can help in managing blood glucose levels effectively.

5. Personalized Diet: Develop personalized diet plans based on individual nutritional needs, preferences and blood sugar levels to ensure optimal diabetes management.

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